AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
BATCH 57

1. SUBJECT CLASSIFICATION
A. PRIMARY: TEMPORARY
B. SECONDARY:

2. TITLE AND SUBTITLE
Instructional innovation and individualization

3. AUTHOR(S)
Klaus, D.J.

4. DOCUMENT DATE
1969

5. NUMBER OF PAGES
451p.

6. ARC NUMBER
ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
AIR

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

9. ABSTRACT
(EDUCATION R & D)

10. CONTROL NUMBER
PN-AAD-183

11. PRICE OF DOCUMENT

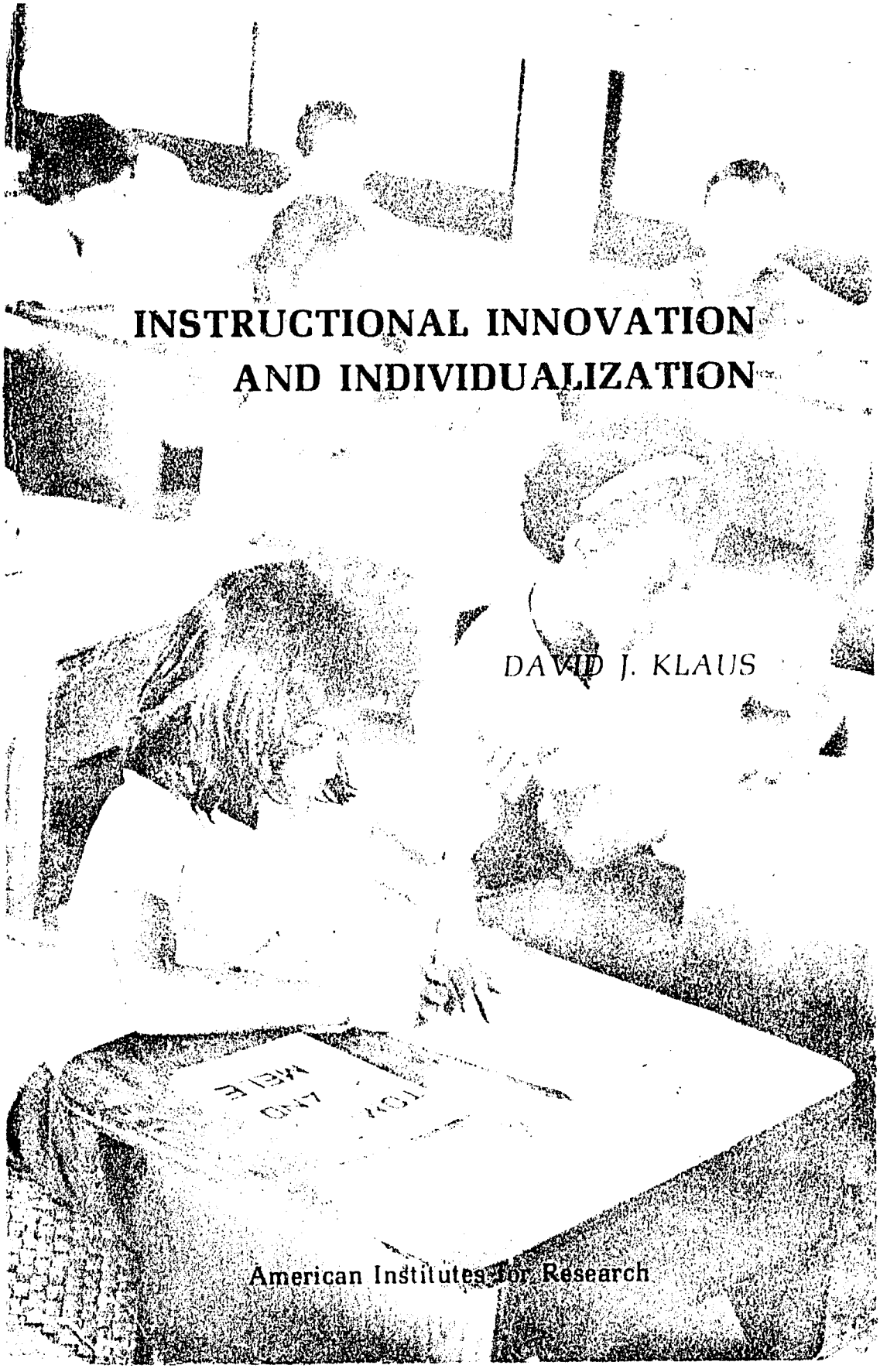
12. DESCRIPTORS

13. PROJECT NUMBER

14. CONTRACT NUMBER
CSD-2160 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)



INSTRUCTIONAL INNOVATION AND INDIVIDUALIZATION

DAVID J. KLAUS

American Institutes for Research

First Printing, 1969

Second Printing, 1971

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INSTRUCTIONAL INNOVATION AND INDIVIDUALIZATION

DAVID J. KLAUS

American Institutes for Research

for the

Agency for International Development

U. S. Department of State

Pittsburgh, Pennsylvania 1969

PREFACE

Education everywhere must overcome almost overwhelming problems to create the reservoirs of skills and knowledge that will be essential for future growth. Some progress is being made but, in many parts of the world, even substantial gains in educational opportunity have been insufficient to keep pace with expanding populations and the demands of modern technology. Instead of easing the deficit, many nations barely have been able to maintain present standards. If real progress is to occur in education, and occur in time to be recognizable during this century, fundamental practices will have to undergo radical change. There is not much likelihood of generating enough qualified teachers, physical facilities or usable materials to depend on traditional teaching practices where these resources currently do not exist. New methods of education will have to be devised and implemented.

It is the purpose of this book to consider alternatives to conventional instructional methods which are or soon will be within the reach of developing coun-

tries. Not all aspects of the proposed approach will be applicable or useful everywhere. Many hinge upon innovations and technological developments which have yet to be tested. All, however, reflect the growing awareness that traditional educational practices have failed to keep pace with rapidly expanding knowledge about the learning process. Some changes are essential if schools are to meet the demands being forced upon them. Present day education is not the best we can do. It is not even good enough.

The preparation of this book was supported by the Office of Education and Human Resources, Bureau for Technical Assistance of the Agency for International Development. Clifford H. Block ably represented A I D and, in addition, made many valuable suggestions as to topics which should be included. Nancy G. Tower and M. Joyce Chowla collected information from a number of ongoing projects and helped gather reference material. Daniel J. Lafferty prepared the art work and diagrams that illustrate the text. Finally, a note of particular appreciation to Margaret L. Lere who labored over the manuscript, organized the bibliography, and patiently kept track of countless details.

David J. Klaus
1969

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ABSTRACT

Education, particularly in the developing countries, faces almost overwhelming problems. There is an ever expanding need for schools and skilled personnel to serve rapidly increasing populations. At the same time, the scope and depth of education each student will need to make a productive contribution to the world he will live in has grown considerably. While the urgency of existing deficiencies is well recognized, there seems to be little real hope that needed improvements in the quantity and quality of education can be achieved using traditional approaches. Instead, emphasis must be redirected toward the creation of imaginative and innovative alternatives to current practices, alternatives which have the capability of providing every student with an effective education even where available resources are limited.

A number of new concepts and technologies have emerged in the last few years which offer the promise of reversing past trends. One of these is the systems approach, a framework for designing workable educa-

tional improvements based on an objective analysis of the problems to be solved and the resources needed to implement a solution. Another is the increasingly influential distinction between conventional methods of teaching which focus attention on presentation methods and new approaches to instruction which focus on learner performance. Research contrasting these methodologies suggests that efforts to individualize instruction so that each learner can receive the practice he needs for complete mastery are far more effective and efficient than solutions which stress the communication and presentation characteristics of educational methods. Because carefully planned systems of individualized instruction need not be more expensive than traditional approaches, and yet can provide education much better suited to each student's needs, their potential for improving the educational programs of developing countries may be enormous.

These profound changes are apt to be contingent, however, on substantial increases in the degree to which classroom instruction makes use of the tools, methods and, even more important, the principles of modern instructional technology. Careful studies of the learning process, for instance, have revealed the beneficial features of tutorial instruction, the futility of punishing errors, the irrelevance of complex concepts of motivation, and the importance of incremental successes during learning. Findings such as these suggest, in contrast to the practices characteristic of conventional teaching, that the burden of learning is properly the responsibility of the instruction itself and not of the student receiving it.

One aspect of instructional technology which has grown considerably in importance has been the use of automation to cope with the worldwide shortage of qualified teaching personnel. Automating the presentation aspects of teaching can be both helpful and eco-

nomical, as experience with instructional media has shown, but automating the conditions of practice may be even more significant. An important step in this direction has been the development of programmed instruction, a technique which gives every learner the advantages of self-paced instruction, precisely controlled practice, carefully sequenced guidance, and reward following the completion of each small step. Although instructional television, for example, generally produces results equivalent to what can be accomplished by a classroom teacher, individualized programmed instruction routinely produces thorough mastery for all students, often with a savings in learning time. The adoption of programmed instruction has been limited, in part, because of the difficulty teachers experienced trying to incorporate self-paced materials in conventional classroom settings. However, many of the features of programmed instruction have become essential ingredients in innovative educational systems now under development.

One of the principles which modern instructional technology has absorbed from programmed instruction is the need to attend to the precise objectives of the instructional process, the specification of exactly what the instruction is to accomplish. Only by predetermining the precise knowledge and skills the student is to learn is it possible to examine the outcomes of instruction to discover whether it has succeeded or, if not, where it has failed so that remedial changes can be made. This process is aided considerably by the use of tests which compare each student's accomplishment, not with that of other students, but with external standards. Interestingly, when these absolute measures are used to assess learning, it has been found that it is the speed of learning and not how much can be learned that is dependent upon the learner's ability. Given enough time to progress through each step necessary for learn-

ing, even slow students are able to master complex facts and concepts.

A second outcome has been increasing interest in the use of devices to assist with the instructional process during individualized learning. Although a number of early devices were designed exclusively for the presentation of information, the control over student behavior advocated by programmed instruction gave rise to a number of teaching machines which contributed to the popularity of early programmed materials. More elaborate instructional devices recently have been created using the capabilities of electronic computers. These range from a computerized keyboard trainer and a 'talking typewriter,' used to teach young children verbal skills, to multiple-terminal computer systems. At the present time, however, computer aided instruction rarely does any more than could be accomplished with much simpler devices or even books. Considering the very high cost of these sytems, it is doubtful that they will have much of an impact in the near future.

Textbooks, on the other hand, are likely to have a major role in improving the availability and excellence of education everywhere. Using alternate production techniques, a typical text which now costs over a dollar to produce could be manufactured for as little as four cents. These books, unbound and printed in newspaper format, would serve perfectly well for one-time use. Before textbooks can assume more of the burden of instruction, however, several changes will be required. Instead of being repositories of information, they will have to be prepared as teaching instruments and receive the benefits of the tryout and revision process now generally applied to other kinds of newer instructional materials.

Conventional audiovisual aids are likely to undergo even greater changes as the individualization of in-

struction becomes more pronounced. Most broadcast and classroom media have failed to result in any improvement over traditional good teaching because they have attempted to replicate only the presentation functions of classroom instruction. Yet, television and other audiovisual media may be indispensable in some developing countries, such as the Niger and El Salvador, where they are alternatives to poor education or none at all. These media also will have increasing applicability for those aspects of teaching for which they are well suited, such as bringing vividness and excitement to the presentation of new content. To enhance their utility, broadcast lessons may be shortened and related to individualized practice. Toys, games and other instructional manipulanda may become more popular as media to enhance learning.

These new techniques and tools of instruction will be important in the future of education but almost certainly they will fail to have a demonstrably significant impact unless they are implemented as a consequence of the systems approach. This approach recognizes that education is a dynamic system with interacting constituent parts and that a change in any component is likely to affect the utility and contribution of all other components. Because education is a particularly complex system, it is essential that hoped for improvements be planned in such a way as to maximize the likelihood of their success. The first step in applying the systems approach is to define the problem to be solved in terms of the desired outcome. The next step is to establish the criteria for the success of the change. The third step is the identification of possible solutions. This is followed by a feasibility step in which various promising solutions are tested. The fifth step is to assemble and implement the new system. The final step is to collect data on remaining deficiencies in the system in

order to establish the aims for a subsequent cycle of improvement.

The systems approach can be applied to establishing or improving both structures of education and instructional processes. For instance, it can be used to plan a system of instruction which has all the benefits of self-pacing but operates within a framework of existing class groupings. It also can be used to meld various technologies into a workable and economical program by avoiding expensive duplications and the underuse of school facilities, materials and personnel. Even more important, the systems approach establishes an orientation which emphasizes continuous quality control practices as a means of securing the best possible education from available resources.

Keeping track of the relevant details of a large and diverse educational system has become almost impossible without modern data processing techniques and equipment. The use of a computer to manage education is not limited to the collection and analysis of statistical information on enrollment and school budgets; some other recent applications have included computerized models of school operation which permit forecasting the effects of change and the use of computers to score both multiple-choice and essay tests. An even more promising possibility is the use of a computer to supervise the operation of a system of individualized instruction by maintaining detailed control over each student's progress and assignments.

A number of media-based systems of instruction have been developed which employ automation to permit individually-paced learning. Among the most flexible of these are the dial access systems now being introduced in a number of locations ranging from elementary schools to universities. These installations originated with the expansion of language laboratory facilities to include instruction on subjects other than

second languages, and the broadening of equipment to permit students to select among multiple audio channels or to provide a visual capability in installations also equipped with television. For individualized instruction, students are assigned to carrels, or booths, from which they can listen in on any one of perhaps as many as 224 different lectures or other instructional tapes whenever and how often they wish. These systems can assume the full teaching responsibility if students also are provided with workbooks that guide the completion of practice exercises and other learning experiences.

Specifically designed worksheets also can be a critical component of systems of collective instruction, such as those using television. In American Samoa, for example, relatively unskilled teachers are supported by the extensive use of classroom television for the presentation of lesson content and by printed exercises which the students are to complete between scheduled segments of transmitted instruction. Although a number of possibilities remain for improving the present operation of this system, it does illustrate how various components representative of modern instructional technology can be combined to meet the specific needs of a particular developing area.

Project PLAN, which was recently introduced in the United States, is perhaps the most encompassing system of individualized instruction yet devised. In addition to lesson materials which fully permit each child to learn at his own pace, the overall curriculum for each student can be tailored to his particular background, aptitude and interests through the use of instructional modules. Each module, representing 10 to 15 hours of instruction, can be assigned separately to construct a unique sequence for each student. Materials soon will be available for the equivalent of all twelve grades of elementary and secondary school plus suffi-

cient advanced modules to provide the equivalent of two years of additional schooling for particularly able students. A heavy emphasis is placed on testing in Project PLAN to insure that remedial steps are taken when needed and to provide each student and his teacher with a flow of information about his aspirations and accomplishments.

Realistically, it is not necessary and sometimes not even desirable to implement a complete system of education all at one time. By automating instruction gradually, it often is possible to reduce developmental errors and economize substantially on the entire process. Techniques for gradually improving instruction have been applied both to technical and academic instruction. With this approach, decisions regarding media and teaching equipment generally are deferred until tests prepared for diagnostic and quality control purposes demonstrate that the content of instruction and the accompanying exercises satisfactorily achieve the desired results.

It is evident from an examination of most new systems that innovation plays an important role in attempts to improve education. However, it also is clear that innovations which have been designed to meet a hypothetical rather than actual need often prove useless. Among recent innovations in education, several have particular relevance for systems of individualized instruction including those concerned with curriculum revisions, teaching methods, school equipment, reading instruction, building design, the use of educational resources, and teacher guidance. The diffusion of innovations remains a difficulty, largely because few innovations can be transferred directly from one system to the next. Nevertheless, demonstrations of new systems in use seem to be an effective way of stimulating change and encouraging new approaches.

Although the conditions which lead to modifications of traditional practices in education are not at all clear, it is evident that constructive change is likely to occur only if it is deliberately instigated. The potential cost of improvement often is suggested as a major stumbling block. Yet, it is obvious that attempts to offer education in its present form to the vast numbers of students who could profit from it is an expense beyond the capabilities of most developing nations. On the other hand, new systems of education, if thoroughly planned, need not be more expensive than present methods. In addition, new systems which have been tailored to meet local priorities and constraints would provide the rewarding educational benefits which modern technology can produce. Change can be encouraged in several ways. For example, the funding of ongoing educational programs could be made contingent both on meaningful evaluations of the program and workable plans for improving it. There is little risk in modifying present practices and materials in that any change based on systematic applications of instructional technology is likely to be beneficial.

Continuing research is desirable, but research which will significantly improve educational practices must be addressed to the solution of significant problems. All knowledge is not equally valuable, particularly when no effort is made to demonstrate the effectiveness of an idea under realistic classroom conditions or when there is no hope that the expected effect will be more than marginal. Perhaps the most pressing among current research problems concerns improvement in literacy instruction, both to enhance how reading is taught and to promote learning from reading. Most learning probably occurs informally, outside of the classroom. To make sure that a student is prepared to profit from the lifelong learning opportunities he will have, it is necessary to improve his talents for

learning from typical written materials or to simplify the materials made available to him to reduce the self-teaching skill required. Other research areas which may be particularly relevant to the development of new kinds of educational systems are studies of instructional content, presentation media, teacher training, student attitudes, educational experiences, instructional efficiency and cost reduction.

Education frequently has been criticized for failing to provide the skills and knowledge that is both wanted and needed. Simple patching is not likely to provide an answer. Instead, completely new approaches must be devised based on systematic applications of instructional technology. The results are likely to be innovative systems, systems which may be far easier to create in developing countries than in affluent nations. No vast new expenditures will be required in that it is not the amount of resources but how they are used which is crucial. Most important of all, the results of concerted efforts to enhance education by increasing both automation and individualization in learning may finally demonstrate that traditional systems of instruction are not necessarily the very best forms of education that can be devised.

1

INTRODUCTION

The most valuable resource of any nation is its people. They operate the machines, harvest the crops, care for the young and plan for the future. Skilled, knowledgeable people are irreplaceable assets, but those unable to count or read, to appreciate or analyze, to design or devise are equally unable to contribute to the world around them. Reasonable standards of health, nutrition and security are necessary to maintain a viable population. Whether this population then can achieve genuine economic, political and cultural growth depends on how thoroughly it has been prepared to meet the demands and responsibilities it must face. Short of the diffusion of instant knowledge through as yet undiscovered pills or implants, every nation must invest in its own future with an effective and encompassing educational program.

Education as an Investment

The investment required for education in the modern world is close to awesome. In the United States, for example, more than thirty percent of the entire

population is either student or teacher and more than six percent of the gross national product is spent on education (Renetzky & Kaplan, 1968). In many parts of the world, including most of the developing countries, the burden on education is far larger. In American Samoa, for instance, where the population is increasing at a rate of about four percent each year, nearly forty percent of the population is of school age, 6 through 17 (U. S. Department of the Interior, 1968). If the available full-time work force is estimated by dividing the number of adults age 25 and over by half — to account for mothers with infants, the aged and the infirm — between five and ten percent of those eligible for employment must be used as classroom teachers regardless of their own educational level.

School enrollment and teacher requirements for a dramatically expanding population is only one educational concern of developing countries. Another prominent difficulty is the need to provide more and more education to each learner. If an increase in standard of living is to be realized, increasingly complex skills and broader knowledge will have to be taught. Median earned income in the United States rises approximately $500 per year for each year spent in school and is more than twice as large for those who have completed twelve years of school than for those who have completed less than eight (Renetzky & Kaplan, 1968). This relationship between individual productivity and educational level is far from uniform throughout the world, and represents only one factor among many which apparently affect economic development (Curle, 1964). Nevertheless, some minimum educational level is required for an individual to be a contributing participant in modern society; this level progressively increases with technological advances, and ever larger numbers of individuals are available to be taught useful skills.

The Need for Innovation

The gravity of the task facing educators in developing nations is clearly evident. Were traditional approaches to be adopted, the dramatic increases in the number of teachers, classrooms and books that would be required inescapably would detract from other sectors equally essential to overall development, if these resources could be produced at all. This rather grim predicament will have to be endured forever into the foreseeable future unless alternative approaches to education are found which go beyond traditional resources and yet can be implemented within the capabilities of the developing countries.

At the present time, no such solution exists. Nor is it likely that any single discovery or device conceivably on the horizon will provide an instant solution. It is very possible, on the other hand, that answers will be found which are capable of providing both the quantity and quality of education needed to fulfill the potential of all individuals. These answers will be the product of serious and systematic efforts to devise practical alternatives to traditional educational practices based on a careful consideration of the role, benefits and costs of each ingredient which could be employed to enhance educational outcomes.

The term 'innovation' often is used to describe solutions to problems which represent a change or departure from current practices as opposed to progressive improvements within an existing framework. For example, adoption of the Initial Teaching Alphabet (i·t·a) for use by children first learning to read English was innovative because it resulted from examining a dimension of reading instruction that previously had gone unchallenged. Similarly, a conversational emphasis in foreign language instruction, work-study programs in vocational education, and the sets-relations-

functions approach to mathematics were innovative because they departed from what was considered standard practice. Unfortunately, education has benefited from rather small numbers of innovations compared with almost any other area of technology. Classroom practices have remained largely unchanged in a world that produced the telephone, penicillin, and the internal-combustion engine.

Emergence of the Systems Approach

The very rapid growth in educational technology in the past few years has done much to reverse past trends and provide renewed hope that effective overall solutions will emerge. The recent abundance of promising innovations has occurred too rapidly, however, to be easily digested. The last decade alone has produced the teaching machine, the behavioral objective, programmed instruction, the proficiency test and computer assisted education. With this range of new resources, the development of a cohesive plan for educational betterment has become increasingly feasible. But, devising a plan that contains all the ingredients necessary to make it work effectively has become increasingly complex as well. Fortunately, another kind of innovation has occurred in education which can help in formulating a smoothly operating, efficient and economical solution. This is called the systems approach, a method for developing a framework which can be used to design, implement and evaluate the components which need to be assembled to reach a desired goal.

In brief, the systems approach identifies and defines the requirements which must be met for an overall objective to be achieved, specifies the characteristics of resources which must be assembled to fulfill these requirements, and provides a developmental plan which permits the resulting product to be evaluated, revised and updated with minimum waste. Recognition that

education is a system, and that the interactions among its constituent parts more frequently than not determine how faithfully its goals will be achieved, has been one of the most important contributions of modern instructional technology. The extent to which systems approach practices have entered into the planning and implementation of an educational change appears to be crucial to the success of that change. The piecemeal application of new concepts, new media and new techniques that so often is characteristic of education today has every probability of failure. Without the timely development of the systems approach it would have been impossible to incorporate recent innovative possibilities into workable educational plans.

It is important, too, to recognize that each individual component of a system, whether intended to be relevant or not, is likely to influence the outcomes of any effort to enhance education. On the other hand, no single combination of elements is essential, and the effectiveness of an innovation does not necessarily depend upon the availability of sophisticated equipment or talented specialists. The unique advantages of the instructional system at American Samoa, for example, probably can be replicated elsewhere for a few cents per instructional hour with the efficient use of local resources. Similarly, the exciting program of individually tailored education being introduced through Project PLAN incorporates no new instructional devices or teacher competencies yet it may vastly improve both attainment and speed of learning. Instructional technology is closely associated with a vast array of new tools. But, computers, television, and dial access systems certainly are not necessary and, very often, not even desirable components of an educational system.

Understanding the impact of each element in complex educational systems such as those in use in Samoa and under development for Project PLAN re-

quires the perspective of a new image of the instructional process. Much of the vigor and direction of recent educational change has been the result of provocative new insights into the way in which learning occurs, insights which perhaps represent the most significant innovation in education in the last hundred years. An awareness of the influence which these changing conceptualizations of learning have had on the design of newer instructional systems is fundamental to an understanding of how these systems can be modified to meet local conditions without any loss in effectiveness.

Configurationist and Connectionist Principles

Education traditionally has implemented principles of learning which focused attention on the presentation, or stimulus, aspects of the teaching situation. This position, which emphasizes the configuration or patterning of the information displayed to the learners, often is called the *configurationist* approach. Other theories of learning also can and have been used as a foundation for developing educational practices. One of these which recently has received considerable attention is the *connectionist* approach. This approach is based on principles of learning which are focused on the response, or performance, of the learner in the learning environment.

An important characteristic of these two theories of learning is that they embody different premises and represent two ways of viewing the learning process, but they are not mutually exclusive. Both are the result of many years of serious study and research on different dimensions of the problem of how to enhance learning. During much of the history of education, the configurationist approach was felt to have the most promise. Recently, however, the connectionist approach has been very influential in education, particularly in the

sense that it has led to many new ideas about learning and teaching and to a resurgence of older ideas that never became widely adopted in the absence of an adequate theoretical framework to support them.

The growth of this new theoretical approach has brought with it a renewed vigor for examining many of the features of the educational process that have gone relatively unchallenged in the past. For example, the primary role of the teacher long has been to present information to the learner, to serve as a model which could be imitated. The best teachers were felt to be those who organized and explained their ideas most clearly, concisely and thoroughly. Learning in the absence of a skilled teacher was felt to be difficult because the presentation of the content to be learned was unconnected, incomplete and tiresome.

However, new ways of looking at the learning process suggest that the manner in which a teacher presents information may not be all that is important. There is considerable evidence that the learner must do more than passively experience a lecture or demonstration. He must be an active participant in the learning process. The teacher who is also a good tutor recognizes this by demanding that the student practice what he is learning. This role of the teacher as a tutor, which rarely has received more than incidental attention in the past, has increasingly become the focus of modern educational research.

The Need for Individualization

One outcome of this changing view has been an increased interest in the performance of the individual learner during instruction. Differences in ability traditionally have been regarded as an important determinant of how well any one student will learn as a member of a class or group. The meaning of the relationship between ability and achievement has been

questioned, however, in the light of rapidly increasing understanding of the importance of the learner's behavior in the learning situation. Traditional beliefs based largely on configurationist learning theories held that no presentation, no matter how effective it was, could communicate the facts, principles and skills being taught equally well to every learner. Each student was felt to be more or less unique in his capability to understand and remember lesson content. He also was felt to be uniquely affected by the kind of presentation he was exposed to, so that some learners profited more from listening while others profited more by reading and still others learned best by watching. The effects of rate of learning were routinely ignored; if a student failed to grasp some point, it was because of a failure in communication.

Connectionist learning theories, concerned with the responses of the learner, long have emphasized that practice is an essential component of all learning. Deprived of all practice opportunities, a learner would not be able to master any content no matter how succinctly or suitably it was presented. Some learners, the connectionists contend, require more practice than others to reach the same level of mastery. Under these circumstances, the individual members of any group of learners would vary in how much they learned from a single presentation not as a result of inadequate communication but because some members would have had too little practice. Rate of learning thus can be all important in determining how much is learned. If rate could be allowed to vary, all students would be able to learn the same content, but in different amounts of time. Many educators who in the past only could suppress their frustrations over the failures of their slower students easily recognized the value of equal mastery for all students. If something is important enough to be worth teaching, it is worth teaching in a way that all

students will profit from it even if they may learn in different amounts of time. How to let each student proceed at his own best pace is a question that has since consumed instructional technology.

Research on Individualized Instruction

The potential of individualized instruction has been assessed in a large number of studies. One compilation of these investigations (Ofiesh, 1965, p. 70) summarized the results of comparisons between conventional versus individualized instruction for 46 military training courses which had fixed objectives. Of these comparisons, 40 indicated greater achievement for those who learned at their own pace than for those who learned by conventional teaching methods. The median gain in achievement was 11%. Almost all of these learners also spent less time than they would have spent in the classroom; the median savings in time was an impressive 40%. An investigation on the improvement of industrial training (Short et al., 1968) demonstrated that individualized instruction, by allowing rate of learning to vary, consistently could produce median achievement test scores of 90% or better. In this study, the slowest learners required about four times the number of days to complete the course as the fast learners.

A trial of self-instructional materials in chemistry for secondary school students (Cook, 1964) showed that students who were at middle ability levels required fifty percent more time to learn the content presented by the materials but had almost the identical achievement of students at high ability levels. The median score at the end of the course again was over 90%. Schramm compiled the results of 36 comparative studies involving individualized instruction including 16 which were done at colleges, four in secondary schools, five in primary schools, ten with adults and

one on retarded children (Schramm, 1964). Of these 36 studies, the differences in 18 comparisons were not statistically significant. Of the remaining, 17 favored those who received individualized instruction and only one favored those who received conventional classroom instruction. In many instances, individualized instruction also produced an overall savings in learning time. Still another compilation of field test comparisons surveyed the results of 15 studies (Silberman, 1962). Among these 15 experiments, the outcomes favored individualized instruction in nine of them and yielded no significant difference in the remaining six. Not one of the studies favored conventional instruction. In all 15 experiments, the students receiving individualized instruction required significantly less learning time than those receiving conventional instruction.

In all of these studies, the learners who received instruction individually were taught by books, tape recordings or instructional equipment and not by a live teacher. Because all students were given the same instructional materials, these results could be replicated over and over again simply by producing and distributing more copies. In other words, once the materials needed for individualized instruction have been prepared, any number of students then can learn without the assistance of a teacher. Even more important, by being permitted to learn at their own pace, all of these students will achieve uniformly high levels of mastery even though their ability levels may vary as much as would be true of an ordinary class. Early in the development of instructional methods suitable for individualized learning, a criterion of ninety percent of the students mastering ninety percent of the content taught was proposed (Klaus, 1964b). This goal is not always achieved, but it is reached often enough to demonstrate that it is not technically impossible even for the present state of the art.

The Prospects for Individualized Instruction

There is nothing about connectionist principles of learning which make them more correct, more powerful or more exacting than configurationist principles. However, their application to education has resulted in a new option for educational planners. Using techniques and devices already created, an educational system can be based upon traditional teaching practices which tolerate differences in achievement to maintain uniform learning time or, alternatively, the system can employ methods of individualized instruction to insure that all learners will learn successfully providing they can do so in differing amounts of time. Wherever a mature educational system exists, as in the United States, the choice between these two approaches actually is more difficult than it might be in the absence of a fixed educational structure. Replacing an approach which has functioned smoothly if not perfectly for many years poses economic and political difficulties which go far beyond the relative merits of the alternatives. Many of the developing countries are not burdened in this way. Not only are these countries in a better position to move in the direction of individualized instruction but, for them, this choice may be the only one which can produce the dramatic increments in the quality and availability of education so necessary for real progress.

Traditional approaches to instruction, even when enhanced by television, radio and audiovisual materials, no longer offer much promise that every student will receive the education he needs to make full use of his own potential. The slower learner in a conventional classroom at best can master only a fraction of what is taught and therefore he leaves that room only fractionally prepared for gainful work, further education or a fully productive life. The able learner, on the other

hand, must sit idly by while points already grasped are reviewed and restated for the benefit of other students who happen to share his instruction with him. The dedication of much too scarce resources to an approach to education which has recognized qualitative deficiencies, enormous manpower requirements and little promise of change is difficult to defend.

Despite the recognized potential of the kind of individualized instruction that can be used to benefit all learners, its application in education has been very limited. One reason for this has been the enormous problem of devising techniques which can provide the necessary control over learning in the absence of human supervision for extended periods of time. A second problem has been the need for more adequate demonstrations of the educational and economic value of individualized instruction within ongoing educational frameworks that originally were devised to serve intact class groups. The third problem, and perhaps the most difficult of all to overcome, has been the reluctance of most teachers to adopt the new roles and methods without which no new technology can ever succeed.

Solutions to these problems, particularly as they relate to the educational planning of developing nations, are almost within grasp. Nevertheless, considerable innovation, effort and organization will be required before these countries will be able to create workable systems which make use of the techniques of individualized instruction. The lesser developed regions of the world face economic, cultural and population growth problems which exert severe constraints on the evolution of their educational systems. Yet, change can occur so long as there is a recognition that existing educational systems can be improved. Obviously, simply increasing the amount or share of resources devoted to education is not a realistic answer. Most nations spend as much on education as

they can afford within the framework and priorities of their fundamental goals. It is possible, however, to make far better use of available resources so that many, if not all, the advantages of individualized instruction can be realized without the expenses usually associated with elaborate media and skilled classroom teachers.

2

FUNDAMENTAL PRINCIPLES

Historically, education has been very resistant to technology. Classroom practices have changed surprisingly little with the passage of time; where changes have occurred they have been mostly in the tools the teacher can use and not in the methods characteristic of instruction. The reasons for change when it has taken place generally have been in response to two very influential forces. First, knowledge progressively has accumulated at an exponential rate, a phenomenon particularly noticeable since the industrial revolution. While once an educated man knew almost all there was to know, he now needs much of a lifetime to master the details of a single chosen specialty. Teachers who collectively once were at ease with all facets of a basic curriculum found it necessary to narrow their fields of interest in order to maintain subject matter competency. The second reason for change has been the need to multiply the utilization of a teacher who was both skilled and knowledgeable. Numbers of students have tended to increase and new patterns of education have had to be devised to permit contact between teachers

and students separated by time and distance. The urgencies of these continuing pressures to expand and upgrade education left little time or opportunity to explore the fundamental tenets underlying educational practices and traditions. Emphasis was directed at teaching not learning.

Classroom Practices and Learning Research

One distinguishing feature between a profession and a craft is that a craftsman will offer to guarantee his work while a professional refuses to be held accountable for the success of his efforts. A plumber expects no payment for a defective connection but a physician sends his bill whether the treatment worked or not. In this sense, education is a profession. Its standards have been largely internal and its methods passed on from one generation of teachers to the next. There has been little reason for education to look beyond itself for new ideas or even to tolerate the sometimes accurate criticism voiced by outsiders. The theoretical foundations of education have grown and matured entirely within this tradition and have remained quite independent of the controversies and discoveries of other disciplines.

Perhaps the most prominent omission from educational thinking in this century has been the immense growth of empirical research on the learning process. The gap between the psychological laboratory and the school classroom came about because of several factors. For one, basic research on learning tended to be based more and more heavily upon the performance of laboratory animals. Studies of how rats and pigeons perform seemed far removed from teaching children to read or calculate. Another reason was that most teachers were quite comfortable with the theories they had. In the absence of overwhelming evidence that these theories of learning were fallacious, there was no par-

ticular reason to consider any alternatives. Still a third reason was that most psychological research on learning was addressed to issues which had no particular relevance in the teaching situation. Rate of responding, hunger drives and the conditioned reflex had no easily recognizable parallels in the classroom.

The wall between learning psychologists and educational practitioners did not begin to crumble perceptibly until a prominent laboratory psychologist, B. F. Skinner (1954), attempted to translate and apply the findings of research on learning in concrete educational terms:

> . . . the advances which have recently been made in our control of the learning process suggest a thorough revision of classroom practices, and, fortunately, they tell us how the revision can be brought about. This is not, of course, the first time that the results of an experimental science have been brought to bear upon the practical problems of education. The modern classroom does not, however, offer much evidence that research in the field of learning has been respected or used. This condition is no doubt partly due to the limitations of earlier research. But it has been encouraged by a too hasty conclusion that the laboratory study of learning is inherently limited because it cannot take into account the realities of the classroom. In the light of our increasing knowledge of the learning process we should, instead, insist upon dealing with those realities and forcing a substantial change in them. Education is perhaps the most important branch of scientific technology. It deeply affects the lives of all of us. We can no longer allow the exigencies of a practical situation to suppress

> *the tremendous improvements which are within reach. The practical situation must be changed* [*p. 107*].

The Connectionist Approach

The knowledge of the learning process that Skinner was referring to was called the connectionist approach in the previous chapter. This position has many antecedents, but its recent past can be traced to the work of Thorndike (1913, 1932). The connectionists believe that learning occurs gradually. Correct responses or response patterns increase in probability through repeated instances in which a reward or reinforcement follows the occurrence of the response. Because a response must occur in order to be reinforced, the connectionists insist that learning necessarily involves active responding. And, because many instances of reinforced practice are required to achieve learning permanence, they feel a large number of learning trials is required. Complex responses can be assembled and shaped by differentially rewarding performance which approximates desired behavior in completeness and correctness. Most connectionists treat the learning process mechanistically. Intention and awareness are regarded as unnecessary inferences unless they can be observed in the learner's behavior.

The absence of any reference to meaning and cognition in the behavioristic approach of the connectionist was not easily digested by most professional educators. If sides were to be taken in the burgeoning controversy over the best way to describe learning, the far more humanistic approach of the configurationists seemed safer, surer and more comfortable.

The Configurationist Approach

The configurationists, such as Tolman (1932), believe that learning consists of the formation of what

are essentially cognitive associations. These associations result from the dynamics of patterns of expectancies devised by the learner to obtain desirable outcomes. In this sense, learning is intentional and goal directed. The configurationists feel that performance is not essential to learning. Instead, responses are learned symbolically as spatial, temporal or conceptual relationships. Selectivity determines which stimulus relationships are perceived and learned. Therefore, the learner's attention must be directed at the relevant aspects of his environment during instruction and these aspects must be arranged in such a way as to facilitate the formation of new cognitive relationships. Insight and ideation are important and must be promoted by the instructional process. Configurationists believe that it is an awareness of the interrelationships between purposeful actions and their consequences and not unmediated responses that are learned. Performance need not be practiced during learning in order to occur later when conditions are appropriate.

Contrasts Between Approaches

The patterns of classroom practices suggested by each of these two approaches are quite different. The configurationist's efforts are directed principally at improving the quality of instructional presentations. Emphasis is placed on organizing the information to be learned in a logical and familiar context and structuring the content to enhance the vividness, coherence and meaningfulness of new material. Because his goal is intelligent learning, the teacher who uses configurationist principles tries to provide the learner with a clear sense of purpose and direction. He encourages the learner to think about what is being taught so that insights can be developed and he avoids fragmenting the content so that the main ideas will not be lost. The configurationist teacher tries to give the learner feed-

back which will provide a clear understanding of his progress and the value of his accomplishments. Specific lessons are likely to reflect the unique properties of the subject matter.

One important characteristic of this approach is that of dismissing practice as an essential requirement of learning. From a configurationist point of view (Gage, 1964):

> . . . *teaching does not proceed by successive approximation of responses to the objective, as is implied by the term 'shaping behavior.' The teacher does not get the pupil to move gradually toward correct extrapolating behavior by feeding him stimuli that gradually take on the form of the problem to be understood, eliciting responses that gradually approximate what is correct, and providing reinforcement appropriately along the way. Rather, the teacher can often produce the desired behavior all at once by judiciously restructuring the student's cognitive field* [p. 278].

Contrast this description of the teaching process with one offered by a connectionist (Glaser, 1961):

> *The essential task involved is to evoke specific forms of behavior from the student and through appropriate reinforcement bring them under the control of subject matter stimuli. As a student goes through a learning program, certain of his responses must be strengthened and shaped from initial unskilled behavior to subject matter competence. . . . The salient feature of this process is making the reinforcement contingent upon the performance of the learner. . . . By differentially applying reinforcement to relatively minute behavioral changes, it is possible to progress from the*

> *initial behavior of the learner in small steps through the development of more complex behaviors* [pp. 19-20].

Thus, the connectionist teacher assumes learning is a direct result of reinforced practice and only that which is practiced will be learned. Emphasis is placed on maximizing opportunities for the learner to respond and on the use of small steps to increase the likelihood that any one response will be correct. Because his goal is proficient performance, the teacher using connectionist principles strives for responses of gradually increasing scope and complexity which eventually will correspond to the desired level of mastery. Reinforcement is provided as frequently as possible but only when the desired behavior or some predetermined component of it occurs. Specific lessons are likely to be organized around the types of performance to be mastered rather than the content to be taught.

For a teacher, the difference separating these two approaches is a difference in which aspects of the learning environment require systematic control. The configurationist position suggests that the control required to insure learning is imposed by the proper manipulation of the content presented to the learner. The connectionist, in contrast, regards control over the consequences of each student's responses as singularly critical to the instructional process. His concern is with the arrangement of contingencies that follow each occurrence of a response.

Reinforcing Contingencies in Instruction

The precise nature of these contingencies has not as yet been fully defined. Simple reinforcements such as food or water often are used in basic research on learning primarily because they are easy to control. But, notions that some physiological drive such as hunger or thirst must be satisfied have been thoroughly

dispelled by studies employing tokens, clicks and even the opportunity to watch a toy train to reward animal learning. Pairing any neutral stimulus, such as light or tone, with access to reinforcement will permit these previously neutral stimuli to serve as effective rewards at some future time, and often such secondary reinforcements are preferred because they are more convenient. Thus, most students are easily rewarded by points, money or high marks, and praise or a smile can be used quite successfully. Simply being correct on a school problem or exercise generally provides enough reward to insure learning and maintain an eagerness to continue.

The type of reward, then, is not critical so long as it is effective. This, in turn, suggests that much of the emphasis formerly given to the role of motivation in learning has been misplaced. The most useful view of motivation seems to be that it increases the probability that some specific stimulus will have reinforcing effects. An animal deprived of nourishment will more likely be reinforced by bits of food than one which has been satiated beforehand. Even this relationship is not universal, however, in that deprivation does not insure motivation and an animal rewarded only with tokens will continue to perform even after amassing large piles of them.

An important finding by Premack (1965) suggests that rewards need be nothing more than the opportunity to do something more preferred than the present activity. He was able to train laboratory animals to run in an activity wheel by reinforcing this activity with opportunities to drink water. He then was able to reverse this relationship, training the animals to drink increasing amounts of water by permitting them access to the activity wheel only immediately following drinking. He also demonstrated this phenomenon with children, requiring some to operate a machine to obtain

candy and others to eat candy so as to be able to operate the machine. Homme and his associates (1963, 1966) have applied this concept in studies on methods for enhancing the teaching of young children in the classroom. After a specified number of problems done or pages read, each child is allowed a few minutes to engage in his choice of activity from an extensive list of possibilities including games, noise making and playing with various objects. One of the more frequently chosen options has been the opportunity to push the experimenter about the room in his swivel chair.

As these studies demonstrate, establishing and maintaining appropriate conditions for learning does not require recourse to complex motivational concepts. Some effort may be required to identify suitable reinforcements for all learners, those which do have rewarding effects, are easily administered and are low in cost. However, just being told they have given correct answers to questions of increasing difficulty is probably an ample reinforcement for most children.

When a reward is given, its value depends heavily on how immediately it follows the desirable response. A delay of even a few seconds is likely to insure that some other, possibly unwanted behavior will be reinforced instead. It also is crucial that rewards are provided differentially. To tell an entire class that they did well is an appropriate reinforcement for those students who were superior in their performance but is quite inappropriate for those few who may not have performed adequately. Similarly, rewards should be tied to discrete responses and not for success or failure relative to the performance of the group as a whole. Perhaps nothing in the practice of education today is more likely to produce a 'drop-out' than continuous

low marks which fail to reflect the occurrence of any correct responses at all. Finally, rewards must be frequent to be of any practical use. Each response made by the learner must be observed, assessed and, if appropriate, reinforced. Performance which is ignored, as often must be the case when a teacher attends to the responses of thirty or more children at one time, cannot be developed differentially.

Punishment and Aversive Control

This discussion of contingencies so far has ignored punishment and other forms of aversive control. The reason for this is that punishment has been shown to have little lasting effect. It is not the opposite of reinforcement; instead, it at best suppresses unwanted responses temporarily (Estes, 1944; Verhave, 1966). In addition, punishment generally produces behaviors, such as hostility and withdrawal, which themselves are undesirable in a learning situation.

The use of punishment as a major tool in classroom technique, the absence of frequent or effectively differential reinforcement, the minimization of practice and reliance on presentations alone as sufficient to result in learning all are instances of the growing discrepancy between current educational methodology and the increasing weight of evidence that the theories of learning which support this methodology are fundamentally deficient. Learning does occur in the typical classroom. Indeed, it is virtually impossible to imagine any conditions which might preclude learning entirely. It also is apparent that some presently used teaching practices are more effective than others in creating learning opportunities. However, it has become increasingly clear that far from all available knowledge of the learning process now is being put to use in meeting the responsibilities of education.

The Responsibilities of Education

Along with this growing awareness that not all demonstrably effective techniques for producing learning are being used, ever larger numbers of concerned individuals have recognized that the function of education has undergone considerable change. In the distant past, school attendance was a privilege reserved exclusively for the rich or exceptionally talented. The birth of democratic processes, institutions and governments gave rise to the belief that education could not be the prerogative only of an advantaged few but must be regarded as a right of all members of society. Thus, it became the responsibility of everyone to insure that education was made available to all who might profit from it. Even this notion has changed in the past few decades. It is no longer possible to consider education as a right. The economic and cultural growth of a nation has come to depend upon all individuals contributing to the limits of their potential and education is essential to achieving this goal.

Compulsory school attendance and required courses are changes which already reflect the new mandatory image of educationally acquired capabilities. However, many classroom practices have not as yet aligned themselves with this new concept of the role of education. Most important among these is the allocation of responsibility within the learning process. The teacher who complains about lack of student progress in terms of a pupil's poor motivation, low intelligence or absence of encouragement from home is refusing liability for the pupil's failure to learn. That the burden of learning routinely is imposed on the student is suggested even by the terms 'schoolwork' and 'homework,' as if the student's efforts were beyond the teacher's control. If the value of education is to be regarded as too great to depend on voluntary participa-

tion, it also must be the obligation of education to insure that learning will occur. The waste that results when a student fails to learn is not his alone, and the burden of making education truly productive cannot be entrusted to him.

Teaching methodologies which in principle reject full responsibility for achieving instructional outcomes are no longer compatible with the needs education must now serve. Presentations which are effective only because of a student's self-initiated efforts during or after a lesson represent only one component of the instructional process. They provide help to the student in what to learn but not in how to learn it. The frustration experienced by almost any learner as he tries to organize lecture notes, prepare memorization drills or work through sample problems is mute testimony as to the deficiencies of traditional instruction. It is more than likely that the very able learner is very able largely because he has hit upon effective self-study techniques. The poorer student quite probably learns less because he cannot come up with satisfactory study routines on his own. He cannot learn because he cannot teach himself. It is in this aspect of the instructional process that the tutor excels. And it is here that connectionist principles have the most to offer.

3

EDUCATIONAL AUTOMATION

If education is to advance quantitatively as well as improve qualitatively it must find ways to multiply not only its effectiveness but also the way in which it utilizes its resources. The demands placed on education by proliferating populations and pursuits are increasing to such vast proportions it is becoming inconceivable that sufficient numbers of competent teachers ever will be realized. The problem is particularly acute in many of the developing countries where, despite expenditures for education that approximate those in the industrialized nations if calculated as a percentage of gross national product, only a fraction — sometimes a small fraction — of those eligible for enrollment actually attend school. In part, school attendance in many regions of the world is affected by limited urbanization which precludes assembling class-sized groups of children near enough to each rural village to be reached without transportation. Even where schools have been established, farm and family responsibilities, illness stemming from inadequate nutrition, religious objections to secular instruction, and

indifference to education due to lack of opportunity all tend to limit attendance.

The Cost of Conventional Instruction

Most of all, however, the high cost of even minimally competent teachers prevents most developing nations from offering instruction to all eligible children or, if they approach this standard, prevents them from providing education which goes beyond a few basic skills. The figures in the following table, derived principally from data on recurrent expenses for primary education collected by the Statistical Office of the United Nations (1969), suggest the magnitude of the problem facing many regions of the world.* In West Asia, for example, the expenditure per pupil in the primary grades is a scant four dollars per year. Even at this level, only about half of all eligible children are enrolled. Two regions, East Asia and Central America, have been able to achieve very high rates of enrollment despite relatively low gross national products, but only by accepting very large class sizes. In three regions, the Middle East, North Africa and East Africa, expenditures per classroom have reached levels greater than five times the per capita gross national product, which is a substantial sacrifice in terms of other needy sectors of their economies.

Overall, enrollment ratios tend to be proportionate to gross national product; even with very low per pupil expenditures, there simply are not enough resources in

* Because of recognized deficiencies in the information pertaining to individual countries, the table was compiled to reflect regional conditions. The values for each of the thirteen regions are averages based on data from three representative countries weighted by population. These findings, reported at various times in the mid-1960's, should be appraised cautiously; for example, the cost figures do not include nongovernmental expenditures and therefore underestimate the amount spent yearly on primary education in many countries. All cost approximations are in U. S. dollars. Estimated enrollment is based on age distribution data and indicates the percentage of children ages 6 through 11 reported as attending school.

regional groupings*	per capita G.N.P. $	estimates for primary grades only: pupils per classroom	expenditure per pupil $	expenditure per classroom $	estimated enrollment %
Middle East	278	23	67	1515	77
West Asia	94	34	4	137	55
South Asia	146	37	13	466	59
East Asia	233	45	21	814	97
North Africa	202	41	42	1712	63
West Africa	99	33	12	411	41
East Africa	78	42	19	798	14
Central Africa	98	40	19	464	53
Northern S. America	328	29	17	511	55
Southern S. America	741	30	84	2114	87
Central America	494	49	23	1091	97
Western Europe	1771	20	223	4732	92
North America	3890	28	486	13131	99

*The three countries selected to represent each region were, for the *Middle East:* Iraq, Jordan, Lebanon; *West Asia:* Afganistan, India, Pakistan; *South Asia:* Burma, Malaysia, Thailand; *East Asia:* China (Taiwan), Korea (Republic), Philippines; *North Africa:* Algeria, Morocco, United Arab Republic (Egypt); *West Africa:* Cameroon, Ghana, Nigeria; *East Africa:* Ethiopia, Somalia, Sudan; *Central Africa:* Congo (Kinshasa), Kenya, Tanzania; *Northern S. America:* Brazil, Colombia, Peru; *Southern S. America:* Argentina, Chile, Uruguay; *Central America:* Dominican Republic, El Salvador, Mexico; *Western Europe:* Germany (Federal Republic), Italy, United Kingdom; *North America:* Canada, Puerto Rico, United States.

many regions to make it possible for all children to attend school. The cost of conventional instruction at the primary level is so great in several regions of the world, in fact, that many nations are forced to deliberately withhold primary instruction from large percentages of otherwise eligible children to permit funding even rudimentary programs of secondary and higher education (Coombs, 1968). Even highly industrialized nations face growing teacher shortages. In 1965, the number of elementary and secondary school teachers in the United States had grown to 250% of what it was in 1930 (Renetzky & Kaplan, 1968). Nevertheless, the shortage of teachers available to fill existing positions was approximately equal to the entire number of individuals who entered the profession in 1965 (National Education Association, 1966) despite a decade of diligent recruiting and substantial pay increases.

In the developing countries in particular, there is little hope for real improvement in the foreseeable future even though growth in gross national product is exceeding population growth at the present time. Coombs (1968) reports that economic growth for the developing countries is averaging 4.25% while school age populations, even in extreme areas such as Central America, are expanding at a rate no greater than 3.75%. At these levels, however, many generations would pass before acceptable levels of enrollment could be reached. Existing deficits in educational opportunity are not likely to be reduced without faster economic development, but economic growth cannot rise much above current rates in the absence of improved education.

The principal obstacle to improved education is, and has been, the cost of the classroom teacher. Although the figures for expenditure per classroom given in the table include certain administrative expenses

and other recurrent charges, such as the cost of books and materials, by far the largest share is accounted for by teacher salaries. Unhappily, where the deficit in education is the greatest, teacher salaries are relatively the highest due to competition among all sectors of the economy for the services of those few individuals who themselves have sufficient education to be at all qualified to teach school. To a degree, some relief might be obtained by further increases in class size or by reductions in the amount and variety of instruction given to each pupil. Such expediencies would afford temporary relief at best, however. All nations are committed to more or less universal education and quality instruction. To meet this obligation while at the same time coping with the cost problem, some teaching functions sooner or later will have to be automated regardless of whether the country presently is impoverished or affluent. The pace and the extent of automation undoubtedly will vary from one nation or region to the next, but the eventual result is irrefutable.

Automation in the Classroom

Certainly, automation in education is almost as old as education itself. Even before the printed book, a teacher could extend his influence both in space and time through the use of hand lettered texts. Now, film and recordings have made it possible to record and bring into the classroom events which rarely, if ever, could be experienced personally by the individual student. The school day is expanded by homework assignments hopefully completed without parental or tutorial assistance. Newer media such as color television, language laboratories and sophisticated computers make it possible to simulate the teacher's appearance, voice and even his decision-making processes. The important question for the future, then,

is not whether at least some aspects of teaching need to be automated or if they can be automated, but rather how they are to be automated to achieve satisfactory results.

One important trend in this direction has been to automate the presentation function of the classroom teacher through radio and, more recently, television. These media, because they have unique capabilities for reaching large populations easily and inexpensively, have been widely utilized in education. For example, in the United States, a recent survey (National Education Association, 1967) found that educational television is available to over one-third of all classrooms, and still other classrooms are equipped to receive commercial television or closed circuit television for instructional purposes. This same survey indicates that educational television is the one instructional resource most desired by teachers who now do not have access to it. However, still another finding from this survey was that only about two-thirds of those now teaching in classrooms equipped for educational television report making any use of this resource in providing instruction. At the present time, then, television is used widely in the United States but not as widely as it could be even with existing installations.

The expense of television has been one obvious drawback to its use in developing countries. The high initial cost of transmission facilities, the requirement for expensive relay systems to transmit signals to remote areas where capable teachers are in shortest supply, and the need for electricity to serve classroom receivers have limited the adoption of televised instruction in many regions of the world. But, equipment costs have not been the only problem. Even within those developing countries where commercial tele-

vision has achieved a fair degree of coverage, the educational potential of these facilities frequently is ignored.

The problems of developing and then operating an effective educational system based principally on television rather than a classroom teacher may seem overwhelming. All too often, there is neither the talent nor the experience needed to produce useful lesson materials. A profusion of local dialects and languages makes national programming extremely difficult. Poorly qualified teachers may resent any loss of prestige to a master television instructor. Administrators, especially those with little experience of competence in instructional television, are unwilling to accept the responsibility of this or any other conspicuous change which conceivably might fail. Nevertheless, television and radio would be invaluable resources if these media could substantially upgrade the quality of instruction, reduce the cost of classroom teaching or, hopefully, accomplish both aims.

Research on Educational Television

Clues to the reluctance which many teachers have to turning on sets already in their classrooms and the resistance shown toward television by numerous responsible educators in part can be found in the results of research on the effectiveness of instructional television. One of the most extensive compilations of comparative studies available (Ford Foundation, 1959) was based on 110 different assessments of student achievement utilizing data from almost 27,000 pupils enrolled in eleven different school systems. Among these comparisons, only 38 were described as statistically significant; of these, 29 studies favored televised instruction and 9 favored traditional instruction. The remaining 72 studies resulted in substantially equal achievement. Another compilation (Smith, 1961),

which probably includes many of the same comparisons, indicates that out of 159 studies, 31 favored instructional television, 14 favored the classroom teacher and the remaining 114 favored neither. Although these findings are viewed quite favorably by the proponents of educational television, the qualitative improvements suggested by them are meager contrasted with the results of comparisons between individualized and classroom instruction already reported. The vast majority of these television studies suggest that students learn about as much, or as little, from educational television as they do from an ordinary classroom teacher.

When the potential advantages of televised instruction are considered, the results to date are even more discouraging. Some of the frequently mentioned features of educational television are that visual material not normally available in a classroom can be displayed, master teachers with ample experience and unique qualifications can be called upon to plan and present the lessons, considerably greater time and resources than those normally available to the classroom teacher can be devoted to the preparation of each lesson, and technically expert aid in television production and direction can be called upon to capture the student's attention and enhance his motivation. Under these circumstances, it is difficult to take pride in findings that instruction presented over television is hardly any improvement over what it would have been without television. Even more important, the lack of any substantial advantage for educational television strongly suggests that the special capabilities usually attributed to television are not really significant determinants of student achievement. In other words, teaching by television does not faithfully simulate all of the important components of the instructional pro-

cess even when the televised lesson is planned and presented by a master teacher.

Limitations on Televised Instruction

One critic of instructional television, William Cartwright, has imagined how the impact of television on education might be described in the year 2065:

> *For a generation after 1950, school systems — even entire states and regions — tried to teach whole courses by television. Ultimately this costly experiment failed. It seemed promising for some time, . . . [but] the disadvantages of the system led to its downfall. The major factor involved was that it proved impossible to apply what the educational scientists learned about the values of individualized instruction in a class in which all of the members were forced by a television set to move at the same pace* [Murphy & Gross, 1966, p. 88].

Although the fixed pacing of a televised lesson is not the only shortcoming of this form of instruction, it is a readily noticeable defect which makes television unadaptive to the realities of classroom teaching. For example, there are a predictable number of student absences every school day. When instructional television is relied upon for the core of lesson content, a student who has been ill usually has no opportunity to view the missing lessons. A certain amount of redundancy normally is included in a televised course just for this purpose, but a missed science demonstration or second language grammar point is certain to have a significant impact on that student's possible mastery level. The greater the population served, the greater is the likelihood that some students will miss one or more essential lessons.

Another limitation on broadcast education as a means of upgrading the quality of classroom instruc-

tion is that it is economically feasible only when the costs can be distributed widely. However, attempts to serve a large region from one central source necessarily creates very severe scheduling problems among the individual participating schools. These difficulties could be overcome by compelling all schools to maintain identical schedules. On the other hand, the economic savings from projects such as the Midwest Program on Airborne Television Instruction (MPATI), which was designed to serve schools in six states simultaneously from transmitters installed in airplanes, easily could be offset by the inability of some schools to adjust their class timetables to meet viewing schedules.

A more fundamental defect in the fixed paced instruction offered over television is that it generally fails to provide for variable learning rates. All students are taught in steps of the same size presented at the same pace. A single lesson may be incomprehensible to some students while being tedious to others. The broader the audience, the more likely it is that the rate of presentation will be unsuitable. Whatever opportunities for practice are included in the lesson usually are designed to produce choral responses by the groups as a whole but rarely do all the individual students in a class bother to participate. All students are treated equally with exactly the same rate of presentation and amount of practice opportunity, as if variability among learners was assumed not to exist.

Learning from Television

It is not surprising that many students fail to learn all of the essential points covered, even following an imaginative, stimulating presentation over television. But, from a connectionist point of view, it is surprising that any students have learned at all. When

learning does take place it can be assumed that the students themselves arranged some practice during or following the lesson. This may consist of note taking, self-planned drill, or attempts to outguess the presentation as it unfolds on the viewing screen. For example, the student may write out a chemical equation or economic principle, he may repeatedly recite a list of new vocabulary words while it is being shown to him, or he may induce his own conclusions from a series of facts or examples in anticipation of having the correctness of his response verified by the television teacher. Most effective learners do engage in some sort of overt or, more often, covert practice while trying to learn from a text or lecture. But even for these learners, the practice they have usually is too sparse and too unplanned to enable them to master all of the content presented. For less effective learners, the presentation may proceed too rapidly to permit them the practice they need.

Although some learning can occur when only the presentation aspects of teaching are simulated by instructional automation, it is likely that simulating the tutorial components of effective teaching would be more valuable. If an effective tutorial approach could be identified, automating the component practices of that approach would permit the benefits of individualized instruction to be replicated for all students. Not only would all students then receive help in the organization of lesson content, but in the organization of the practice they need as well.

The Tutorial Approach

An analysis of the principles of tutorial instruction provides one basis for deciding which techniques used by a good tutor are essential to learning and, therefore, which techniques need to be automated. To begin with, the tutorial approach can be characterized by contin-

uous interaction between the tutor and the pupil. Each interchange generally consists of a brief delivery by the tutor followed by some response on the part of the student. The tutor's presentation may take the form of a statement or demonstration designed to serve as a model, an explanation or a clarification of some principle, a question or problem for the student to answer, or a comment on the correctness of the student's preceding response. Precisely what the tutor does at any point is determined by his assessment of the student's progress. As the learner's skill and knowledge evolves, the problems presented by the tutor become more difficult, the criteria applied to the quality of the response become more exacting and the amounts of help and guidance given the learner are reduced.

Generally, tutorial instruction proceeds in fairly small steps so that no increment is too large to be practiced in its entirety. The tutor routinely expects that each practice occasion will be successful for the learner. Early steps contain considerable guidance and require little from the learner; only as the instruction progresses is this help gradually withdrawn. As is typical of most other forms of teaching, tutorial instruction is carefully sequenced. Complex skills and thorough understanding are developed gradually through a succession of increasingly relevant or realistic exercises. Retention is encouraged by demands for the frequent repetition of newly acquired responses. A good tutor rarely becomes impatient. Rewards for learned accomplishments are frequent and they promptly follow desired responses.

Even more important, tutorial instruction is designed so as to be adaptive to the individual learner. The rate at which instruction progresses closely parallels the rate at which the student learns. Ample time is given the student to make his responses. Any errors made by the learner are quickly corrected — usually

by the turor returning to an earlier point in the lesson and again trying to build up the learner's competence — only this time with smaller steps and the more gradual withdrawal of coaching and guidance. Specific learner difficulties or deficiencies in a particular student's background are dealt with individually by adjusting the rate of instruction or by the insertion of remedial sequences.

It should be immediately evident that any attempt to replicate exactly what a tutor does when presenting a lesson would require automation with extremely sophisticated capabilities. A separate plan and sequence of instruction would have to be developed for each learner to be fully adaptive to his needs. The greater the differences among learners, the greater the differences in the lessons that would have to be produced. Some of the adaptiveness characteristic of a tutor may be superfluous or irrelevant, however, just as some of the features of a televised lecture or single passage in a text may not be essential to its success. It is likely, for example, that close-up views of the speaker's face presented over television literally may distract the student from more essential content voiced by the speaker and that a paragraph containing long and flowery sentences may be read with less understanding than a more compact and concise version.

A tutor may adapt a lesson both quantitatively and qualitatively. Quantitative adaptions include the use of more but shorter steps, allowing variable amounts of time for the student's response, and presenting more and more background instruction which might be prerequisite to an understanding of the aim of that lesson. Qualitative changes include the use of different kinds of assistance for different kinds of students, different ways of rewarding correct responses, and different consequences or remedial se-

quences following an error depending on the type of error made.

Research on Adaptive Instruction

Actually, all of these phenomena have been simulated at least to some degree by developers of automated, individualized instructional materials and methods. However, adaptive techniques which feature the use of different instructional materials to adjust to learner difficulties generally have only minor effects on instructional outcomes. For example, instructional materials once were prepared in varying step-size densities on two separate topics (Klaus, 1964a). The expanded versions in each set averaged 82% more steps than the corresponding compacted versions. For one set of materials, making the steps smaller increased achievement about 5% but, for the other set, the added steps resulted in an achievement loss of almost 6%. The results also indicated that the expanded versions required only 13% more time to complete. Thus, changing the number of steps in these materials to accommodate learners at different ability levels had surprisingly little effect either on achievement or study time.

Another study investigated the value of materials which provided alternate sequences based on the kind of error a student might make (Silberman, Melaragno, Coulson, & Estavan, 1961). This experiment assessed a procedure equivalent to what a tutor might do to differentially correct students who make different kinds of errors on the same problem, providing a different remedy for a student who replies 'bigger' when asked for a synonym for 'big' than for one who replies 'small.' Learners in one group were provided with corrective steps following each error which reflected the probable cause of that error as indicated by the content of the incorrect response. The members of a

second group, instead of receiving corrective help based on the content of their own errors, arbitrarily received the remedial steps that happened to have been appropriate for some one member of the first group. The two groups did not differ appreciably in achievement.

On the basis of a review of several studies similar to these, Holland (1960) concluded that adjustments in the content or sequence of instruction to reflect the actual performance of an individual during learning produce little or no advantage. A lesson which is demonstrably satisfactory for one learner will be reasonably satisfactory for a second learner, at least within a moderate latitude of differences, compared with any modification of that lesson. Because lessons containing identical steps presented in the same sequence can be used by everyone in an entire class does not mean that all students will learn at the same rate. Studies described in the first chapter indicated the value of allowing students to proceed through lessons at their own rate to permit all learners to master the content presented to them, even if learners at varying ability levels require substantially different amounts of learning time. Automation which permits rate to vary seems to provide all of the flexibility characteristic of tutorial instruction which must be replicated to secure the benefits of individualization.

Automation as a Basis for Revisions

Another feature of instructional automation is that it not only can replicate teaching functions of a master lecturer or tutor, but actually can improve upon the human teacher. The reason for this is that media permit the instruction to be recorded permanently. Once recorded, student achievement from lessons or lesson segments can be evaluated, weak portions which failed to produce learning can be identified, these portions

can be revised, and the revised material can be substituted for the original content in a new version of the lesson. Effective lessons or lesson segments can be retained and incorporated into the new version for future use. This process frequently is employed during the preparation of almost any audiovisual instructional material. However, in most instances, revisions are based on the opinions of 'experts' who prophecy the distinction between good and poor portions of a lesson without the advantage of empirical data. Thus, it is not surprising that even after routine adjustments have been made during their production, the rigorous use of tryout data to enhance instructional materials leads to worthwhile improvements.

For instance, one study contrasted a lesson based on the classic example of tutorial instruction presented by Socrates, as reported by Plato in "Meno," with a revised version (Cohen, 1962). Following learning, only 17 of 32 college students were able to replicate the proof of the theorem as Socrates taught it. The revised version, however, led to mastery by 27 of 33 similar students. Even group paced instruction of the kind presented over television can be improved by revisions based on the performance of students. Conventional lessons were prepared for telecasting on two different topics in science (Gropper, Lumsdaine, & Shipman, 1961). These lessons then were 'previewed' by sample classes to obtain achievement data and the test results were analyzed to identify defective sections. These sections were revised by changing the commentary or the visuals used at that point and the revised lessons again were recorded. The effectiveness of the two versions of each lesson then were compared with new classes. Achievement from the revised versions averaged 19% greater than from the original versions.

Without a capability for recording lessons permanently in a book, on film or by some other means, much of the value of systematic tryouts will be irrevocably lost. Even the most skilled and experienced educators are humanly fallible and do make errors. By recording a lesson it is possible to preserve the good portions while at the same time changing those portions which contain mistakes or weaknesses. Over successive tryouts, it is possible to improve a lesson to a level of perfection which a live instructor could never achieve. In this sense, automated instruction has a potential for not only equaling but ultimately surpassing the excellence of any master teacher.

Instructional Implications of Automation

Both conventional and individualized instruction can be and have been automated. One consequence of this trend in education is that the differences between the configurationist and connectionist approaches have been magnified greatly. Because of added resources and preparation time, the teacher who presents a conventional lesson on film or over television is able to enrich the presentation far beyond what is possible in an ordinary classroom. Concomitantly, these media reduce opportunities for interactions with students which are contingent on their individual responses. Thus, without the recitation and discussion that normally occurs in almost every class, televised or filmed education becomes uniquely presentation centered. An automated individualized lesson, on the other hand, permits students to practice and learn at a pace which is far more personalized than can be arranged or tolerated by a classroom teacher. At the same time, individualized instruction rarely can benefit from the vividness or drama of a well planned lecture or demonstration and still be furnished at an acceptable cost. Thus, automated individualized in-

struction tends to become uniquely response centered. The mixture of techniques so characteristic of everyday teaching disappears when automation which faithfully reflects uniquely configurationist or connectionist biases is introduced into the classroom.

Worthwhile combinations based on both approaches only recently have begun to appear. For example, television, radio and other media which can be so effective in presenting instruction with a richness and accuracy that is beyond the reach of classroom teachers can be coupled with other instructional methods that allow each student to practice what he is learning at his own pace. One of the major advantages of such a combination is that classroom personnel then would be relieved both of presentation and tutorial functions. Thus, it no longer would be necessary for the excellence of instruction to be limited by the competency of the classroom teacher. In addition, the automation of these functions could greatly reduce the cost of conventional instruction while actually enhancing its quality; a classroom could be monitored by an untrained adult while the students learned from materials that had all the advantages of expert preparation and thorough tryouts. In this respect, at least, the benefits of new instructional technologies are as attainable within the resources of most developing countries as they are for industrialized nations.

Because of the opportunities inherent in educational automation, the degree and thoroughness of control that can be exerted over the learning process has been extended considerably. The outcomes of conventional instruction invariably must be limited by the competency of available classroom teachers, but automation can erase these deficits and even improve upon the skills and talents of very superior teachers. The future may well bring with it a still greater understanding of how learning occurs and a parallel re-

quirement for still greater control over the conditions of learning than now is felt necessary. Thus, as odious as automated teaching sometimes may seem, the advantages of individualized instruction at a realistic cost well may be impossible without it.

4

INDIVIDUALIZED LEARNING

As innovative and as radical as automated and individualized instruction may seem, educational programs designed around concepts of individual progress and rewarded practice have both ancient and modern antecedents. As already noted, Socrates was greatly concerned with the individual learner. The Roman, Quintilian, stressed the importance of learner participation and self-direction, and even designed an automated teaching device to help students learn good handwriting (Stecchini, 1964). Comenius, the 17th century teacher whose contributions often are regarded as the foundations of many modern educational practices, recognized the importance of individual differences and felt that instruction needed to be adapted to the capacity of each student.

Individualization in the Classroom

It was not until John Dewey established his Laboratory School in 1896, however, that individualized instruction had its first test as a systematic method

of instruction. In Dewey's classroom, according to Saettler (1968):

> *An observer found none of the conventional arrangements, routines, or activities. . . . Some children might be busily engaged with books; others, with pen and paper; and some might be painting or using hammers. The teacher could usually be found mingling with the children, offering counsel and guidance as the pupils proceeded in their activities* [pp. 53-54].

Montessori early in this century, and then Burk, Parkhurst and Morrison all developed systems of individualized instruction which permitted students both to learn at their own rate and, to a more limited extent, pursue educational goals which reflected their own talents and interests (see Saettler, 1968; Washburne, 1925).

Perhaps the most widely publicized of all early attempts to provide self-directed instruction on a comprehensive scale was Washburne's Winnetka Plan introduced into the Winnetka, Illinois, public schools in the 1920's (Washburne & Marland, 1963). The heart of the Winnetka plan was the division of instruction into units or modules each with its own aims and tests of learning progress. Text materials and, where appropriate, workbook exercises were prepared for each module to permit the students to study the intended content on their own and at their own pace. These instructional materials were developed largely by the classroom teachers who adopted a writing style similar to the one used for correspondence courses in vogue at the time. Emphasis was placed on anticipating learner difficulties and on personalizing the lesson materials. The exercises were scored and corrected by the children themselves using the answers provided at the end of each lesson. Promotion from one grade to the next depended solely on the progress evidenced

by each student on the unit tests given every six weeks.

Although consideration was given to all phases of instruction in Winnetka, only lessons for traditional academic subjects were individualized. Enrichment courses, which represented about half of the program for each school day, were taught largely using discussion methods with groups of students. Group methods also were used to deal with problems which could not be overcome by supplying the children with additional practice exercises and when there was not time to tutor these children individually. The materials were revised, sometimes repeatedly, on the basis of teacher observations regarding student difficulties. The children were assigned the instructional modules in sequence. Although rate was allowed to vary, every child was expected to follow approximately the same program. Some flexibility was permitted in allowing students to progress more rapidly in one subject than another but considerable encouragement was given to spending more time on difficult content so that the child's educational development would remain roughly even across subject matter areas. Motivation and record keeping were combined by giving each student a permanent summary of his progress in terms of the instructional goals he already achieved.

Limitations on Early Individualization Efforts

These experiments with individualized instruction captured the attention of education but, while they stimulated educational thinking and inquiry, they had little impact on ordinary classroom teaching. Any number of reasons can be postulated to explain why these systems were not routinely adopted elsewhere. More than likely, however, two important considerations precluded the spread of these innovations to any major extent. First, the qualitative gains which could

be attributed to the individualized approach in these experiments were not impressive. Most were aimed at enriching the learning environment more to heighten appreciation and enhance participation for its own sake than to produce better and faster learners. The quality of the instructional materials, even at Winnetka where the teachers prepared their own to meet student needs, were incapable of producing significant increments in the amount learned by the average student despite the advantages of self-pacing. And, second, the management of a classroom of students who each were engaged in a separate and widely different activity was beyond the capabilities of most teachers. These systems simply were not very practical. Students were free to learn but they were equally free to become discouraged when they did not learn. The focus was on letting students teach themselves, not on improving the efficiency of the instructional process.

Individualization Through Automation

A somewhat different approach to individualization was suggested by Pressey as early as 1924. His aim was not to reduce the teaching function of classroom personnel but to enhance it by eliminating the burdens of routine drill. The teacher would then be free to spend more time stimulating and developing students. His approach was built around the development of:

> . . . *a simple apparatus which automatically gives and scores a test, and which will also, automatically, teach — and teach informational and drill material more efficiently, in certain respects, than the 'human machine'* [*Pressey, 1926, p. 35*].

Pressey did not question the instructional value of traditional testing and drill. Instead, he was concerned mainly with automating these components of con-

ventional teaching to relieve the teacher of unnecessary labor and the clerical task of scoring classroom quizzes. Pressey's device presented a series of multiple-choice questions to the student, scored his responses automatically, and could be arranged to prevent the student from proceeding on to the next question until he had selected the correct answer. No teaching, in the sense of presenting new information to the learner, was involved.

It is important to note that there is an important distinction between Pressey's concept and the individualization promoted by Dewey and Washburne. Pressey did not introduce individualization on the basis of any theoretical position which postulated that his approach to education was better than traditional instruction. He did not aim for individualization itself as the goal of his efforts. Instead, Pressey recognized a specific problem in the way classroom drill was conducted and devised an answer which he hoped would improve the efficiency of learning during those periods of instruction. He made no effort to extend his solution to the entire instructional program. In looking back on his work and the work of others, Pressey (1962) said:

> *Typically, enthusiasts carry a new idea to extremes; soon these are eliminated, and the proven residual becomes part of educational practice . . . the larger usefulness of auto-instruction will be found in co-ordination with, not replacement of, other materials and methods* [*p. 37*].

His strategy for cautiously introducing innovations and the reasons behind it were expressed in another paper (1960):

> *. . . if the learning theorist plans to go into business in the neighboring country of education-land, he should make a real and friend-*

> *ly effort to understand the language and local culture, and study closely the goods or processes he hopes to improve or supplant. His plans may thereby be facilitated . . . [he] may even find that the exceedingly complex processes of learning which go on in the schools have characteristics he has failed adequately to take account of in his automating, and perhaps even in his basic theories* [pp. 497-498].

Pressey was well aware that innovations had to be both a practical convenience for the teacher and serve a specific educational function to be successful. Drill and testing were tedious for the teacher and student alike. Pressey's goal was to mechanize these routine aspects of teaching; he wanted to solve a problem, not experiment with cultish solutions. In fact, any relationship between his device and theories of learning seemed to be afterthoughts. Pressey himself relegated to a footnote the "somewhat astounding way in which the functioning of the apparatus seems to fit in with the so-called 'laws of learning' [Pressey, 1926, p. 37]."

Limitations on Early Automation Efforts

Although the technique was generally effective (see Pressey, 1950), the magnitude of gains from answering self-scoring practice items were not sufficiently impressive to lead to much expansion of Pressey's form of individualization. As Lumsdaine (1959) has observed:

> *For some reason these multiple-choice devices, though shown by experimental tests to be quite effective aids to learning, never caught on widely during the two decades following the initial development of Pressey's first machines. This may be partly because the times were not ripe for their acceptance and partly*

> *because they were conceived primarily as testing devices and only secondarily as teaching machines. Also it may have been due in part to some of their inherent limitations. One of these limitations is that, as multiple-choice devices, they appeared to be limited to recognition responding, rather than permitting the student to compose or construct his own response* [*pp. 9-10*].

The use of testing with instantaneous feedback as a useful adjunct to teaching survived, however, and Pressey's machine must be recognized as an early forerunner of a rash of instructional devices and specialized materials designed to increase the efficiency of classroom instruction. Several of Pressey's students, including Briggs and Crowder, reintroduced many of Pressey's basic ideas in efforts to meet military training requirements of the 1950's and their approach evolved into one of the main streams of current notions on how to automate and improve the teaching process.

Skinner's Approach to Instruction

The next wave of interest in automated, individualized instruction was stimulated by Skinner in 1954 in a paper which strongly criticized the discrepancy between what was known about learning and what was regarded as competent teaching. Skinner's interest was neither in restructuring educational environments nor in automating traditional practices but in improving the effectiveness of classroom learning. His focus was on ways of incorporating connectionist principles into the teaching process. The essence of Skinner's approach was to design a method of instruction which would bring the individual learner's behavior under precise control through the use of frequent and indi-

vidual reinforcements. He saw effective teaching as a procedure which would lead to:

> . . . *the gradual elaboration of extremely complex patterns of behavior and the maintenance of the behavior in strength at each stage. The whole process of becoming competent in any field must be divided into a very large number of very small steps, and reinforcement must be contingent upon the accomplishment of each step . . . in the present state of our knowledge of educational practices, scheduling appears to be most effectively arranged through the design of the material to be learned. By making each step as small as possible, the frequency of reinforcement can be raised to a maximum, while the possibly aversive consequences of being wrong are reduced to a minimum* [Skinner, 1954, pp. 108-109].

Once again, arguments supporting a fundamental change in teaching practices went practically unnoticed by most of the educational world. Skinner persisted, however, and by 1958 he was able to present a more cogent case developed during the course of four years of experimentation by himself and several coworkers (see Skinner, 1958). This Harvard University group was responsible for virtually all of the implementation of Skinner's approach between 1956 and 1960 (see Lumsdaine & Glaser, 1960). The success of these early efforts was not particularly impressive although it was possible to demonstrate that university students could learn psychology (Skinner & Holland, 1958), lower secondary students could add to their vocabulary (Meyer-Markle, 1960), elementary school students could become better spellers (Porter, 1959), college students could develop an elementary reading knowledge of German (Ferster & Sapon, 1958) and preschool children could learn visual discrimina-

tions of the kind needed for 'reading readiness' (Hively, 1960) using self-instructional materials of Skinner's design.

The principal ingredients of Skinner's approach were derived from his laboratory studies of animal learning. Emitted responses, frequent reinforcement, very small steps and control over the range of responses through the use of prompts all are features of the programs of instruction prepared according to this model. An important consideration in the development of these instructional materials was that every effort was made to maximize success and minimize failure at each step. Reinforced practice in making relevant responses is the aim of this kind of instruction, and segments which lead to errors are revised to make them as free of deception as possible. This emphasis on error-free performance differentiates an instructional program of the kind suggested by connectionist theory both from a test and from the types of instructional material traditionally used in education. Commenting on whether instructional programs can be too easy, Skinner (1958) said:

> *The standard defense of 'hard' material is that we want to teach more than subject matter. The student is to be challenged and taught to 'think.' The argument is sometimes little more than a rationalization for a confusing presentation, but it is doubtless true that lectures and texts are often inadequate and misleading by design. But to what end? What sort of 'thinking' does the student learn in struggling through difficult material? It is true that those who learn under difficult conditions are better students. But are they better because they have surmounted difficulties, or do they surmount them because they are better* [p. 153]?

To permit the degree of control over reinforcement he felt was necessary for truly efficient learning, Skinner maintained that the instructional materials should be presented to students by means of a machine. In retrospect, the use of a device seems to have been predicated on the analogous use of electro-mechanical devices in the laboratory to insure the immediacy and consistency of reinforcement during research on the learning of laboratory animals, and to reduce the likelihood of unavoidable human errors that would result from teacher efforts to administer the thousands of steps making up each program to all the students in a class. Research quickly demonstrated, however, that machines were not all that essential in that it was feasible to use a 'programmed textbook' to provide adequate control (Glaser, Homme, & Evans, 1959). A most fortuitous consequence of Skinner's references to 'teaching machines,' however, was that the term became an instant catchword for sizable numbers of specialized manufacturers and popular writers. A rash of literally hundreds of magazine and newspaper articles quickly appeared, prepared by journalists attracted to the notion of mechanized instruction, and scores of devices were designed and readied for production by commercial concerns eager to capitalize on the forthcoming market.

Interest Grows in Programmed Instruction

By mid-1961, Foltz (1961) was able to catalog 98 kinds of devices that had been designed or placed into production by 82 different manufacturers for the purpose of presenting instructional programs, but he could identify only 53 producers of programmed materials themselves. No more than a handful of the programs that were available commercially represented more than a few minutes of instruction. Nevertheless, by design or by chance, programmed instruction and auto-

mated teaching suddenly had become a lively force that was vigorously promoted in the marketplace. Considering the rather primitive state of the art at that time, and the absence of very much rigorous research on either devices or programs, it is not likely that programmed instruction would have had the impact it did without this outside help.

Progress was somewhat slower from a technical standpoint. Part of the problem was that several different approaches quickly were subsumed under the 'programmed instruction' label. One of these was led by the behavioral scientists, principally connectionist-oriented psychologists, who were well versed in the practices and theories of learning research. Another group was represented by technical training specialists, such as Briggs (1959), who had been applying variations of Pressey's testing model in industry and the military for almost a decade. Although their approach was more consistent with configurationist principles than with concepts of response shaping, their use of devices and attention to individualization made them an integral part of the rapidly mushrooming field. Neither group had any special familiarity with the problems of education. As a result, a third force soon evolved. These were young and enthusiastic educators who were determined to see the potentials of programmed instruction applied to meet the needs of students in ordinary schools.

By 1961, information about programming methods began flowing freely. The earliest book devoted specifically to programmed instruction was Galanter's compilation of technical papers from a December, 1958 conference supported jointly by the University of Pennsylvania and the U. S. Air Force (1959). This was followed shortly by Lumsdaine and Glaser's extensive collection of published papers from Pressey to then current authors dealing with teaching machines and

programmed instruction (1960), and an influential series of papers presented at the Institute for Communication Research which grouped programmed instruction with television, film and other educational media (Institute for Communication Research, 1960). The following year saw the publication of the survey by Foltz (1961), a programmed introduction to programmed instruction by Cram (1961), a series of programmed lessons on how to prepare instructional programs (Meyer-Markle, Eigen, & Komoski, 1961), the proceedings of symposia at the Pennsylvania State University (1961), at the Foundation for Research on Human Behavior (Lysaught, 1961), at Sacramento State College (Edling, 1960), and at the Center for Advanced Study in the Behavioral Sciences (Mills, 1961) dealing in whole or in part with programmed instruction, a monograph by Stolurow published by the U. S. Office of Education (1961), an exhaustive collection of papers reporting media research conducted for the military and having implications for programmed instruction (Lumsdaine, 1961), and a popularized brief account of the teaching machine movement (Epstein & Epstein, 1961). Numerous articles appeared in a variety of psychological, educational and scientific journals and magazines. Three periodicals devoted specifically to programmed instruction appeared, the *Automated Teaching Bulletin* in 1959, and *AID (Auto-Instructional Devices)* and the *Programmed Instruction Bulletin* in 1961 — as an historical footnote, all three of these publications are now defunct.

Educational interest in programmed instruction was stimulated considerably by the publication of *English 2600* in 1960 (Blumenthal, 1960). This program, designed both for remedial and routine use principally at the secondary school level, was prepared by a recognized educator and textbook author and it found almost immediate acceptance in the public schools. This and

other programs, especially the school-oriented series of courses by Encyclopedia Britannica Films and by Teaching Machines, Inc. and Grolier, and the adult series by U. S. Industries and Doubleday, provided clear demonstrations to anyone with the purchase price that programmed instruction could be effective. Still further impetus to the growth of programming came from the National Defense Education Act of 1958, a federal government program which included support for research on media-based instruction. While initially enacted to support studies on radio, film, television, language laboratories, and so forth, funds made available by this legislation were allocated to programming research as early as June, 1959 and experimental studies, developmental projects and dissemination activities concerned with programmed instruction quickly came to be prime contenders for support under this program.

Early Applications of Programmed Instruction

The earliest comprehensive efforts to include programmed instruction as an integral part of the educational process began in 1959 at the privately operated Collegiate School in New York City under the direction of Eigen and Komoski. Soon afterwards similar efforts were initiated at the Baldwin-Whitehall schools near Pittsburgh under Glaser and at the Roanoke, Virginia, city schools under Rushton and Calvin (see Hanson & Komoski, 1965). Perhaps the most extensive of these early efforts was the project at Roanoke. Beginning with programmed materials corresponding to the content of plane geometry and two years of algebra in 1960, the experiment grew considerably. By the 1963-64 school year, programs were in use for 18 different subjects. The instructional materials were selected from those commercially available at the time from the Encyclopedia Britannica organization. Patterns of use of the programs varied from class to class depending on

teacher preferences. In some classes the materials were not used at all while in others there was at least one programmed assignment per day; in a few classes programs were used as the principal source of instruction.

The results obtained from the materials, whether due to the quality of programs that had reached the market in these early days or, as Rushton (1963) suggests, to the lack of enthusiasm teachers had for an unfamiliar teaching technique, were not particularly impressive. Conventionally instructed students and those taught by programmed materials were roughly equivalent in performance. The Roanoke schools did not continue to use the materials once the experiment was completed (Robertson, 1969). One reason was that the materials were felt to be too expensive. A second was that the available materials did not reflect the educational aims of the school system. Quite recently, however, some mathematics programs have been reintroduced.

Limitations on Programmed Instruction

Other early projects had generally similar experiences and outcomes. Programs were not available for the entire spectrum of courses offered by a typical school, the quality of those that were available was at best uneven, and teachers were hard pressed to manage classes of students who were not all doing precisely the same things at the same time. The lack of careful planning that was needed to take full advantage of programmed instruction is evident from the case histories of these pioneering efforts (see Hanson & Komoski, 1965; Fund for the Advancement of Education, 1964). As a result, it became more and more commonplace to find programs assigned as homework, particularly as remedial assignments to students deficient in some subject, but conventional teaching continued to dominate during regular school hours. Why

teachers felt they confidently could depend on programmed instruction to overcome deficiencies in slow learners but felt uneasy assigning programs to their more able students for routine use will have to remain a mystery.

In retrospect, it is clear that programmed instruction has not created the revolution in educational practices once heralded for it. On the other hand, it is inescapable that programmed instruction has had a very significant impact on classroom teaching, the design of educational materials, the curriculum and objectives of instruction, and the way in which mastery is viewed and assessed. By itself, as Glaser (1969) has pointed out, programmed instruction cannot create the conditions necessary to realize the substantial benefits expected from individualized instruction:

> *. . . when a school system buys and uses a programmed instructional course, it should not use the course in a fixed environment, but encourage the changes that can grow out of this innovation — changes such as more individual student pacing, revised classroom structures, more effective use of teacher time, greater specificity of achievement standards, and so forth. . . . The effect of any innovative device must be considered in the context of the system in which it is used. Programmed instructional materials can have only very limited success if they are marketed and accepted as packages to be plugged into an existing school operation. In contrast, they should be considered as enabling devices around which system redesign can take place. The school system employing these materials and equipment must accommodate to their operational implications* [p. 172].

An analysis of the actual consequences resulting from the use of programmed materials in traditional

classrooms has been reported by Carlson (1965). First, principals did not know what to look for and assess in a teacher's handling of programmed instruction. Second, the teachers paced the students, restricting the fast learners and plodding the slow ones so as to be able to deal with content problems on a group basis and avoid the dire difficulties of what to do with those students who finished early or those who were unable to complete their work during the school year. And third, teachers felt they had lost some of their teaching role to the programs and frequently found reasons to introduce segments of more traditional instruction during the use of programmed materials.

The Impact of Programmed Instruction

At the present time, it is possible to identify only two schools that depend almost entirely upon programmed instruction to meet fairly traditional educational aims. These both are privately operated schools for adults who have failed to complete a secondary school education and who have elected to seek an equivalency certificate offered in lieu of a diploma by taking a written examination. The two schools, one in Chicago and one in Pittsburgh, are operated as the Encyclopedia Britannica Academy and use programs developed and sold by the parent firm. A total of some one hundred students are enrolled in the two locations at any one time. Despite the dearth of completely programmed instructional systems, more and more schools are making some use of programmed instruction. Surveys have shown that in 1962, eleven percent of responding schools made some use of programs. This figure rose to thirty-six percent in 1963 (Glaser, 1969), but has remained relatively constant since then with twenty-nine percent of teachers reporting having made some use of programs in 1966 (National Education Association, 1967a). Larger schools make considerably

greater use of programmed materials than smaller schools (National Education Association, 1967b), probably because of the costs involved and the greater range of abilities likely to be found in an urban school.

Programmed instruction has not been a panacea for education but it did become a useful tool in the instructional process. Even more important, research on programmed instruction was able to demonstrate that techniques finally were available which permitted students to learn entirely on their own. Assistance or intervention from a teacher was not required to produce acceptable levels of mastery. That schools have not made greater use of programmed instruction is not altogether surprising considering the degree to which individualized instruction is incompatible with traditional educational practices. In countries such as the United States where there is an almost sufficient supply of qualified teachers, it has not been felt necessary to turn to substitute methods to achieve educational goals, particularly when radical changes in normal routines would be required to take full advantage of the opportunities for individualization afforded by self-contained teaching materials. In developing nations, the costs of preparing and manufacturing programs sorely has restricted their adoption to meet qualitative and quantitative requirements. Despite these limitations, the total impact of programmed instruction has been considerable. Individualized instruction and the application of connectionist principles in education are far nearer to being realized as a result of the programming movement. And it is more than likely that there will be a resurgence of interest in programming, and a consequent improvement in quality and reduction in cost, when an adequate framework for using programs has been developed.

5

INSTRUCTIONAL PROGRAMMING

Techniques for preparing and using instructional programs have continued to improve even in the absence of zealousness among educators. One reason for this continuing progress has been the ever increasing utilization of programmed instruction by industrial concerns and the military services. Unlike public and private schools or institutions of higher learning which often charge tuition for their services, these users must pay salaries to their students while they are learning. This requirement often produces an increase of tenfold or more in the cost of instruction and any technique which can reduce training time or increase attainment during the time that is spent is gratefully welcomed. A second reason is that many features of programmed instruction have come to be incorporated into traditional education. Connectionist learning theory and its applications to classroom teaching are now standard in the content of teacher-training curricula. Explicit objectives, mastery testing and learner-sequenced instruction have become almost routine practices, and a foundation in the techniques of programmed instruc-

tion has become a convenient vehicle for teaching these skills. Even the textbooks, practice exercises and audiovisual aids prepared for use in conventional instruction have absorbed many features of programmed materials. A third reason is that many instructional technologists and behavioral scientists have not yet given up hope that the advantages of programmed instruction someday will be a practical reality.

It often has been suggested that reading about programming is no substitute for actually taking a program and that neither provides a fraction of the insights into the principles involved that immediately become evident when one attempts to author a program himself. As anyone who ever has written a program will attest, few experiences are quite so humbling as an early tryout of a neophyte's very first programmed sequence. The sudden shock that all of his accumulated knowledge about learning and teaching is incapable of insuring rapid and thorough learning is far from the reinforcing state of affairs the programmer himself feels is conducive to maintaining his own programming behavior. These problems notwithstanding, much has been written about the programming process, the selection of published programs and the features of programmed materials which theory or practice suggests may enhance their effectiveness or utility.

Types of Instructional Programs

Any reasonable sample of programmed materials will make it apparent that many styles are represented and that lessons prepared by different authors or organizations frequently seem to have little in common. Among the various styles, however, two schools of thought are prominent (Klaus, 1965a). First, the connectionists tend to develop materials similar to those shown in Figure 1. This example (taken from Klaus, 1961, p. 131) shows three of the small steps or 'frames'

that might be included in the program. During learning, the student would see only one frame at a time. He would read each item, write out his response and

1. A fire can keep us warm because it gives off energy in the form of _____. The sun also gives off _____ in the form of _____.

2. Heat is one form of _____. Physicists call it thermal energy. A quart of boiling water has more _____ energy than a quart of cold water.

3. As a warm object grows cooler, it loses heat, that is, it loses _____ energy. When a cool object gets warmer, it gains _____, that is, it gains _____.

Figure 1. Example of a connectionist small step program.

then turn the page or be exposed to the correct answer some other way as a reinforcement. Perhaps thousands of frames, each requiring one or more responses from the learner, are required for a complete program. Sufficient help, or 'cuing,' is provided at each step to insure the response will be the correct one and to prevent the student from practicing errors. As learning proceeds, the complexity of responses can be increased and cues gradually are diminished, or 'vanished,' until the difficulty of the task fully reflects desired level of competence. This, in general, is the style of programming that was advocated by Skinner and others who view learning as the result of reinforced practice.

The style often adopted by the configurationists is one developed by Crowder (1961). A brief sample of this kind (modified from Klaus, 1961, p. 140) is shown in Figure 2. Each of these steps presents some information to the student, requires the student to use this

information in answering a question, and then on the basis of his answer either directs him to go on to new information or corrects the misconception by reviewing or restating what is to be learned in a simpler way. The student would read the information given, answer the question and then proceed to an analysis of his answer. In this sample, a 'scrambled text' format has been used; the student turns to a page indicated by the number in the brackets. If he chose answer 'a,' he would turn to page 21 where he would be admonished for his error, and where the principle would be explained again. If he chose answer 'b' and turned to page 47, he would be told his answer was correct and

Temperature and heat have different meanings. Heat, the amount of thermal energy stored in an object, depends on the mass of the object and what it is made of as well as its temperature. Heat is measured in calories, but since heat and temperature are not the same, we do not measure temperature in calories.

If we apply a flame to a small container of water, it will boil sooner than if we apply the same flame to a large container of water. Why?

a. the large container must reach a higher temperature before the water boils [21]

b. the water in the smaller container must accumulate less heat due to its smaller mass [37]

Figure 2. Example of a configurationist scrambled text program.

he would be given new information and another question. In terms of what the learner does and the assumptions made about how learning takes place, this style of programming follows in the tradition of Pressey and

others who regard learning principally as a cognitive process.

More extensive examples of these two principal styles of programming can be found in many of the books that have been written to explain programming and the programming process. These include introductory books by Deterline (1962) and Richmond (1965), texts describing programming procedures by Fry (1963), Lysaught and Williams (1963), Thomas et al. (1963), Hughes (1962), and Green (1962), and actual programs on programming methodology such as those by Brethower (1963) and Meyer-Markle (1964). Far from all programs consistently reflect the 'linear' style of programming advocated by many connectionists or the 'intrinsic' style which has been adopted by many configurationists. Other formats have been developed, such as the 'mathetics' approach by Gilbert (1962a, 1962b) which emphasizes connectionist principles but incorporates substantially larger steps or learning increments in each frame, and many 'adjunctive' programs have been devised which depend on outside sources, such as a textbook or film, to provide the student with information he then uses to answer questions of the kind devised by Pressey (see Pressey, 1950).

Contrasts Between Programming Styles

There are a number of similarities among these various styles of programs, particularly in the procedures used during their development. But there also are a number of important differences. The most basic of these is in the kinds of help provided to the learner. The connectionists are 'response-centered' in their approach because they believe learning occurs as the result of practice. For this reason, a response-centered programmer does not emphasize explanation in what is presented to the student. Any reasonable, or sometimes even contrived, way of getting the learner to

emit the correct response in the proper context so that it can be reinforced is acceptable. For example, "Because they find uncles indigestible, aardvarks eat _____" (Klaus, 1965, p. 133) produces practice of the desired response even though the cuing is entirely illogical. The configurationists are 'stimulus-centered' in their approach because they believe learning occurs while the presented material is read. The question following each passage is not designed to produce learning but rather to insure that the desired learning has indeed taken place.

Other differences also distinguish response-centered from stimulus-centered programs (Klaus, 1965). The kind of response demanded of the learner is one of these. In a response-centered program, the learner is asked to rehearse the actual behaviors he is expected to master. These 'constructed' responses often are time consuming and seem repetitious to the learner, but the practice is felt to be essential for building the response and insuring it will be retained. Stimulus-centered programmers see the response serving only a testing or diagnostic function. They believe that simple recognition responses adequately serve these needs. Qualified programmers of either type generally reject the notion that the purpose of responding is to keep the student active and thereby maintain his attention, a characteristic of programs frequently emphasized by journalists after a quick look at programmed materials. Large numbers of programs have been prepared and published, however, in which the only relevance of the response is to demonstrate that the learner is doing something.

The stimulus content of the program steps represents another way in which programming styles differ. Response-centered programs have no apparent conceptual organization; with them it is almost impossible to skip ahead or review or locate instruction dealing

with a particular sub-topic. Stimulus-centered programs on the other hand aim for the same coherence and orderliness that is inherent in most well-prepared textbooks. Underlying this difference is the question of whether exposure to knowledge, regardless of how thoughtfully or clearly presented, is sufficient to produce learning. It is almost impossible to argue logically against the proposition that the questioning approach used in stimulus-centered programs would be unnecessary if the material consistently taught what the student was expected to learn in the first place. Stimulus-centered programmers contend that their format is more interesting and, therefore, more motivating to the learner. Considering most available programs, this undoubtedly is true but certainly not necessary.

A third difference is in the part played by giving the learner the correct answer following his response. The response-centered programmer regards the confirmation of a response as a form of reinforcement. Whether this is the best reinforcement that could be provided has been questioned but, in a practical sense, verification that a response was correct seems to be sufficient to produce learning and to maintain interest in the program. The occasional use of alternate forms of reinforcement might be desirable, however, if the program was long and the student's efforts had to be sustained over considerable periods of time. To the stimulus-centered programmer, confirmation following a response is meant as feedback or knowledge of results. Not only are correct answers verified but incorrect answers are coupled with additional information on what was wrong and on how the learner's understanding must be revised so that he will be capable of supplying correct answers in the future.

The fourth way in which stimulus-centered and response-centered program writers differ, and perhaps the most important, is in their concern over student

errors. A response-centered program is designed to reduce learner errors to a minimum. Each wrong answer provides undesirable practice and eliminates an opportunity to reward a response. Many stimulus-centered programmers feel not only that errors rarely are harmful but that they actually may enhance the learning process. As is true of many variables felt to affect the success and efficiency of an instructional program, experimental results on the effects of errors during learning are conflicting. This should not be unexpected considering that the role of the response and, therefore, the consequences of an error are quite different in the two kinds of programs. A high error rate in a response-centered program will be incompatible with effective learning because no provisions have been made to deal with an error that has occurred. Errors in a stimulus-centered program, on the other hand, are regarded as a characteristic of the instructional process and are treated accordingly.

Tryouts in Program Development

In recent years, less and less emphasis has been placed on the detailed features of programming format. Connectionist and configurationist approaches are still widely separated from each other, but there has tended to be a convergence with respect to the size of program steps, the need to make responses relevant and the inclusion of motivational content in the material presented to the student. The reason for this decline in dogma has been the profound similarity among approaches with respect to program development procedures. All techniques emphasize the empirical basis of programmed instruction, that is, that revisions must be made in the materials to reflect the results of learner tryouts regardless of theoretical considerations or format biases. The real test of a program, then, is how

thoroughly and how quickly students learn what the program was designed to teach.

The importance of thorough tryouts is both a feature distinguishing programs from most other instructional materials and a demonstrable necessity. One very clever study by Rothkopf (1963) compared the judgments by twelve educators as to the relative effectiveness of seven programs and the actual effectiveness of these sequences as determined by administering them to groups of students. The estimates of the educators, all of whom had recently completed a three-week course on programmed instruction, correlated -.75 with the actual results. In other words, the ability of these educators to judge the effectiveness of the materials was far worse than chance; the programs they said were good were really very poor and those they felt were poor generally were effective. Another study which suggests that experts generally are not adept at outguessing the performance of students in an instructional situation was carried out by Mager (1961b). This experiment compared the sequence of preplanned instruction on electronics as it would be taught by experienced teachers with instruction that was sequenced by the learners themselves. Whereas the standard courses on electronics surveyed all began either with magnetism or electron theory, the students all chose to begin their instruction with the vacuum tube. What is a logical starting point for most instructors was not felt to be the best one by the students themselves.

Giving the student greater participation in the development of instructional materials has been one of the more significant contributions of programmed instruction. This approach profitably could be applied to the development of more conventional materials, but not without frequent opportunities to observe student progress. Even the technique used by Gropper,

Lumsdaine and Shipman (1961) to improve lessons intended for television by administering diagnostic tests at the end of the lesson to determine what the students did and did not learn fails to provide explicit information on precisely where the lesson went astray. For purposes of revising instructional materials, there seems to be no substitute for tryouts which include frequent observable responses from the learner. Even when no revision is contemplated, the regular collection of feedback from students can increase attainment. Various devices have been devised to permit students to answer questions during a lecture or to indicate periodically whether they felt they were learning. The results are displayed to the instructor by lights or meters so that he can adjust his presentation accordingly. Corrigan (1964) has reported significant improvements in learning using such devices both for classroom presentations and for live telecasts. At least one such system, combined with an audiovisual capability, is available commercially from the EDEX Corporation.

The Cost of Program Development

The often lengthy process of tryout and revision is perhaps what makes good programs so expensive to produce. A skilled and experienced programmer often requires a week or more to develop strategies for and then draft the equivalent of a single hour of instruction, regardless of the programming style he has adopted. Repeated tryouts and revisions generally add at least another week of effort, and still more time may be involved if the program systematically is reviewed by collaborators to identify segments which could be shortened using alternate strategies and by editors to correct mechanical errors that could detract unnecessarily from the finished product. At this rate, a team of three or four competent programmers would have to

spend at least a year producing the equivalent of one year of secondary school physics or elementary school arithmetic.

These tremendous costs tend to result in programs of substantially dissimilar quality. For example, military and industrial training specialists are more than ready to invest heavily in program development even for a few thousand trainees. Even at the present state of the art in programmed instruction, these training managers routinely expect that a finished program will lead to virtually complete mastery by almost all learners in considerably less time, on the average, than could be obtained from conventional instructional methods. Commercially published programs, on the other hand, tend to be somewhat less effective because an individual author cannot invest the time needed to produce a good program solely on the basis of anticipated royalties which rarely exceed those obtained through the sale of a regular textbook. An author can, as many textbook writers do, produce a program working at his kitchen table in the evenings and forego most or all of the tryout and revision routine. As might be expected, the quality of these programs is very poor and the results from their use usually are unsatisfactory.

Programs written to meet specific instructional needs have another advantage in addition to their typically higher quality. It rarely is the case that several educators can agree on the exact outcomes expected from instruction or that the students in widely separated schools all will have the same background and combination of abilities. Attempts to produce a program which will have fairly general applicability is far more difficult than preparing a textbook for the same purpose. A classroom teacher can resequence or otherwise complement a textbook but interfering with the sequence or content of a program is likely to be disastrous.

The Availability of Published Programs

These problems have not kept large numbers of programs from being written and published. Hickey (1969) recently reported the availability of more than 2,220 published programs at all levels from preschool to professional education available from more than 445 different sources. Almost 200 subject matter areas are represented. Over half of the programs are designed for use in adult technical training, however, and because of their specificity and intended audience these programs would be unsuitable for routine educational use. Also, despite general agreement that the standards for published programs prepared by the Joint Committee on Programmed Instruction and Teaching Machines (see Lumsdaine, 1965) should be adopted, very few published programs are accompanied by the suggested statements about their empirical effectiveness. Lists of currently available programs, together with ordering information, are contained in periodically issued catalogs prepared by Carl Hendershot (1968) and Northeastern University (1968). Earlier catalogs, particularly *Programs '62* and *Programs '63* prepared by the Center for Programed Instruction (1962, 1963) which contained sample pages from most of the programs cited, no longer are being published. Today, the cost of programmed materials reproduced in book form for one-time use ranges from ten cents to more than a dollar per hour of instruction. Programs intended for school use, in contrast with those developed for adult markets, tend to be in the range of ten to twenty cents per instructional hour (see Center for Programed Instruction, 1965).

Instructional programs have not been widely developed or used outside of the highly developed countries. A recent survey by Spaulding (1967) reported on the locations of program publishers and developmental centers throughout the world together with informa-

tion on professional organizations, publications and consultants primarily interested in programmed instruction. Excluding data on the United States, Canada, Australia, New Zealand, all of Europe and southern Africa, only 39 nations reported any activity whatsoever. Centers exist in Ghana and Nigeria, in Cuba, Guatamala, Mexico and Puerto Rico, in Argentina and Uruguay, in China (Taiwan), Japan, Republic of Korea, the Philippines and Thailand, in Cyprus, Egypt, Israel, Jordan, Lebanon and Syria, and in India. Most of these seem to have been fostered by conferences and workshops held in these countries such as the ones directed by Green in Jordan and by Komoski in Nigeria in the Summer of 1963 under the sponsorship of UNESCO (Spaulding, 1967) and a series of courses offered by Moon in Venezuela to representatives from 16 Latin American countries during 1967 on behalf of INCE, the National Institute of Educational Cooperation. There are very few instances where any sort of programs are being used in developing countries other than experimentally at the present time.

The possibility of translating programs into other languages has been considered many times. Several of the elementary school programs prepared by Teaching Machines, Inc., and distributed by TMC-Grolier have been adapted into Spanish language versions (Hendershot, 1968). It is quite evident from the inspection of almost any program, however, that much will be lost in the translation. Most programs depend heavily on verbal cues embedded in the context of a frame for their success. Consider what would happen, for example, to these frames: "Two and two more adds up to _____," or "Every time a telephone rings it reminds you of its inventor, Alexander Graham _____." Then, too, a very large proportion of programs are designed with a specific curriculum and orientation in mind. What could be usefully translated is perhaps

limited to science and mathematics. In any case, since every translation would have to be given thorough try-outs before it could be used with confidence, it may be just as easy to prepare a program from the beginning as to translate an existing one.

The Prospects for Programmed Instruction

Programmed instruction, which was responsible for the dramatic increments in attainment and savings in time evident in the studies reported in the first chapter, is a potentially powerful instructional resource. Programming techniques can insure that each and every student will learn. Three developments will have to take place before the advantages of programmed materials can be realized, however. First, programs simply are too expensive to be used as supplements to conventional instruction. Unless they replace the traditional teacher, as they were designed to do and are capable of doing, programmed instruction is not likely to fit within typical budgets for educational services. Teachers are felt to be necessary adjuncts when television or textbooks form the basis of instruction but their presence is not essential when well prepared programs are used.

Second, the system of education must permit the self-pacing that is an inherent requirement of programmed learning. Most schools now have instructional schedules which focus on what the teacher presents rather than on what the students learn. However, any system which can tolerate uneven achievement in order to keep time constant certainly ought to be able to devise some structure which will permit learning time to vary in order to produce uniform levels of mastery. Third, quality programs which reflect both effective technique and desirable content must be produced. Unfortunately, those who tend to be most skilled as programmers rarely have the background in educa-

tion needed to insure their programs will find acceptance in the mainstream of educational practice. Similarly, those who are most likely to be expert in curriculum and subject matter content rarely have the extensive training or experience in programming technique needed to produce an entirely satisfactory program. New kinds of educational specialists are needed who represent both of these skills.

Programmed instruction is regarded by many educators as a tool for classroom use. The principles upon which programmed materials are based, however, represent a significant departure from traditional teaching practices. The advantages of programmed instruction are in producing a degree of control over the learning process that cannot be attained by a teacher or even implemented by a tutor. The substantial evidence already accumulated that reinforced practice not only can result in learning but can do so with an efficiency and effectiveness that cannot be replicated solely by communicating information to a student provides new insights into the meaning of quality in education. Programmed instruction has not revolutionized educational methodology. It has, on the other hand, unequivocally demonstrated that education is not making full use of existing knowledge about how learning occurs and that instructional goals can be achieved in the absence of skilled classroom teaching. It represents an alternate route to educational excellence.

6

AIMS AND OBJECTIVES

Dividing instruction into very small steps necessarily focuses attention on precisely what is to be practiced and learned during each step. Programmed instruction writers, particularly those who were trying to produce completely self-contained instructional materials, quickly learned that traditional educational objectives lacked the explicitness needed to determine exactly what responses are to be taught. As connectionist theorists, most of these early programmers were used to describing instructional results in terms of observable behaviors rather than as traits or intentions. They found it quite difficult to translate expressions such as 'understand gravity' or 'appreciate poetry' into response units.

The pronounced gap between how educators described what they wanted students to learn and how response-centered programmers wanted these objectives expressed was narrowed greatly by the publication of Mager's *Preparing Objectives for Programmed Instruction* (1961a). Written in programmed form so that it also served as an example of the technique for

those who were unfamiliar with programs, the book distinguished between the process of instruction — such as, laboratory experience with mirrors — and the product — such as, mastery of the principles of reflection — and between cognitive constructs — such as, knows the principles of algebra — and observable performance — such as, solves a simple quadratic equation. The value of objectives stated in terms of behaviors expected at the end of instruction had been recognized earlier but never had they been communicated so effectively.

Characteristics of Instructional Objectives

According to Mager, the kinds of educational objectives most useful in the preparation of instructional materials are those which describe and delimit the expected behavior of the student following learning. Three components are involved. First, the objective must indicate what the student is to do in the sense of performance that can be observed. This is not really as easy as it sounds. For example, a teacher might want a student to "know how to divide," but does this mean the student must learn to explain the process or perform the arithmetic? Describing behavior is increasingly difficult as the responses become more and more complex. For instance, when a teacher wants a student to "understand a poem," does this mean he must paraphrase it, answer questions about it or contrast it with other samples of literature; does a knowledge of English mean someone must be able to read textbooks, write letters, simultaneously translate radio broadcasts or speak without an accent? Frequently, doing really consists of several behaviors and all of these must be identified and described.

The second component of a useful objective is that it must specify upon what the behavior is to be performed. Obviously, dividing one number by another is

far more difficult when fractions are involved than if the problem and the answer consist only of integers. In a similar way, it usually is much more difficult to present a thesis before a potentially antagonistic audience than to write out the same thoughts. The objective must specify the possible range of problems and the tools that will be provided for use in arriving at a solution. Is an essay to be prepared with or without a dictionary? Can a slide rule or logarithmic table be used? How much of a sample will be provided for chemical analysis?

The third feature of an acceptably stated objective is that it must indicate how adequate performance is to be defined. Establishing criteria for academic accomplishments can be very difficult. Surprisingly, teachers seem to feel they confidently can grade an essay or evaluate a student's knowledge of history but that it is impossible for them to communicate their standards to someone else. As Mager points out, teachers who contend they are teaching skills which are intangible and cannot be evaluated put themselves in the awkward position of making it impossible for them to demonstrate that they are teaching anything at all. The speed of performance sometimes is as important as its accuracy and completeness; typically, the criterion component of an objective will include several dimensions if the terminal performance aimed for is at all complex.

Several other characteristics of instructional objectives have been recognized as important by the developers of instructional materials. One of these reflects the vast difference between 'doing' and 'knowing about.' It is perhaps easy to recognize that the skill needed to ride a bicycle is enhanced very little by knowledge about the workings of a gyroscope. On the other hand, students frequently are expected to improve their composition skills by increasing their knowledge of great literature, and to make better deci-

sions as citizens because they know about history. In selecting and describing objectives, it is extremely important to separate the means of instruction from the ends. Teaching a student biology is a very cumbersome way of helping him select more nutritious foods as an adult. The traditions of educational content have become so fixed in many disciplines that they remain even though the outcomes no longer are relevant or even identifiable. Students very often know more about the formal structure of a second language, which they speak poorly if at all, than they do about their own native language. They memorize proofs to geometric theorems but cannot apply the logic they supposedly learned to their everyday lives.

The Explicitness of Objectives

The scope of each objective has serious implications for the design of instruction. Many early efforts involving programmed instruction, for example, began with a detailed list of each and every behavior the student was expected to evidence at the end of instruction. The objectives for a course on chemistry might have included several hundred reactive equations to be balanced and the objectives for a course in government may have embodied a long list of significant names and dates. These highly molecular objectives soon proved to be both unwieldy and misleading. By being forced to identify objectives, teachers soon recognized that much of conventional course content was quite arbitrary. Because some specific examples or facts were particularly useful in illustrating a general principle or fundamental concept did not mean these details should themselves be objectives of instruction. As programmed instruction evolved, objectives became broader but no less explicit. Molar objectives, which depended on sampling desired skills, replaced the thorough enumeration of all that was to be learned.

The way in which objectives were stated also changed. At first, instructional objectives were prepared in the form of a statement. Many educators suggest preparing objectives this way (see Lindvall, 1964), and this format was used by Bloom and his associates in developing taxonomies of educational objectives which provide extensive numbers of examples of how loose instructional aims can be made explicit (Bloom, 1956; Krathwohl et al., 1964). It quickly was recognized, however, that this approach left considerable room for interpretive errors when preparing questions to assess whether or not the objective had been attained. A simple solution was to express the objective directly in the form of test items. This left no room for doubt as to the behavior to be taught, the conditions under which the behavior was to occur and how the adequacy of performance was to be determined. Objectives stated in this form not only made clear what was to be taught but what distinguished satisfactory from unsatisfactory performance as well.

Another change has been in the clearer distinction between terminal and interim objectives. A procedure that came to be adopted was to specify the ultimate outcomes of instruction and then work backwards to the level of entering students by specifying subordinate, 'enabling' objectives (see Taber, Glaser, & Schaefer, 1965). The difficulty with this approach was that it determined the strategy or approach to instruction as well as its aims. An extreme example of where interim objectives preclude the use of alternate instructional strategies is the objective "distinguishes between a bell and a buzzer" as one aim of materials to teach children to read. Instruction to help children differentiate subtle differences in how words sound is but one of many approaches that have been designed to prepare a student to learn to read, however, and the use of a bell and buzzer as an early step in this approach is only

arbitrary. How the aims of instruction are to be achieved should not be a component of instructional objectives.

Objectives and Instructional Aims

Clear objectives are an essential component of any teaching, but the need for them is amplified by programming techniques which aim at full mastery of anything and everything taught. Content not specified by the objectives appropriately should be deleted from instruction; there is no value in including content in a lesson which is not required to produce part of terminal performance. This view often made early programs prepared by behavioral scientists unacceptable to educators. The programmer frequently took it upon himself to derive instructional objectives for subject matters in which he had no particular competency. For this reason, many early programs taught what they were designed to teach exceedingly well, but they happened to teach irrelevant, incomplete and often erroneous information. Teachers had considerable difficulty preparing objectives for programmers to use.

The reasons for the difficulty educators experienced in preparing objectives remained obscure for some time. Most proponents of specific instructional objectives were adamant in their insistence on the need to state objectives in terms of observable behaviors. When a teacher expressed a goal of instruction as 'appreciation of art' or 'a grasp of economic theory,' the programmer demanded greater concreteness and specificity. Inferred behaviors were not allowed. This requirement has continued to be a weakness in the programmer's approach. He views these kinds of objectives as vague because the teacher has not indicated the explicit outcome expected of instruction.

The problem is not in the inability of teachers to determine objectives, but in their inability to express

them in language the programmer is willing to tolerate. The teacher does mean something by judgment, creativity, understanding and other terms frequently used. However, instructional technology has not advanced far enough to be of much help to the teacher in expressing these goals in objective, measurable terms. It is quite possible that many programs have deleted truly important aims from instruction because their attainment cannot be measured. One frequently seen example related to how definitions are to be learned. Teachers often encourage their students to learn to express definitions or statements of principles in their own words. They are aware that this leads to difficulties in judging the accuracy of a response but prefer it to the rote memorization which all too often is a product of the tight control of an instructional program.

Many of the concepts used to create instructional objectives have been derived from research on training rather than education. This again is understandable considering the relative cost of attaining superfluous or incorrect objectives when students are paid while they learn. There are characteristics of education, however, which preclude the indiscriminate utilization of findings from training research. One way in which training can be differentiated from education is that the precise goals of training usually are well defined while those of education purposefully are not; training is oriented toward a specific occupation but education is felt to be relevant to all vocational and leisure pursuits. Another, suggested by Glaser (1962a), is that uniformity is an aim of training but diversity in performance is an expected and desirable outcome of education. In these respects, the expected outcomes of education cannot be derived from occupational requirements. They must be determined by efforts to outguess the probable needs of the individual and the society he will live in at some future time.

It is clear, on the other hand, that simply too much knowledge exists to make it possible to teach everything. Selecting among objectives is as important as being able to express them clearly and productively. Within a specific course, objectives tend to be determined by what can be taught and tested easily. This is a very unfortunate and artificial method of ascertaining what is important and what is not. Nevertheless, in the absence of reliable ways of teaching and measuring such skills as effective social action, sociology teaches definitions; in geometry, students memorize theorems instead of creating logical proofs. Even vocationally oriented courses seem to spend undue amounts of time on the historical and conceptual introductions to a trade or technology as if to avoid having to face the problems of teaching the use of a saw or testing competence in soldering a circuit. In technical training, emphasis is placed on removing unessential objectives from instruction, those which represent information which is 'nice to know' but which is never evident in actual job performance. In education, terminal performance is far less well defined and, typically, the aims of a course turn out to be quite arbitrary. The freedom often provided to teachers in permitting them to modify the detailed objectives of a course reflects this capriciousness of educational objectives. It is difficult to imagine how a classroom teacher has the background to delete, adapt or add to content that already was selected by a textbook writer with the aid of technical experts and curriculum specialists.

The Goals of Education

At the present time, there is little that can be said about ways to improve course content. It is clear that cognitive growth does continue in school and that this depends on the courses that were taken. Project TALENT, an ambitious effort to test and then follow

the careers of some 440,000 students in U. S. secondary schools, found that all of the general abilities measured increased between the time when a sample of ninth grade students was tested origionally and then retested three years later (Shaycoft, 1967). Development was differential and depended substantially on whether or not the skills measured related to school subjects taught during the period between tests. The tests themselves did not attempt to measure the acquisition or retention of the myriad of specific facts included in a typical course, however. When one considers the vast amount of time the average student devotes to memorizing the succession of heads of state, the order of phylum in biology or the forms of 'to be' in a second language, only to forget these specifics as soon as the final examination is over, one cannot help but wonder if the time and investment of educational resources could not have been used more wisely.

If the goal of education is to produce generalizable skills which usefully can be applied after school years have ended, greater attention will have to be given to these skills as the end products of education. They cannot continue to be regarded as fortunate by-products of instruction that is devoted primarily to the mastery of arbitrarily selected and functionally isolated facts. There also is very little evidence to distinguish between the cognitive growth which occurs as a specific result of classroom teaching and that which results from informal learning in the everyday environment. When the mostly forgotten specifics are excluded from consideration, the real contribution of education may be less than imagined. In this sense, the length of school attendance is at best a very rough measure of the amount learned, particularly if the ultimate relevance and usefulness of what is learned is taken into account.

Elementary school seems to reflect more useful aims than secondary school. Basic literacy, which func-

tionally includes not only writing and reading comprehension but arithmetic ability, socially conventional behavior, and a business-like attitude toward attendance, punctuality and neatness as well, seems to represent skills which are likely to be valuable regardless of career goals and probable adult roles. In this respect, it has been estimated that literacy for a minimum of some 40% of the population is essential to an industrialized economy (Bowman, 1964). On the other hand, the contribution of post-primary education in producing national economic growth is highly variable from country to country (Curle, 1964). Since what is learned is as important as how many students learn it, curriculum planning must be tailored to forecasts of economic growth. Funds for educational expansion are never sufficient to permit the adoption of all desirable programs at the same time. But, instead of selectivity in the design of programs which would permit the greatest gains for a given expenditure, most curricula emphasize the traditional goals of academic education.

The Relevance of Aims and Objectives

One example of educational wastage is in the early specialization of course content which sometimes occurs at the primary level but more often in secondary schools. Some generalizable knowledge about the principles and approach of science, for instance, probably is very helpful to most adults regardless of their occupations. On the other hand, the usefulness of the content of a typical science course, such as chemistry, to most of the students enrolled in the course probably is marginal at best. Some familiarity with chemistry, or physics, geology or physiology for that matter, may be of value but this likely represents no more than a fraction of what is covered in a year long course in secondary schools. Between what will be forgotten before any use can be made of the knowledge and the changes

in content that may render obsolete much of what had been retained, even those who do go on to careers in chemistry or allied fields will never realize the gain for their time and efforts that they might have gotten from a course which taught more fundamentally useful skills. More people probably own automobiles, marry or engage in business than use chemistry. Yet, chemistry traditionally is considered a more desirable component of a school curriculum than safe driving practices, family relations or salesmanship.

One possible approach that could be used to increase the relevance of education is to determine what content is useful to adults, and to confine basic education principally to that content. Specialization should be delayed as long as possible. The practice of deciding on a curriculum plan for a child at an early age presumes much more accuracy in measuring interests and aptitudes and much more knowledge about changing career opportunities and requirements than presently is available. By delaying the introduction of specialized content as long as possible, the value of all education received will be enhanced. A curriculum which assumes maximally delayed decisions runs against the grain of some modern educational thinking, but it would protect against the teaching and learning of useless knowledge. When choices among courses must be made, they should be directed at eliminating unlikely specialties rather than at selecting among specialties. In this way commonalities among the remaining options can be preserved and the risk of a student learning totally irrelevant content will be reduced.

An opposite philosophy should prevail when interests have narrowed to a specific occupational choice. At this point, education for some reason encourages generalities when every effort should be made to prepare a student for a specific job. A potential machine

operator, for instance, must learn to operate one or more particular machines; broad principles will be of little help to him. The lack of interaction between employers and educators at this point in educational development is particularly unfortunate. Work-study programs which divide education between classroom instruction and actual work experience are a step in the right direction but still greater benefits would result from giving potential employers still greater say in what is essential during vocational education. To the degree that job training within the schools is both expensive and ineffective, it might be far better to establish government supported training programs at job locations as an integral part of an overall educational system.

Overall Curriculum Planning

The individualization of instruction can add a surprising amount of flexibility to curriculum planning with very little effort by permitting depth of interest to vary as well as direction. There is no reason to take all of a standard course in algebra to learn enough about equations to manipulate a simple formula in finance or statistics. A potential mechanic should not need to learn about sound waves in order to receive instruction on levers and gears as part of a course in physics. Individualization not only has a capacity for adjusting rate of learning, but to provide uniquely tailored curricula as well. Even without individualization, however, substantial improvements are possible. There seems to be as little logical or empirical basis for dividing a school year into at most two terms or semesters as there is to have precisely twelve years of education as a standard in almost every country in the world. Three, five or even ten terms would allow students who do not as yet have career choices to avoid specialization while increasing it for those who do have explicit plans.

More must be done, also, to increase the pertinence of instruction. The emphasis frequently given to academic content in the secondary schools of industrialized countries no longer is regarded as particularly relevant to the plans and expectations of large numbers of students. One finding from Project TALENT, for example, was that almost half of the boys in their last year of secondary school in the U. S. felt they were taking courses that would not be of help in an occupation after leaving school (Flanagan, 1965). But, important as it would be for these students, better vocational preparation is not the only change required if education is to meet its responsibilities. Good judgment, creativity and analytic skills are as necessary today as basic literacy has been in the past. These abilities are too important to be left to chance and their development must be an integral rather than peripheral or incidental aim of education. Curriculum emphasis on academic content is difficult to defend when rising crime rates, boring leisure hours and apathetic concern for the future dominates the lives of many 'fully' educated adults in modern urban societies.

The problem of what to teach is no less of a concern in those developing countries which have attempted to emulate historically affluent nations. It is almost impossible to reconcile the differences between the demands of economic necessity and the aspirations of educational tradition. The objectives of instruction, in this sense, need to express the aims, standards and priorities of a nation's people. The arguments and counter arguments over a vocational emphasis in the educational programs of developing countries, for example, only recently have included acknowledgement that job training often is resented by those who see education as a way to escape from the manual labor which characterizes their membership in the peasant classes (see Anderson, 1969; Coombs, 1968). Imposing

a curriculum which substitutes occupational topics for the classical content of academic instruction may seem rational to those who are economically advantaged but can be viewed as duplicity by those the education is meant to serve, whether they are paddy farmers or ghetto blacks. Even worse, this orientation presumes to predict the future and its needs without questioning the relative value of manual and intellectual skills for eventual prosperity and other ultimate goals.

Cultural Values and Educational Goals

Who should receive instruction when educational resources are too scarce to provide for all is a similar problem. If a choice must be made, it is better to devote teachers and classrooms to basic education for every child or to limit enrollment so that some can continue secondary instruction and beyond? Is it better to reserve existing opportunities exclusively for the young or to divide them somehow between the new generation and their parents? Is it better to plan improvements in the educational system to emphasize the quantity of pupils or the quality of instruction? Answers to these questions are not simple to obtain nor understand because they frequently reflect underlying cultural beliefs which themselves may be quite subtle. Cultural values more often determine curriculum patterns than technological principles. In this sense, the overall aims of education are not likely to be molded by instructional technicians.

The importance of creating workable solutions within existing constraints frequently is viewed as an unnecessary frustration to educational planners. For instance, many of the newer nations of the world are comprised of quite separate, and often quite competitive, ethnic groups. National unity may be a basic aim of the country's leadership, but one which is extremely difficult to implement in its educational program. The

adoption of a single language of instruction may seem to be the most efficient solution, but in some countries that course of action well may alienate the members of those minority groups who would be forced to abandon their own interests by allowing their children to attend school. Aiming toward one goal may interfere with achieving another, and a solution which failed to incorporate both aims would be unsatisfactory.

The unique problems which must be faced by educational planners in the developing countries often seem insurmountable. The pattern of educational objectives which have met the needs of industrialized nations often have little relevance where economic opportunities are fewer and where even the advantages of education are not at all clear. Under these circumstances, educational planning must begin with explicit knowledge as to precisely what the educational system is to accomplish. The answer may not be universal enrollment or the upgrading of vocational skills or even an introduction to the modern world of science and industry. Education can be an instrument of change in a developing country but the direction of this change need not reflect the same goals and values which happen to characterize presently affluent societies.

7

ASSESSMENT TECHNIQUES

Programmed instruction led to more explicit statements of objectives and, in turn, to new techniques for measuring educational attainment. Educational measurement historically has been *norm-referenced.* That is, the performance of an individual learner is compared with the performance of other learners to determine how much has been acquired. The typical achievement test, whether prepared by a teacher for administration to a particular class or developed centrally to measure the accomplishments of students in a large number of classes, is an example of a norm-referenced test. The newer types of tests being devised to assess instructional outcomes, particularly in individualized instruction settings, are *criterion-referenced.* In contrast to norm-referenced measures, criterion-referenced tests compare the performance of an individual with some external, absolute standard. This distinction between types of test instruments is uniquely important in technical training where standards of acceptable performance can be derived from job requirements (Glaser & Klaus, 1962). However, the

value of criterion-referenced measures to education has become increasingly evident and these test instruments have become more and more widely used to determine the outcomes of instruction.

Differences in Test Types

A norm-referenced test, the kind traditionally used to assess educational achievement, compares a student's performance with that of other group members. His score indicates his relative standing along some continuum of excellence but it does not provide much information, if any, about what the student can do. The score on a simple quiz in arithmetic or spelling may show that a student performed better or worse than the average of other students, but it does not indicate whether he routinely can be expected to spell a given set of words or solve certain multiplication problems correctly. A criterion-referenced test, which sometimes is called a 'proficiency' measure, yields a score which describes the content of the student's performance. For example, it might indicate how accurately a student multiplies single digit numbers or how many trees he can identify from their leaves. The standard against which performance is measured is an absolute one which defines the objectives of instruction.

The difference between norm-referenced and criterion-referenced measures is reflected in the way scores can be reported. Performance on an achievement test often is expressed as a 'percentile' which indicates the position of a student's score relative to those in the standardization group. Knowing a student scored at the 70th percentile in fifth grade history means that he was substantially above the mean, or average. But, the score does not indicate how much history he has mastered. On the other hand, performance on a proficiency test legitimately can be expressed in terms of a 'percentage.' For instance, it

would be possible to report that a student can name the capitals of 90% of all the member countries of the United Nations. This use of percentage scores is not equivalent, of course, to their very arbitrary and misleading use in many educational settings to mean the percent of test items a student has answered correctly.

Unlike achievement tests, then, proficiency measures have two characteristics. First, they assess attainment relative to some independent standard and, second, they yield scores which are descriptive of the content of performance (see Flanagan, 1951; Ebel, 1962). The value of these measures to education are clear from the immediate implications of a description of test results. For example, the very large testing project described earlier, Project TALENT, used proficiency measures to ascertain academic competence. The spelling test that was used demonstrated that the average twelfth grade student could correctly spell 92.5% of the 5,000 most commonly used English words and a reading test revealed he was able to comprehend 67% of what he read from Louisa May Alcott but only 47% from the writings of Jules Verne (Flanagan & Staff, 1963). These scores are in a form that is uniquely meaningful to pupils, teachers and parents alike.

The Meaning of Proficiency Scores

The relationship between proficiency measures and behavioral objectives has led to an increasing use of criterion-referenced tests in education, particularly in assessing attainment following individualized instruction. However, the interpretation of proficiency test scores is quite unlike the interpretation of achievement test scores. Achievement tests are designed primarily to differentiate among individuals. Therefore, in selecting items for an achievement test, items which almost all students answer correctly or those which very few answer correctly are discarded (Adkins-

Wood, 1947, 1961). The end result is a test which maximizes the spread of scores among individuals who all have similar backgrounds and instructional experiences. This forces the item writer to emphasize questions which either relate to minor details or are heavily weighted with intelligence components. Proficiency tests can and do include items which all students answer correctly, or all students miss, in that they are designed to assess mastery of the instructional objectives. As a result, it is more than likely that scores following competently designed instruction will be concentrated near 100%. Figure 3 shows some data collected by Cartier (1963) on an instructional program requiring about three hours to complete. The pretest

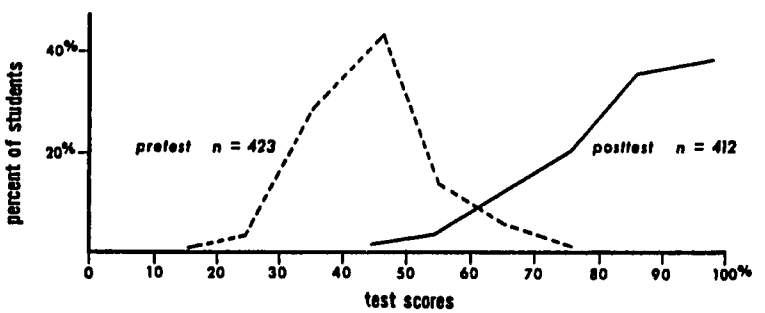

Figure 3. Pretest and posttest results from a three-hour instructional program.

data represented by the dotted line has the distribution of a typical 'normal' curve. The posttest scores, on the other hand, are massed at the upper end of the scale.

Results similar to these are not at all unusual following the use of programmed materials and when a proficiency test is used to measure what has been learned. When a program to teach listening skills was tried out on ten insurance salesmen, seven of them scored ninety percent or better on the final examin-

ation (Liberty Mutual, 1965). When 25 trainees took a 70 hour program on using a computer language, 22 scored ninety percent or better on the criterion test (Burroughs, 1965). In none of these instances did performance following training result in even an approximation of the 'normal' distribution of scores usually obtained from achievement testing. Were a norm-referenced test to be used following programmed instruction, the scores more than likely would be distributed in a 'normal' curve because the items would not have been designed to accurately reflect the specific instructional objectives the lesson had been developed to reach. Similarly, if a criterion-referenced test is administered following a well-prepared conventional lesson, a 'normal' distribution would result to the extent that differences in ability have not been absorbed by allowing learning time to vary.

Implications for Educational Practices

This distinction between types of tests has a number of implications for research on instructional methodology. Clearly, the application of criterion-referenced measures is preferable over norm-referenced measures to the extent that the objectives of instruction have been specified in advance. Once a determination has been made of what content is to be mastered, that content should form the basis of tests used to determine whether or not the instruction was effective. Only when the burden of learning rests with the student would it be at all appropriate to determine how well the student assumed responsibility for insuring his own success. Variability among students is an expected outcome of conventional instruction. The strength of this assumption is reflected in assigning grades at the end of a course which depend upon tests that amplify even small differences among students with total disregard for often very substantial similar-

ities in attainment. Presently used achievement tests attempt to indicate how much was learned in a constant period of time. Whether what was supposed to be learned indeed was learned seems only incidental to this type of assessment process.

The statistical characteristics of criterion-referenced scores make them quite unlike those obtained from norm-referenced tests. A few of the many differences (see Glaser & Klaus, 1962) will illustrate the atypical qualities of proficiency test results. The 'mean,' or average, will be artificially low when scores are compacted at the high end of the scale and usual measures of dispersion, such as the 'standard deviation,' will be reduced in size. Even more important, traditional concepts of test reliability will not apply. As all scores approach the maximum possible value, the effects of chance errors will become increasingly pronounced. As a result, traditional reliability estimates will be exceedingly low. Correlations between aptitudes measures and instructional achievement also will be low. When errors on a test of attainment are largely due to chance, a low ability student will have about as much opportunity to receive a perfect score as a high ability student; to the extent that the instruction has been designed to permit mastery by all students, the predictive accuracy of aptitude measures will be near zero.

Another feature of criterion-referenced measures is that they are better suited than norm-referenced tests as instruments for research comparisons among instructional methods. Ideally, a test designed to assess differences between groups includes minimal emphasis on differences among individuals (see Glaser and Klaus, 1962; Glaser, 1963; Glaser & Cox, 1968). The demonstrable effects of differential treatments will be clouded to the extent that the individuals within a treatment group do not achieve similar scores.

Technically, this is a corollary of the procedure used to determine the trustworthiness of experimental findings on the basis of a comparison between the magnitude of treatment differences and the magnitude of nontreatment differences. The same considerations apply when comparing the performance of students before and after instruction. Ideally, a test designed for the purpose of evaluating instructional quality should be sensitive only to content that was unfamiliar before instruction but which should have been mastered by the time instruction had been completed.

Ability and Proficiency Measurement

The lack of any expected relationship between aptitude measures and mastery scores following learning from programmed instructional materials is not a function of the test alone. Ability and achievement obviously are related and ability will be predictive of achievement so long as instructional time remains constant. By permitting learning time to vary, however, programmed instruction is capable of absorbing ability differences. A rather dramatic example of this outcome is evident in data reported by Cook (1964). Rank-order correlation coefficients computed from his results show the expected absence of much relationship between I.Q. and pretest scores, -.04, which is just about chance. The correlation between I.Q. and posttest scores is -.20; this result does not differ statistically from zero, considering the number of cases, and also must be regarded as a chance result. The correlation between I.Q. and learning time, however, was -.85 which is evidence for a highly significant relationship. In essence, all of the entering variability among students in ability was absorbed by permitting each student to use as much learning time as he needed and, because of the opportunity for self-paced study,

all students learned equally well regardless of ability level.

These findings are unusually dramatic but they are not unique. For example, Holt (1963) reported a correlation of -.45 between ability and study time for 34 trainees who took an extensive programmed course in basic electricity. The correlation between ability and achievement was reported as 'lower' but the exact figure was not given. Carroll (1963) reported correlation coefficients of +.60 between language aptitude and performance following programmed instruction but a more substantial -.72 between language aptitude and learning time. Interestingly, a number of studies have reported a correlation between aptitude and achievement which was as high or higher than that between aptitude and learning time following programmed instruction. For example, Alter (1963) found a correlation of +.53 between I.Q. and posttest performance but only -.24 between I.Q. and time needed to complete the program. Average attainment from the program was only forty-nine percent, however, suggesting either that the test did not measure what the program taught or the program did not teach what the students were expected to learn.

The relationship between ability measures and mastery levels, even when it is fairly substantial, is probably a better demonstration that the program failed to achieve its objectives than evidence for any necessary causality. It should be possible to prepare a program which results in perfect scores for all learners, within the limits of chance errors, providing the test used accurately reflects the aims of the instruction and does not introduce performance requirements which were not covered during the instruction. If all students perform equally well on the posttest, the correlation between proficiency scores and all other measures obtained from the students must be zero. This

relationship assumes only that the entering behavior of all students meets the prerequisites of instruction. A student who cannot read obviously cannot learn from a program that includes written text. For this reason, it is important to differentiate between aptitude measures, to the extent they predict rate of learning, and prior accomplishment measures, to the extent they describe whether or not the learner has the skills necessary to profit from the instruction at all.

Intelligence as a Learning Measure

A system of education built around criterion-referenced rather than norm-referenced measures may have a completely different view of generalized measures such as mental age (M.A.) and intelligence quotient (I.Q.) than now is prevalent. The function of most intelligence tests is to assess how much skill and knowledge an individual has acquired from among that which could be learned, incidental to a formal education. The more that has been learned, the higher the score, or M.A., that will be obtained. For a group of students all of the same chronological age (C.A.), those who demonstrate they have learned the most are really demonstrating a faster rate of learning in that learning time has been constant for every member of the group. This is the meaning of I.Q., the ratio of M.A. to C.A. Those with a higher I.Q., regardless of their M.A., are those who learn the fastest; those with a higher M.A., regardless of their C.A., are those who have learned the most.

I.Q. has been a good predictor of achievement following conventional instruction because it represents rate of learning. It already has been shown, on the other hand, that the relationship between I.Q. and mastery can be zero when learning rate is allowed to vary. There is no necessary reason, then, to consider any instructional objective unattainable so long as

sufficient learning time is available. With properly designed instruction, an individual can learn anything taught to him if he has the proper prerequisite skills and knowledge which, conceptually at least, is represented by M.A. and is the product of past learning. When conventional teaching techniques are used, it is undeniable that some children learn and others do not, and that this outcome is somehow related to intelligence. Instead of intelligence representing a ceiling on what can be learned, however, it is possible that it represents an upper limit on rate. Even unlimited time will be of no value, though, unless the student brings to the class the background the instruction assumes he has. It is not surprising, then, that a slow learner is regarded as an incapable learner after years of schooling in which he acquired only a fraction of what he was expected to learn each year. The cumulative deficit is apt to preclude any further increments from instruction geared to the length of his past exposure.

Measurement to Assess Instruction

Mastery tests, when properly used, measure both how much each student has learned and how effective the instruction was for all students as a group. Considering the overall purpose of education and its role in improving human resources, the diagnostic and evaluative function of measurement is far more productively applied to assess instruction rather than learning. It is unfortunate when one child does not learn as much as he could have learned during some fixed time period, but it is tragic when an entire class or even generations of students do not accomplish what would have been possible during their school years. When teachers are asked what they have taught they usually respond in terms of how much information they were able to present. If all that was presented by most teachers was included in the test it would be evident

that only a very modest proportion was acquired by the pupils. Half learning, however, is an obvious waste of valuable instructional resources and student time.

A test which parallels the objectives of instruction can be used to measure both the adequacy of teaching and the adequacy of learning. For this reason, it is far from inappropriate to 'teach the test,' by offering instruction designed to insure that every student will achieve a perfect score on the examination at the end of the course. Perfect mastery by only some students is not enough. Most educators recognize that teaching bright students is relatively easy because they can learn under even the most difficult of circumstances and in spite of ineffective instruction. It is the slow learner who is the problem and who needs competent instruction. This same point has been made by Jensen (1969), who also criticizes the nature of the assumed relationship between 'g,' or general intelligence, and scholastic achievement:

> *At present, I believe that the educational system . . . even as it falteringly attempts to help the disadvantaged . . . operates in such a way as to maximize the importance of [general intelligence] . . . as a source of variance in scholastic performance. Too often, if a child does not learn the school subject matter when taught in a way that depends largely on being average or above average on 'g,' he does not learn at all . . . [p. 16].*

An interesting consequence of 'teaching the test,' when instruction is entirely automated and, therefore, preserved for future use, is that once the materials are perfected through tryouts and revisions the test no longer is required. If repeated demonstrations reveal that all students achieve the instructional objectives, there is no particular need to test future learners for

the same purpose. For this reason, the kind of test prepared to assess instructional outcomes can be both exhaustive and require elaborate administrative procedures. Once it has been demonstrated that students do learn all they were expected to learn, the examination given at the end of instruction can be brief, or even eliminated entirely unless it serves a motivational or quality control function.

Evaluating Effectiveness and Efficiency

Many methods have been proposed to assess the quality of an instructional program. Comparisons between it and conventional instruction can be very misleading, however, unless both the program and the teacher are equal in quality. The finding that a science program, for example, is more effective than a single teacher does not mean the same program will be more effective than all science teachers or that programmed instruction is better than conventional instruction (see Lumsdaine, 1963). Only when the results of a fairly representative sample of programs are contrasted with the results of a fairly representative sample of teachers is the comparison at all meaningful. The validity of measuring the quality of a program by considering the gains between pretesting and posttesting similarly is questionable; pretest performance may be too high to permit much gain to occur. A ratio of gain to possible gain has been proposed (McGuigan & Peters, 1965) to overcome this objection. The most usable index of program quality, however, seems to be the degree to which the program has eliminated the usually predicted effects of ability on amount learned from self-paced instruction.

Techniques which could be used to assess the efficiency of instruction are not as numerous as those which measure effectiveness. One approach has been to administer an independently prepared criterion test

to the two groups being compared and then divide the resulting scores by the time spent in instruction. This seems a convenient way of weighting outcomes to equate for differences in study time between conventionally taught and individualized classes, for example, when the students in one or both groups may proceed at their own pace. It has been observed, however, that if 15 minutes are required to teach 15 objectives, it does not follow that 30 minutes will be required to teach 30 objectives (Shettel & Lindley, 1961). The added objectives might be far different in difficulty level and there may be a confounding effect due to interference among objectives. A student may be able to recite the symbols for five chemical elements after hearing them only once, but he may need many presentations of a list of ten symbols and elements to recite all ten correctly. Time is an appropriate measure of instructional efficiency only when attainment is perfect for all learners.

Individualized instruction affords more numerous opportunities for accurate assessment and depends more heavily on it than conventional classroom teaching. More elaborate systems of individualization often include comprehensive evaluations of entering skills for placement purposes, frequent testing during instruction to diagnose weaknesses before they can become compounded, and periodic measurement of student competence on previously learned materials to assess retention (see Lindvall & Cox, 1969). Criterion-referenced tests, which are based on explicit instructional objectives and thus provide detailed information on precisely what has and has not been learned, have begun to replace the crude measures that have been characteristic of education. Even now, however, it is usual to hear educational accomplishment expressed in terms of time — "he finished two years of grade school" or "she had three years of college" or "they

completed one year of biology" — a way of expressing hoped for changes in performance otherwise used only in reference to experience in penal institutions — "he spent five years in prison."

It is fallacious to assume that the accomplishments of education cannot be measured more meaningfully than they are now or that they need not be measured at all. The further evolution of instructional practices will depend on the accuracy and thoroughness with which the changes in skill and knowledge that occur between entering and leaving the educational process are assessed. The greatest value of effective measurement is not necessarily in the opportunities it provides for supervising the progress of each individual student, but in the insights into educational methodology which may result. By focusing attention on what actually is acquired, the needless dissipation of time and talent on communicating information which is not learned can be avoided, the attainment of truly important objectives can be insured, and the iniquitous proposition that ability necessarily limits accomplishment finally can be put to rest.

8

INSTRUCTIONAL DEVICES

The interest generated by Skinner's early papers describing machines that could teach (1954, 1958) has abated somewhat in the last few years. As noted in a previous chapter, many of the devices designed and offered for sale during the early 1960's had no programs to accompany them and they soon disappeared from the market. Programmed texts, which are books that present programs in such a way as to control the learner's access to the reinforcement or 'confirmation' portion of each frame, seemed to serve as adequately as a device and tended to be considerably less expensive and less awkward to use. Although teaching machines no longer predominate schemes to enhance educational practices, they continue to be relevant components of futuristic systems for individualized instruction. No book affords the degree of control over the learner and his environment that can be attained even by a simple electrical, mechanical or electronic device. And no teacher has the persistence, patience or consistency of a machine in allowing each student to learn at an optimum pace.

Skinner designed several different teaching machines, including ones which permit the student to write out his answers; these were used for teaching psychology to adults and for teaching spelling to young pupils (Skinner, 1958). His first device, one to teach arithmetic (1954), was:

> *. . . a small box about the size of a small record player. On the top surface is a window through which a question or problem printed on a paper tape may be seen. The child answers the question by moving one or more sliders upon which the digits 0 through 9 are printed. . . . When the answer has been set, the child turns a knob. . . . If the answer is right, the knob turns freely and can be made to ring a bell or provide some other conditioned reinforcement. If the answer is wrong, the knob will not turn. A counter may be added to tally wrong answers. The knob must then be reversed slightly and a second attempt at a right answer made. . . . When the answer is right, a further turn of the knob engages a clutch which moves the next problem into place in the window* [*p. 110*].

Early Teaching Machines

Skinner, of course, was not the first to propose a teaching machine. Mellan (1936) identified more than 600 patents for teaching devices issued by the U. S. Patent Office through the year 1935. The earliest of these was awarded in 1809. Many were designed exclusively for the presentation of information. They did not particularly emphasize responding, reinforcement for correct answers or other features now felt to be important in teaching machine designs. Pressey's early machine, which was first displayed in 1924 (Pressey, 1926), was probably the first to include both

response and reward capabilities. The student selected a correct answer instead of constructing it, but the device could be arranged so that he would proceed on to the next question only if his answer was correct. A later model even was equipped to dispense small candies as rewards (Pressey, 1926).

Little use was made of these early devices except as research tools and playthings, probably because of the absence of any real need to automate instruction. Yet, many games and toys for children were developed in the 1930's based on these basic principles and these playthings were avidly bought by parents during the craze over educational psychology which emerged during that decade. A spelling game allowed children to 'dial-a-word' and then check their own accuracy by sliding open a window to reveal a picture of the object spelled. A toy scale taught youngsters to add by letting them see if digits, weighted according to their numerical values, would balance. An information game provided feedback for answering multiple-choice questions, by rewarding children with a light and buzzer for touching a probe to the correct terminal posts. Less mechanical, but no less educational, apparatus for individual use has been available to teachers and used in schools for some time including models, cutouts, and equipment for seatwork projects.

Characteristics of Instructional Devices

Including some instructional playthings as teaching machines does not mean that all toys, manipulanda or materials, even those labeled 'educational,' clearly serve legitimate instructional purposes. Some learning undoubtedly occurs any time a child interacts with the world around him. How constructive this activity is in an educational sense depends both on the degree to which the learner's responses have differential consequences contingent on their sufficiency and the ex-

tent to which the performance of the learner is guided and assisted by the apparatus itself. Equipment or materials which serve only one function or the other cannot be considered teaching machines. Thus, while most toys can be operated or used with generally rewarding consequences, the child's responses are not limited by the design of the toy to behaviors that have been specified in advance. In contrast, many classroom aids present information to guide what the learner does, but they are not teaching machines because they do not differentially reward a learner depending on whether or not he has made an error in his response to them.

It is unfortunate, perhaps, that so little interest has been shown by educators in learning activities which are truly fun. Learning certainly does not have to be dull to be effective. Yet, most children would rather play than study and would rather watch entertainment over television than sit through instructional lessons. One advantage of teaching machines is that they inherently have many of the qualities of a game or toy. Skinner suggests the reasons for this are that an instructional device rarely has or needs to have aversive consequences for learner mistakes, that it tirelessly will present reinforcements to the learner through the thousands of steps necessary to produce mastery and that it is capable of presenting a sequence of instruction without deviating from the intended order (1954).

Pressey and Skinner Machines

Considering the number of devices available in 1962 or 1963, it also is evident that teaching machines must be at least as much fun to design as to operate. Many pioneers, in fact, devised a number of different models of machines. Pressey developed both the multiple-choice device described earlier and punch boards

into which cardboard stencils, with holes representing correct choices, could be inserted to record errors and provide feedback when a stylus was inserted. These machines are shown in Figure 4. Pressey also was instrumental in the development of various printed materials which used erasable opaque coatings or

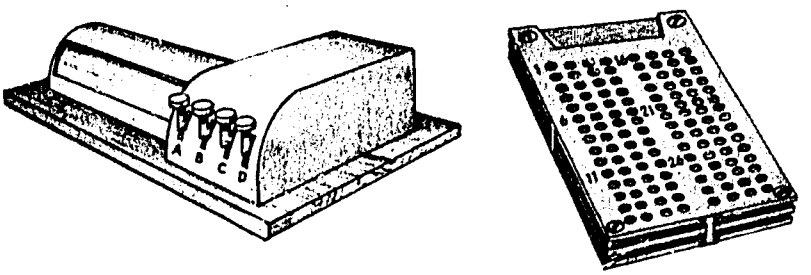

Figure 4. The Pressey multiple-choice device (l) and the Pressey instructional punch board (r).

chemical treatments that would reveal colors when touched with a special pen to permit students to take self-instructional tests (Pressey, 1950, 1962).

Skinner is responsible for the design of both of the machines shown in Figure 5. In the earlier of the two, the program was reproduced, frame-by-frame,

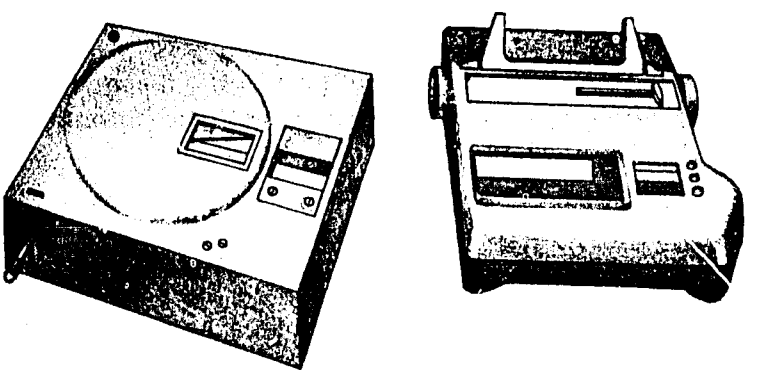

Figure 5. The Skinner disk machine (l) and the Rheem-Califone "Didak" (r).

on a paper disc about fourteen inches in diameter. About 80 frames and their answers or 'confirmations' could be typed on each disc. By moving one handle, the student could advance the disc to expose the next frame and then, by moving the other handle, expose the confirmation to that frame. Responses were recorded on a paper tape at the right. To prevent cheating, the tape containing the student's answer advanced from the opening to a position under a transparent window when the confirmation was exposed. Advancing the disc to the next frame also advanced the tape so that the previous response was then completely hidden.

The machine on the right in Figure 5, manufactured by the Rheem-Califone Corporation and called the Didak, functioned similarly although the design was somewhat different. Using it, the student advanced the program with a knob. The frames were reproduced on strips of paper which then were taped together in fanfold fashion. One feature of the device was that the tape also contained 'hints' to the student which could be exposed if he were having difficulty. Each time the hint feature was used, a hole automatically was punched in the response tape. The learner was asked, also, to punch a hole himself if he made an error so that these could be found easily when the tape was analyzed later.

Problems with Early Devices

These and many other devices of roughly similar design, few of which are still being promoted actively, are of historical interest because they reveal how even experienced manufacturers were unable to anticipate problems which seem readily apparent in retrospect. The primary difficulty associated with these devices was in the complex problem of preparing the programmed material in a suitable form. Although the

discs for the Skinner machine could be printed commercially, getting them cut to fit the device was expensive. The only alternative, typing out the frames on plain paper and then pasting them on a blank disc, proved to be a very slow, expensive, and inefficient process. Preparing long strips of printed tape required by the other devices was equally exasperating. Taping sheets together was not only laborious, but several experimenters reported that the machines frequently jammed and tore the strip. This meant opening the machine and splicing the tape as often as several times an hour.

One inexpensive device featured small print and could provide as much as an hour of instruction on less than twenty feet of tape. However, printing even that long a tape by rotary presses would require a printing drum roughly seven feet in diameter. One investigator was reported to have prepared programs for this device by taping mimeograph stencils together, laying a strip of suitable paper out on a gymnasium floor, setting the stencils on top of it, and inking the stencils and copy with an ink roller in lawn mower fashion. A Canadian concern offered to print unlimited lengths of paper-tape programs using rubber mats spliced together in a large diameter belt. However, the problems of tearing and the difficulty in loading machines which used paper tape prevented any of them from becoming popular.

Improved Response-Centered Devices

The next development was the design of two very similar machines, the Min/Max II at the left of Figure 6 and the Koncept-O-Graph at the right of the figure. Both of these devices used standard size sheets of paper stacked in a hopper. The top sheet is pressure-fed across the window by a foam rubber roller, or by a spring-loaded toothed wheel, each time the knob is turned. Both devices were well engineered, inexpensive,

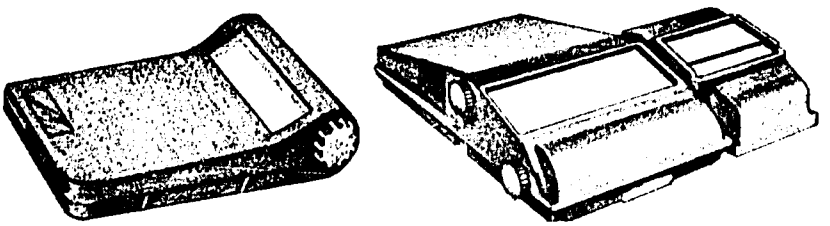

Figure 6. The TMI-Grolier Min/Max II (l) and the Graphlex, Inc., Koncept-O-Graph (r).

and easy to use and maintain. The only real difficulty experienced with either has been that the sulphur content of ordinary paper is sufficient to harden and deteriorate the foam-rubber roller over a period of time. Both devices are optionally equipped with a response device which advances a blank paper tape simultaneously with the program. Otherwise, without the device, the student records his responses directly on the printed sheet through an opening. These devices were priced at about twenty dollars, one-fifth to one-tenth the cost of earlier machines. Similarly designed and equally suitable teaching machines easily could be manufactured to sell at even a lower price were there to be a demand for them. In fact, several other devices in this price bracket were no more than books with a simple paper or plastic mask that prevented the learner from seeing the confirmation panel printed beneath or to the side of the presentation frame until after the response.

A number of machines were designed which used film rather than paper, such as the Dukane Redi-Tutor shown at the left in Figure 7 and the Keystone Mast machine at the right. The first used 35mm film strip, the second used cartridge loaded 35mm film. An interesting feature of this latter device is that only half the film is projected at one time so that the cartridge is rewound when it is turned over and the second half

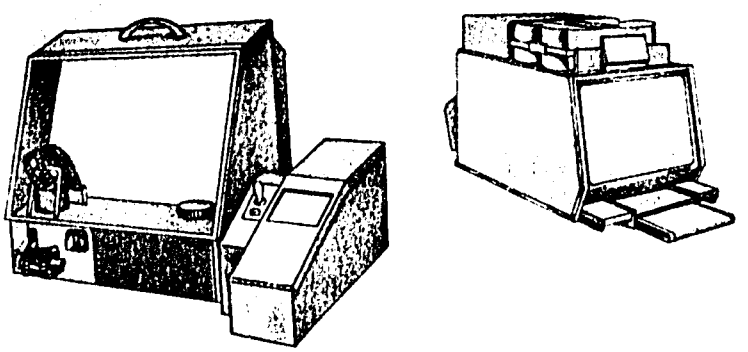

Figure 7. The Dukane Redi-Tutor (l) and the Keystone Mast Teaching Machine (r).

of the material is projected. Another feature is that the device can be used with a stereo-viewer.

Improved Stimulus-Centered Devices

An intrinsic program, the kind of question and answer materials usually developed by configurationists, uses multiple-choice responding and therefore allows for somewhat greater automation of the instructional process. This feature of intrinsic programming seems to appeal to the gadget-minded. The Honor teaching machine designed by Bolt, Beranek and Newman, is shown at the left of Figure 8. It used a paper tape which was coded by means of a series of punched holes representing the correct answer. The operation of this device is almost identical to the operation of Pressey's early machines except that a battery-driven motor is used to advance the paper tape. A feature of the Honor machine is that it permits a limited amount of 'bypassing.' If he can correctly answer a difficult question early in a sequence, the student can bypass several frames designed to give added practice on that topic to other students who did have difficulty on the 'gate' frame.

A far more elaborate device for presenting intrinsic programs is the U. S. Industries AutoTutor Mark II at the right in Figure 8. This machine, which was priced at over one thousand dollars, presented the student with a text passage followed by a question. The student selected his answer by pressing one or more buttons at the right. The device then automatically indexed the stored roll of 35mm film to present either the next frame, if the response was correct, or the proper remedial frame if the student made an error.

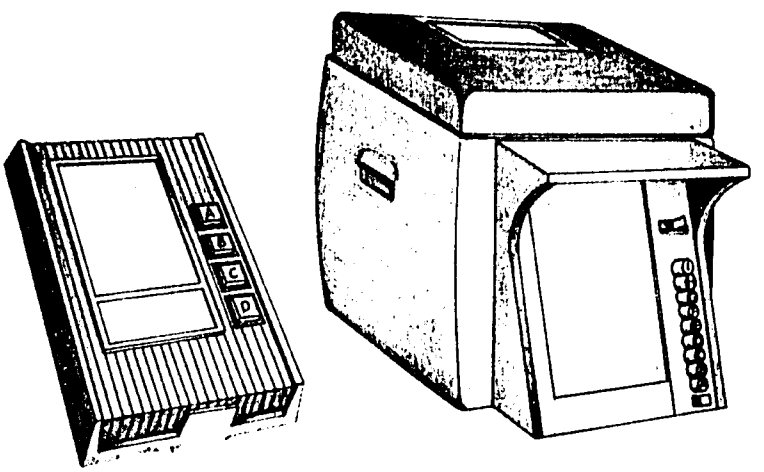

Figure 8. The Bolt, Beranek & Newman Honor teaching machine (l) and the U. S. Industries AutoTutor, Mark II (r).

Scrambled and Programmed Texts

Although devices of various kinds were used widely during the early years of programmed instruction popularity, it was readily evident that most kinds of programs could be presented to a student in book form without the aid of a machine. A format for presenting intrinsic programs not using a device was the 'scrambled text' created by Crowder and his associates. As illustrated in an earlier chapter, the usual paragraph of information and accompanying question and choice

of answers were presented together on a single page. Each answer was followed by a page reference indicating to the student where in the book he was to turn next to discover the correctness of his choice. Although all of the pages the student might turn to usually were grouped nearby in the book, they were arbitrarily scrambled so as to give little or no cue to the learner while he was making his choice as to which was the correct alternative.

Response-centered linear programs also were published in book format. One technique, placing the presentation portion of a frame on one page, the confirmation portion on the following page, the next presentation panel on the next page, and so forth, was workable but the tendency toward very brief frames meant that the space on a page was badly used and the printing costs therefore tended to be exorbitant. Alternatives, which came to be known as 'programmed texts,' had the frames arranged in four or five narrow bands per page. One relatively popular style had the student work down a page, covering succeeding frames with a piece of cardboard. Another had the student work through the book on the upper band of frames and then start again on the second band, and so forth, until he had completed all the frames.

Programmed instruction in book form eliminated any need to invest in even inexpensive devices and was particularly popular in applications where the programs were assigned as homework and had to be carried back and forth by students. Some of the appeal of learning from a device was missing when books were used, but this added motivation was minor compared with the enthusiasm students typically expressed as they saw the progress they were making contrasted with what would have been the case following conventional instruction. Not all programs were motivating, just as not all were accurate in their con-

tent or representative of good programming technique. Many, however, were at least as interestingly written, well illustrated and carefully planned as the traditional textbooks they replaced.

The cost of printing programs in book form was similar to the cost of printing textbooks. But, because they served a different purpose, the overall cost was considerably higher. Most textbooks are designed to be studied a few pages at a time and a single volume usually contains enough content for an entire school year. Programs, on the other hand, are meant to replace conventional instruction rather than supplement it. As a result, a fully programmed course may entail many thousands of frames and consist of several volumes. This can be an expensive addition to a school budget particularly when the program is designed to elicit written answers and only can be used once. Innovative approaches to textbook printing, which will be described in a later chapter, may be an answer, however. In the meanwhile, properly designed devices which permit the reuse of a program may be the most practical way of furnishing individualized instruction to students in areas of the world where improved education is most needed and can be least afforded.

Display Features of Teaching Machines

The design of any teaching machine involves four features. Display features are those concerned with what the student can see or, in some cases, hear. Most devices are designed to present only one frame, or a small unit of instruction, to the student at any one time. Typically, a frame is very brief, less than a page long for intrinsic programs and only a few sentences long for linear programs. Thus, the viewing surface need be only a few square inches in area; in fact, the majority of programs in book form are likely to allow only about five square inches per frame if just text is

presented, and perhaps eight to ten square inches per frame if many of the frames contain simple sketches or diagrams. Not all programs have the same requirements. For this reason, it is sometimes desirable for the viewing area to be adjustable. If it is not, there is a tendency for the device to determine the instructional characteristics of the program. Thus, a long but very appropriate and relevant example or diagram may be omitted because the planned means for displaying the program is incapable of presenting it.

The use of auxiliary material is a way of adapting a basic device to meet unusual instructional requirements. As part of the program, the student can be directed to some sort of adjacent display. This may be a reference chart, working model, series of illustrations, or even a motion picture or textbook. At the proper point in the program, the frame could direct the student to "view the film in the projector" or "watch for cell division to occur in the microscope." Whenever such directions appear, the student could do what he was told and then return to the program where he would receive further instruction regarding what he had just seen. One advantage to the use of auxiliary panels is that in most cases far fewer items of the auxiliary equipment are required than there are students. Because programs are self-paced, not all students proceed at the same rate. Thus, a particular display which may involve only two or three minutes of a student's time can be shared by all the students in a class.

Control of the sequence of presentation is another dimension which must be considered. Ideally, the student should be exposed only to one frame at a time. He should not be permitted to look ahead or skim back through previous steps. In particular, he should not be allowed to see the preceding few frames which may contain the responses the learner is supposed to recall,

either as part of the stimulus panel or as answers displayed in the confirmation panel. Many devices incorporate mechanisms to prevent opportunities to look at more than the one frame the learner is supposed to be working on. In most programmed texts, limiting what the student can see is accomplished by 'snaking' the pages. Frames are reproduced in bands with a stimulus panel, confirmation panel, and the next stimulus panel on successive pages. Thus, at any one time, the student may see the several frames that appear on any one page but they are at widely separated points in the program and presumably offer no uncontrolled assistance to the learner.

For many programmers, the student's opportunity to cheat by examining the confirmation panel before responding has been the primary reason for employing a teaching machine rather than a simple book. However, experience with programmed instruction has shown that it is the quality of the program, more than the characteristics of the learner, which determines whether cheating will occur. A properly prepared program provides the learner with the appropriate amount of assistance he needs to be correct at every step. Only when the program writer is under the misconception that the purpose of programmed instruction is to test rather than teach, and the frames are prepared as tricky questions rather than opportunities for guided practice, does cheating become an important consideration. In fact, with a good program, students often ignore the confirmation panels completely.

Response features are those which control what the student does as he learns. The responses called for in a properly prepared program are relevant to the terminal performance sought and they gradually increase in complexity or difficulty. Multiple-choice devices are far easier to design than those which require the student to construct his responses by writing out

a word or two, by composing an entire sentence, drawing a sketch or even using equipment such as a meter or calculator. Because recording responses overtly takes time and consumes materials, many attempts have been made to have students only 'think' their responses covertly. Most studies dealing with this question conclude that the importance of overt responding increases as the complexity of the responses increases. It seems that learners, unless required to compose their responses overtly, often fail to practice complete responses and tend to reply with a brief "Yes, I understand" when asked a difficult question which normally would require a response of several sentences. All programmers agree that overt responding is essential during the developmental stages of a program so that the answers given to each frame can be analyzed and the necessary revisions or corrections made.

Confirmation features are those concerned with how feedback or reward is supplied to the student following a response. Intrinsic programmers regard confirmation primarily as a source of information to the learner. Most linear programmers, on the other hand, regard confirmation as a reward which strengthens the probability of occurrence of the preceding response. This distinction is complicated, however, in that supposedly well written intrinsic programs very frequently inform the student in glowing terms that he answered correctly and linear programs almost invariably rely upon knowledge of the correct answer to reinforce the student following his response.

Regardless of which kind of program is used, it often is felt that automation would be desirable in assessing the correctness of the learner's responses. Particularly when a program is based on constructed responses, it is necessary to depend on the learner himself to compare his response with the correct answer. Very few suggestions have been made as to how

confirmation might be supplied more effectively during learning from a linear program, short of using a computer to assess the correctness of a response, except to make the comparison easier for the student.

User Features in Device Design

User features are meant to overcome the various problems which might influence a learner or be of concern to an administrator responsible for acquiring and maintaining the device. It might be reasonable to assume that machines designed for students would evidence some thoughtfulness with respect to user needs. But this is not always the case. There rarely is any systematic use-testing of a device which is at all comparable to the thorough tryouts of the instructional programs they contain. As a result, many devices were marketed which proved to be unsuccessful because they were difficult, and in some cases impossible, to use.

Perhaps the most significant design errors from the user's point of view are those characteristics of a machine which interfere with the instructional effectiveness of the material contained in it. It is not unusual, for example, to find that the edges of the content of a program reproduced on tape, paper, or film are not visible through the display opening. In many cases, the size of the display opening is so small that the instructional material must be condensed in size to the point where it is difficult to read. Devices which depend on magnification frequently use poor lenses. Devices using backscreen projection generally produce a 'hot spot' at the center of the screen; literally, the student sits staring into a projection lamp. When mirrors are used, printed material often shows up with 'ghosts.' Rarely do projection devices allow an adjustment in light intensity to compensate for variations in room illumination. The screen often is posi-

tioned in such a way as to catch reflections from window light or ceiling fixtures which is acutely annoying after the first few minutes.

Nothing is probably so frustrating to a learner as a teaching device which jams with all too consistent regularity. Paper tapes tear, sheets crumple, and sprocket holes on film become worn, destroying the copy of the program and causing considerable delay while the device is opened and the difficulty corrected. Just the loading of a device with a new lesson of material is often a major task requiring both skill and training. The overall size and shape of the device also presents problems. Many are too large to fit comfortably on a typical student desk and, while most school desks slant, this is rarely taken into account in the design of machines. Occasionally, they are so large as to require their own special space in the classroom. Other devices, small and light enough in weight to be relatively portable, are much too fragile to be carried around. As much as ten percent of the population may be left-handed, but only a small portion of all of the devices sold can be operated by either hand. Future instructional devices will have to be almost maintenance free, damage proof, and long wearing before they will be accepted by buyers who are familiar with the treatment the device can be expected to receive from school children.

Some time ago, an ingenious manufacturer of educational products distributed a small wooden paddle for advertising purposes. It was labeled "The Original Teaching Machine." While certainly humorous, the novelty was all too truthful to be ignored as a clever joke. The usual aversive control of student learning hardly needs improvement through the use of devices. Machines can contribute to the effectiveness and efficiency of the instructional process but emphasis in their design will have to be given to features which

clearly ease the learner's burden. The mechanization of education is not, in itself, a demonstration of the use of instructional technology despite the wishful belief of many indiscriminate purchasers that substantial investments in almost any sophisticated classroom equipment somehow will enhance instructional outcomes. Instrumentation which successfully automates even limited teaching functions, on the other hand, may be indispensable where competent teachers cannot be recruited in numbers to match existing needs. In the more distant future, it is quite probable that devices will replace teachers rather than substitute for them. This degree of automation will not come about, however, until devices are designed and manufactured which more closely approximate the advantages of a personal human tutor.

9

COMPUTERIZED INSTRUCTION

The concomitant emergence of electronic data processing equipment and interest in machines that could automate teaching functions perhaps enhanced the idea of using the two together. At any rate, the notion that computers might be used as extraordinarily flexible and capable teaching devices has been a continuing influence in automated instruction research. Ramo described possible uses of a computer both for teaching and school administration in 1957; Pask discussed computerized control of the learning process in 1958 and shortly afterwards proposed 'adaptive' devices that themselves might learn how to adapt to the idiosyncrasies of individual students; and Weimer described a classroom teaching system based on computer processing of student responses in 1958 (Ramo, 1957; Pask, 1958, 1960; Weimer, 1958). The Galanter book, published in 1959, included a chapter by Rath, Anderson and Brainerd (1959) which described preliminary trials of an arithmetic program using a computer as a teaching machine.

Computer Applications in Education

Despite the efforts embodied in numerous research studies, the development of new terminal equipment to ease the interface between the student and the workings of the computer, and the many cost savings as computer technology advanced, there is today no school district which has adopted computer aided instruction on a routine basis. Several school systems in the United States have experimented with computerized instruction and others are presently conducting feasibility projects. For example, Zinn (1967) lists 26 research centers where experiments with computer assisted instruction are in progress. However, any large-scale application of computers as primary sources of instruction seem well in the future. The interest shown in computers and their relevance to many plans for individualizing instruction, on the other hand, suggests that the concepts underlying computerized instruction may have a lasting influence on educational practices whether or not computers someday become familiar classroom equipment.

Computer aided instruction (CAI) is the general term used to describe applications involving continuous interaction between the student and the computer during learning. Computer managed instruction, the use of electronic data processing equipment to supervise the sequence of instructional units for individualized instruction, is a quite different concept and will be described in a later chapter. In computer aided instruction, the computer functions as a teaching machine. The student depends on it for the presentation of information, uses a computer terminal to record his responses and relies on the computer to evaluate the correctness of each response. Because of its vast and rapid data processing capacity, the computer can be arranged to take many actions beyond the capability

of a mechanical teaching device. It can, for example, rearrange instructional sequences in response to student errors, insert review material contingent on past performance, and even adapt the difficulty or pace of instruction to meet individual needs.

Computers as Instructional Devices

The earliest uses of computers as instructional devices included the 'SAKI' developed by Gordon Pask (1958) to teach the operation of a ten-key keyboard and the 'Talking Typewriter' devised by O. K. Moore (1964). The Pask machine, shown in Figure 9, contains no program in the usual sense. Instead, the operation of the presentation unit at the left is controlled by the

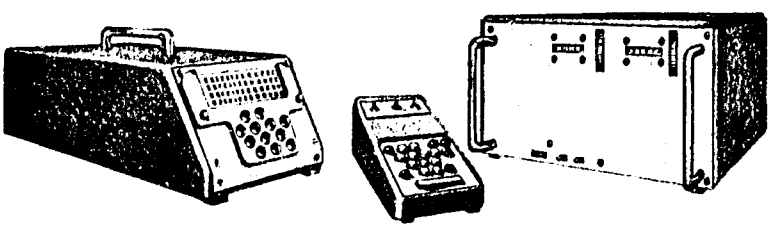

Figure 9. The Solartron Electronics "SAKI" instructional device designed by Pask.

electronic processer unit, shown at the right. The student learns to position his fingers from the array of lights at the lower section of the presentation unit, which are arranged in the same pattern as the keys on the response unit at the middle. After practicing depressing keys in the order they are presented by the sequence of lights in the array, the learner 'graduates' to the top portion of the display unit which presents an endless series of digits in random order for the student to practice. The basic task, of course, is learned easily; instruction is required mainly to help the learner gain speed and yet maintain accuracy. This is accomplished by presenting the stimulus digits at a rate

which depends on the student's accuracy. If the student is quite accurate, the rate of presentation gradually is increased until appropriate proficiency levels are attained. However, if errors are made, the rate of presentation is slowed to the point where the accuracy level is acceptable. If necessary, the device will revert to remedial practice using the lower display to correct persistent student errors.

Moore's machine, shown in Figure 10, consists of an electric typewriter keyboard and several integrated display mechanisms all coupled to a small computer.

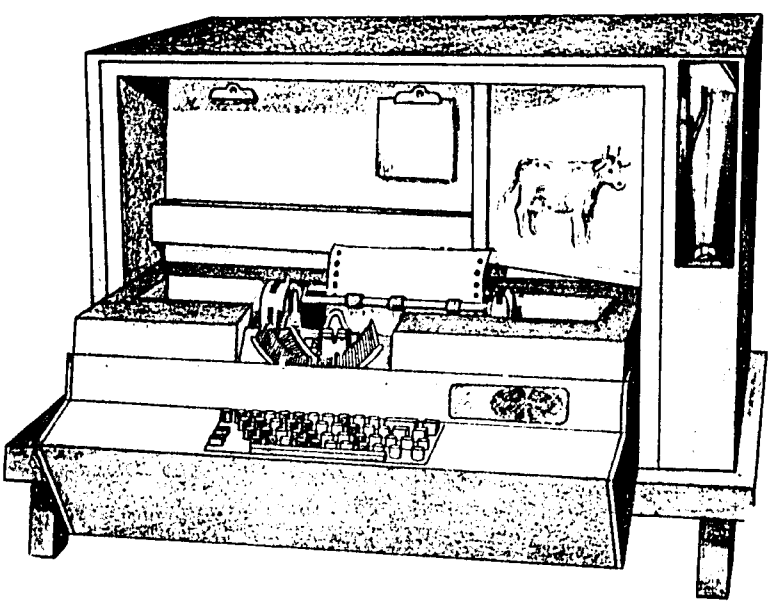

Figure 10. The McGraw-Edison "Talking Typewriter" developed by Moore.

This version of his design, manufactured by Edison Laboratory, is intended to teach verbal skills to preschool age children. As the child presses a key, the letter is typed so the child can see it and, at the same time, a recorded voice pronounces the sound. After a

period of experimentation, when the child randomly operates keys and gets used to the device, the mode of operation is changed. A letter is displayed to the child on the screen above the console and he must locate and press the corresponding key. All other keys are locked in place. As the child progresses, further modes are introduced so that after several months a child may be typing correctly spelled words and even sentences, either copying what he sees, answering questions posed by the computer or making up his own short stories using words that have been stored in his computer on the basis of the frequency of their appearance in the child's oral behavior.

The present device costs about 35,000 dollars, and it is not expected to be adopted on a wide scale. Rather, it is an experimental tool to investigate learning in young children. The achievements which can be realized with the 'Talking Typewriter' are quite astounding, particularly in teaching low I.Q. children to read and write in as little as a few months of part-time instruction. In addition, Moore reports that six-year-old children who have had experience in his laboratory write, edit and publish their own small newspaper in the first grade.

More conventional computer terminals — those resembling standard electric typewriters or teletype consoles — have been used on several occasions as teaching machines. Typically, the device prints out the stimulus material for the student to read and the learner responds by typing out his answer (for descriptions of some examples, see Coulson, 1962; Hickey, 1968). Although there is continuous interaction between the student and the computer, the instructional material in these very basic systems is presented in a predetermined sequence and there is no adaptive rearrangement of the material contingent on the student's performance.

As is true of any teaching aid, the cost of introducing complex equipment where none is required is unjustifiable. However, in many of these arrangements, the computer itself judges the accuracy of the student's response according to criteria stored in its memory. Thus, a computer is some instances can process alphabetic information to a degree impossible for a less sophisticated mechanical or electrical device. Several efforts are now underway, in fact, which are aimed at allowing a computer to judge the correctness of a student's response even if it contains misspellings or minor grammatical errors. Should any of these systems become practical, particularly those which are capable of evaluating handwritten or oral responses or answers which are syntactically original, the benefits of using a computer to gather and assess student responses may well outweigh its cost. On the other hand, there is no evidence to suggest that students are incapable of judging the correctness of their own replies by comparing them with a model, even when the spelling or wording is not precisely the same.

Drill Mode of Instruction

Truly adaptive teaching systems based on computer capabilities can be divided into several types (Atkinson, 1967; Suppes, 1967; Hickey, 1968; Stolurow, 1968). There is considerable overlap among types, and any one application may consist of several types all intermixed. Nevertheless, four types or modes can be used as convenient labels for describing the operation of any specific system. The 'drill' mode presents a functionally linear sequence of practice items. As each item is presented, the student must respond with an answer. If the answer is the correct one, the next problem in the series is presented. This may be a slightly more difficult problem of the same kind or be the first problem in a new series. If the answer was incorrect,

the next problem will be a simpler one and will resemble those which already were answered correctly earlier in the sequence. The problem responded to incorrectly will be presented again only after the student has had additional practice with easier problems of the same kind. The content of instruction most readily organized into a drill format include arithmetic, spelling, labeling in geography or physiology, second language vocabulary, and so forth. This kind of system can present problems at a given difficulty level in random order if desired, insert review sequences based on frequency of past errors, and use rate of responding as well as correctness as a measure of skill development.

An example of computerized drill is the Stanford Arithmetic Program first used at the Brentwood Elementary School in East Palo Alto, California (Suppes et al., 1968). The system has sixteen student stations to serve third through sixth graders. An abbreviated sample of a drill for fifth graders which, in its entirety, consisted of sixteen problems is shown in Figure 11. For simplicity, this figure shows the computer's output in roman characters and the student's responses in italics (adapted from Suppes et al., 1968, p. 29). An average drill was designed to last only four to six minutes to allow each student in a class to take one lesson each day.

Tutorial Mode of Instruction

The second type of adaptive instruction that can be presented by a computer employs a 'tutorial' mode of operation. Each lesson is divided into a main stream plus various branches or loops of instruction designed to supply more detailed and easier instruction on points covered quickly within the main stream. The computer automatically decides whether or not a learner has to proceed through a remedial sequence following an error. Each branch from the main sequence gen-

```
PLEASE TYPE YOUR NAME

MIKE JONES

          DRILL NUMBER 502021

(42 + 63) / 7 = (42 / 7 ) + (63 / 7 )

(48 - 38 = 38 - 48
WRONG

48 - 38 = 38 - 4
WRONG, ANSWER IS 28

48 - 38 = 38 - 28

76 - (26 - 10) = (76 - 26) + 10

4 X (7 + 13) = (4 X 7 ) + (4 X 13)

(90 / 10) / 3 = 90 / (10 X 3)

(72 / 9) / 4 = 72 / ( 9 X 4)

(54 + 18) / 6 = (54 / 6) + (18 / __)
TIME IS UP

(54 + 18) / 6 = (54 / 6) + (18 / 6 )

60 - (19 - 12) = (60 - 19) + 12

(63 / 7) + (56 / 7) = ( 63 + 7 ) / 7
WRONG

(63 / 7) + (56 / 7) = ( 63 + 56) / 7

       END OF DRILL NUMBER 502021


         NUMBER  PERCENT

CORRECT    13      81
WRONG       2      12
TIMEOUTS    1       6


CORRECT THIS CONCEPT - 81 PERCENT, CORRECT TO DATE - 59 PERCENT

GOODBYE MIKE.
```

Figure 11. Example of a computer assisted instruction drill.

erally is designed to reflect not only that an error has occurred, but the nature of the error as well. This diagnostically specific remediation is far easier to deal with in principle than it is in practice. Considerable trial-and-error is needed during the development of the corrective loops to insure that students will not find themselves in a perpetual cycle. The only solution in the case of a student who does have repeated difficulty with a certain type of problem usually is to give him the correct answer and tell him to proceed. This practice frequently is utilized to overcome uncommon learner difficulties but it negates the philosophy of computerized instruction which stresses the need for adaptive teaching because learners are unique.

The degree of adaptiveness in a tutorial-mode system depends on the number of branches or loops accompanying the teaching sequence and how these are prepared. If they are written in advance, as many are, it is likely that a number of the remedial steps will never be used. One of the axioms of instructional technology is that students rarely seem to have difficulty where difficulty is anticipated. On the other hand, if the need for remedial steps is determined empirically, it generally would be just as expedient to add the steps to the main stream or to alter it so that its teaching efficiency is improved. Because those students who are not experiencing difficulty will work through any additional steps very quickly, the time lost for these students will be quite small.

Perhaps the most widely cited application of computers in a tutorial mode is the PLATO project at the University of Illinois under the general direction of Bitzer (1962). The learner is given text to read which is displayed to him by a slide projector under the control of the computer. When he finishes, he is presented with one or more questions or problems which he must answer before he can proceed on to further text. Should

one of his answers be wrong or should he determine for himself that he needs more thorough instruction, he enters a 'help' sequence automatically or by pressing the appropriate control key. As necessary, the help sequences themselves can be supported by more elementary help sequences for use by students who are having serious difficulty.

A novel aspect of the system is that a learner can interrupt a help sequence at any time by pressing the 'aha!' key. This feature permits the college students who use the system to avoid more explanation than they really need. In the process of refining the PLATO system, Bitzer has made a number of technical contributions of possible future value to computer assisted instruction. One of these is a 'plasma screen' which is a substitute for a cathode ray tube display and requires no regeneration to maintain image quality. Another has been the development of methods for combining computer generated displays with other displays stored on slides; both displays can be projected on the same screen simultaneously under the control of the computer. Bitzer recently estimated that new equipment still in the design stage will permit the PLATO system to be expanded to over 4,000 stations associated with a single computer at a total cost of less than 25 cents per student hour (Hickey, 1968). This figure, which is amazingly low compared with most cost estimates for computer aided instruction, is still $7.50 per hour for a class of 30 students, or more per year than the average cost of a classroom teacher.

Dialogue Mode of Instruction

The third adaptive use of computers in instruction might be called a 'dialogue' mode. Systems using this principle are based on a dynamic rather than static computer output. A few models of these systems emphasizing traditional educational content have been

prepared (Hickey, 1968) but by far the most common use of this mode has been in teaching decision making through computerized games which simulate strategy problems in business administration, military maneuvers and personnel management (for an example, see the Carnegie Tech Management Game by Cohen et al., 1964). In an academic setting, the system might begin with a series of replies to hypothetical questions, each having a probabilistic rather than a correct answer. After obtaining preliminary data which defined the scope of the problem, the student then could proceed to indicate what questions he would ask and what decisions he would make to arrive at some final determination. The application of such systems to the teaching of medical diagnosis and chemical analysis is now underway. The important characteristic of instruction in this computer mode is that it is designed to teach problem-solving strategies and not the answers to particular questions.

Inquiry Mode of Instruction

The final, and perhaps most imaginative, use of computers in instruction is in the 'inquiry' mode. These applications hypothetically would permit every student to discover the subject matter for himself by giving him easy access to an almost unlimited store of readily available information. With the help of a computer, a student could follow his own interests and paths of inquiry into such subjects as history or geography. No curriculum necessarily would be involved and each student could develop a capability in whatever field or fields he chose, to a depth limited only by the depth of knowledge stored in the computer. Actually, several kinds of inquiry programs already exist for a variety of purposes including the identification of likely reference sources based on the use of key-word library indexing systems and the electronic generation of visual

displays based on variations in mathematical formulae supplied to the computer. Practical systems of this kind, however, will depend on computer logics which are capable of interpreting ordinary language syntactically regardless of word order, grammar or the use of synonyms.

Status of Computer Aided Instruction

Even in its simplest form, when the problems of instructional design are minimized, computer aided instruction has not been widely used. The Stanford-Brentwood system briefly described above, for example, has been expanded to some half dozen other school districts in various parts of the country on an experimental basis. But it has been dropped from the Brentwood Elementary School where it first began, reportedly because of its cost, following the end of a series of financial grants that permitted the installation of the system in the first place. At the time of the latest available survey, terminals for computer based teaching were available as resources to 3.2 percent of all classroom teachers in the United States, or about one in every thirty. In many instances, access consists of a single terminal located in a school for use by all the students and the twenty or thirty teachers who taught at that school. Less than half of the teachers reporting the availability of a terminal also reported making any instructional use of the equipment (NEA Research Bulletin, 1967a).

Cost certainly is a major deterrent to the routine acceptance of computer aided instruction. Present systems, such as those being manufactured by IBM ("System 1500"), RCA ("Instructional 70-71") and Technomics ("System 6700"), have a minimum cost in the thousands of dollars per fully equipped student station plus the cost of central processing equipment, communication lines and the necessary 'software' or in-

structions controlling the operation of the computer. An experimental system recently installed in Philadelphia, Pennsylvania, contained the following hardware:

a. a computer central processer unit,
b. disk memory storage for one million characters,
c. the computer control unit to permit time-shared access from several terminals, and
d. eight terminals each with a 64-character keyboard, a cathode ray tube display capable of presenting pre-taped TV segments and a 'light pen' which permits the student to write, draw or point to something on the cathode ray tube display and have this response detected by the computer.

The cost of each 'cluster' of eight student consoles and associated central computer equipment is estimated at about 800,000 dollars; the Philadelphia school district has calculated that each installation will provide student instruction at a cost of about ten dollars per student hour, assuming full utilization of all terminals during normal school hours over a ten year period (Padden, 1969).

An even more important concern is the practical desirability of computers as teaching devices at this stage of their development. Any competent educator would be justly disappointed on seeing expensive equipment used to present a dozen or so drill problems to a student, as if drill activity in any way represented the core of educational practices. Even where more sophisticated modes than drill are used, the fundamental logic of most computer assisted instruction is questionable. Teaching sequences and strategies which are adaptive to each learner inherently assume that learners differ sufficiently one from another to suggest that most learners would profit from individually tailored steps. Except with respect to rate of learning, however, these differences never have been demonstrated to be

other than minor. Thus, instruction is likely to progress with reasonable efficiency even if every learner proceeds through the same steps and finds some of them unnecessary. As long as the probable advantages are likely to be small and the high cost of terminals and central processing equipment is likely to remain at near present levels, it is doubtful that computers will have much success as sources of instruction except as experimental devices with which to study the learning process. As discoveries are made on how computers might improve the learning process, it is likely that less expensive and more practical ways will be found for implementing these findings in ordinary classrooms.

Controlling Learning with Computers

Almost all of the emphasis in research on computer aided instruction has been focused on adaptive learning sequences. This is unfortunate in that the detailed control which can be imposed by a computer may be more productively applied to other aspects of the instructional environment. A child probably learns the intended instructional content during only a small fraction of each school day. Proportionately, very few of his responses are under the full control of instructional materials. Part of the problem is temporal. Half or more of a student's time may be spent in educationally irrelevant activity as he looks about the room, listens to other children recite or responds to his own inner thoughts. Ideally, every moment of classroom time should be productive and accountably contribute to learning progress. Part of the problem also is spatial. In the laboratory, learned responses to very minute changes in stimulus conditions are very difficult to produce particularly in a distracting environment. Similarly, a page of text may occupy only a small percentage of a normal visual field and considerable effort may be required to sort out the teacher's voice from all

the noises which usually are present in a classroom. At any rate, the degree of control normally exercised over student attention and learning in a traditional school environment is quite small.

One of the more promising uses of computers, then, might be to keep track of and manipulate the appearance of stimuli in the learner's environment. The use of a computer to identify or even correct for lapses in attention that produce errors is not particularly different from what can be done using a simple instructional device or programmed book. It is possible, on the other hand, that computers may have the processing capability to deliberately manipulate the learner's environment and reduce the likelihood that irrelevant behaviors will occur in instructional situations.

Rate of performance may be another variable which can be controlled more effectively by a computer than by other means. Instructional programmers generally rely upon each individual student to determine a rate of learning that is best suited to his own needs. This practice usually is effective; at least it represents a substantial improvement over a pace determined by the teacher and applied indiscriminately to the entire group. At least one study, however, has shown that learners do not always select a pace which is optimal for their own needs (Gropper & Kress, 1965). In this research, a number of high-ability students were identified who tended to work on programs at a pace that was too deliberate for efficient learning and a number of low-ability students were found who worked at a pace that was too rapid for effective learning. Some of these students, at least, could be aided by externally imposed pacing that was tailored to their own needs, slowing them down when they made errors and speeding them up so long as their errors did not increase. This was a feature of Pask's computerized

teaching device and is a teaching method which easily could be applied to more typical academic content.

Computers and Automated Teaching

The cost of terminals for student use is apt to be reduced more rapidly by efforts to determine which features of computer aided instruction are beneficial and which can be deleted than by technological developments in manufacturing and production. Emphasis on gadgetry has been the focus of much of the work on automated instruction. What the computer is asked to do may be of no value to learning. Bright (Gerard, 1967) points out that:

> *. . . what we are talking about is using the computer as a substitute for a tutor, and I doubt that anybody in this room knows how to tutor effectively. That is an educational function that just never has been done, so one of the first things that you want to do is decide how you go about setting up an effective individualized tutoring facility* [p. 54].

Bright adds that this research work need not entail a computer at all:

> *We have simulated the computer, which is much cheaper than putting one in because you can change it very easily. What we have done is to write course material in specific words to be presented by a computer and have a person present the material the same way. He will hold up the picture that the computer would show, he will deliver the same verbal message the computer has been programmed to deliver. He will observe the student's reaction, will make the same logical decisions as the computer would* [p. 54].

In other words, it is not necessary to have a computer to simulate computer assisted instruction and the use

of an actual computer may be quite undesirable to the extent that the particular model used may happen to be incapable of replicating some simple but essential teaching function. It sometimes takes considerable time and money to become convinced that it has been the shortage of knowledge as to how the instructional process can be enhanced and not the absence of radical designs for equipment which has limited real growth in educational technology.

10

PRINTED MATERIALS

In contrast to the often costly teaching machine, the printed textbook is perhaps the least expensive instructional tool ever devised. It also has been suggested that the book led to the most important changes that ever occurred in education. Three of these changes stand out. First, a book can be used to store instruction that otherwise would have to be provided firsthand; the words of a master teacher, when recorded in a book, can be distributed to learners everywhere for their use at any time. Second, the availability of the printed book for the first time provided purpose to literacy and, as a result, learning to read and write became a cornerstone of mass education. Third, the textbook author, unlike the classroom teacher, could be held accountable for his errors; accusations of heresy no longer depended on the testimony of a pupil and the quality of what had been the private art of teaching was opened to public scrutiny.

Textbooks as Educational Resources

Despite the enormous potential of books, however, classroom practices actually changed very little. Instead of books replacing lectures as the primary source of instruction, pupils were expected to master two sometimes conflicting presentations instead of one. The misuse of textbooks in education is all too common. The undertrained, insecure teacher reads from the text, destroying the one opportunity pupils might have to learn at their own pace. The more competent teacher often does just the opposite, pointing out defects in the textbook's coverage, resequencing topics and inserting new explanations with complete disregard for the author's expertness in both content and teaching.

The expert who sets out to author a textbook is faced with generally unfamiliar responsibilities. Few people write with ease and the author of a textbook, who might have been an enthusiastic and stimulating teacher, tends to write down his thoughts with deliberate caution, formality and concern over shades of meaning. Thoroughness often takes precedence over clarity and exuberance usually is replaced by qualifications and ambiguity. The teacher who is open to argument from his students somehow as an author is reluctant to expose himself to the criticism of his colleagues.

The difficulty seems to be in the role which education has forced upon the textbook. Just as the teacher, the textbook must be the source both of the information to be taught and the source of instruction on it. Thus, in its role as a reference a textbook is expected to be thorough, concise and authoritative but as teaching material it must be explanatory, redundant and permit some form of practice by the learner. Most authors, understandably more sensitive to criticism by their peers than their ultimate pupils, concentrate on the in-

formation aspects of their text far more than on its instructional components. As a result, most texts not only are difficult to learn from but contain far more information than even the most optimistic author might expect his students to master.

Several alternatives to the standard textbook have been devised specifically to provide instruction. One of the most familiar of these is the 'teach-yourself' book. Almost every literate person owns at least one such book and yet generally has finished none of them. The motivation to learn is evident, but the technique must be regarded largely as a failure. A second alternative has been the development of 'workbooks' which usually consist of practice exercises coordinated with the information presented by a standard textbook. The third alternative is the 'programmed text' which presents the same kind of instruction presented by a teaching machine, only with somewhat less control over the learner's behavior.

The Cost of Textbooks

The standard textbook, however, remains the most flexible and easily provided teaching tool yet devised. In the hands of a learner, a textbook can provide highly individualized instruction at extremely low cost. Just how low the cost can be is evident from an examination of how the costs of a typical textbook are distributed. The most frequently seen type of book in the United States has a page size of approximately 5½" by 8½" with a printed area of between 28 and 36 square inches (180 to 230 square centimeters). It is 300 to 400 pages long and has a retail sales price of approximately $6.50. This amount is divided as follows (from Cheney, 1960):

	$ amount	% of retail price
retail price	6.50	100%
less retailer's markup	2.275	35%
wholesaler's price	4.225	65%
less wholesaler's markup	.325	5%
publisher's price	3.90	60%

The publisher's cost can be broken down further (Cheney, 1960):

	$ amount	% of retail price
publisher's price	3.90	60%
selling costs	.81	12%
internal costs	1.03	16%
author royalties	.67	10%
manufacturing costs	1.39	21%

And, the manufacturing costs can be divided again (Cheney, 1960):

	$ amount	% of retail price
manufacturing costs	1.39	21.4%
cloth binding	.63	9.7%
printing	.47	7.2%
paper	.25	3.8%
composition	.04	.6%

These figures apply to books printed in quantities of approximately 100,000. The effects of quantity greatly influence composition costs, while the costs of printing, binding and paper are relatively constant regardless of the number of copies reproduced. The effects on total manufacturing cost attributable to the number of copies produced can be seen from the following figure which assumes a cost of composition and plate making of $10.00 per page (Cheney, 1960).

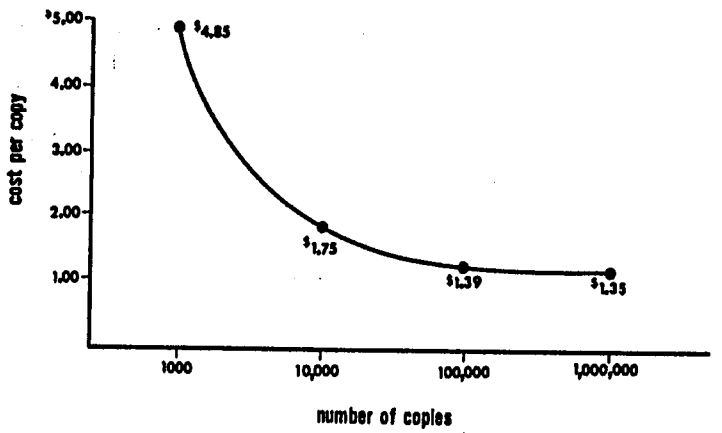

Figure 12. Relationship between quantity and manufacturing cost of textbooks.

Quantity printing is not the only way in which the cost of books could be reduced. For example, the use of a paper binding instead of cloth binding would result in a reduction of about $.25 in the manufacturing cost of each copy. Still further reductions can be achieved by using alternate production techniques. The average book is designed for durability. The paper will remain white and the sewn binding will securely hold the pages in place for many years. Some books, however, are designed largely for one-time use. The retail selling price of inexpensive paperback volumes, generally known by the trade name *Pocket-Books*, is about one-tenth that of a standard book of the same length, about $.65. Although the size of each page is considerably smaller, a proportionately larger share of the page area is used and the type size is not as large, allowing about as much content per page for a paperback as appears in a traditional book. The breakdown of paperback costs seem to be a trade secret. However, the manufacturing costs are probably under $.20 in lots of 100,000 copies.

Still other alternatives exist which can reduce the cost of texts still further. Newspapers, with their high manufacturing volume, toleration for typographical errors and lack of binding are even less expensive to produce than paperbacks. A typical metropolitan daily in the United States has a printing area of about 500 square inches, twenty to twenty-five times that of a typical paperback. To print the equivalent of a 350 page book would require only 15 or 16 newspaper pages. Newspapers with circulations of 100,000 or so spend approximately $.16 per copy to produce an edition of 60 pages. At this volume, the unbound equivalent of a full length book printed in newspaper style could be manufactured for only $.04 per copy.

Quality and Quantity Considerations

Because the cost of manufacturing textbooks tends to be more uniform throughout the world than teacher salaries, the developing countries find it particularly difficult to afford texts for student use, yet, selecting the kind of textbooks best suited for a certain region and a particular application is a decision which cannot be based on price alone. Even if all printing costs were minimized, some distribution expense would be involved in putting the texts in the hands of the students. Cloth covered books with sewn bindings and quality paper usually can be expected to last through several uses while newspaper style texts probably could be used only once even with reasonable care. However, in climates where humidity, mildew and insects are important determinants of the life of a book, it is not likely that the typical clothbound book will last very long in any case. The intended use of the book also must be considered; secondary school students can be expected to take better care of books than primary pupils and a book kept at school will last longer than one which a student takes home every day. Finally,

expecting several years of use from a text in rapidly changing fields such as physics or political geography is likely to be overoptimistic.

Books to be provided to every student at the primary level are required in large quantities. For these applications, the least expensive book possible is probably the most economical. The necessary text could be reproduced in newspaper format, with the pages reduced to book size and held together with staples if desired, and packaged in opaque plastic to retard paper deterioration due to humidity and sunlight. Distributing only sections of the book at a time would reduce the consequences of a child accidentally losing a book or allowing it to be damaged. On the other hand, books that are not required in large numbers and which easily might be shared by several students should be manufactured to be as durable as possible.

Microforms as Textbook Substitutes

Still another alternative to the standard textbook is the use of 'microforms,' the general name for microfilm and other types of microtransparencies. Several types of microforms currently are being manufactured (Hawken, 1966). Probably the most conventionally used is roll microfilm furnished on spools generally 100 feet long of either 16mm, 35mm or 70mm stock. The original document is recorded on film approximately one twentieth of its original size (one four hundredth of its original area). Copies of the film then are prepared which can be viewed using a special projector. The copies may be positives, with black letters on a clear background, or negatives, with clear letters on a black background. Positives seem to be slightly easier to use, particularly by beginners or when illustrations are included in the text, but negatives are preferred by most users because they decrease the glare when illuminated film viewers are used, and therefore can be

used for longer periods without eye strain. Greater use could be made of positive transparencies if colored filters were inserted to reduce the contrast on the viewing surface but this would require an increase in the brightness of illumination. Filters which polarize the light also might be of value if positive transparencies were desired.

At a one-to-twenty reduction, roll microfilm can store up to 2000 or so pages on one hundred feet of 16mm film, 4000 pages on one hundred feet of 35mm film, or 8000 pages on one hundred feet of 70mm film. Rolls of film are difficult to handle, however, and generally permit only one person to use the film at one time. This has led to the increasing popularity of microfisches which are small sheets of film, most often about 4 by 6 inches. They contain images of printed pages which are reduced in about the same proportion as for microfilm, and similarly are available as positives or negatives. Up to 72 pages normally can be reproduced on a 4 by 6 inch microfische.

Microprints are positive opaque copies of microfisches reproduced at the same one-to-twenty reduction on photosensitive paper. A magnifying reader also is required except that the viewer is designed as an opaque projector which bounces light off of the microprint and on to a viewing screen. Some microprints also are being manufactured by printing text at a reduced size using high quality, photographically prepared printing plates. A still newer technique has been the development of the 'ultramicrofische' (Educational Technology, 1969) which contains images at nearly one two hundredth of their original size (one 40,000th of original area). A 2 by 2 inch square of film can contain roughly 1550 pages of text, permitting entire libraries to be kept in a single desk drawer. Special qualities of film are required which are considerably more expensive per square inch than the film

used for microfische. Still further in the future is the 'holographic' microfische based on new photographic techniques which employ lasers. The potential storage capacity of this medium could turn out to be as vast as to permit the recording of one million pages in the equivalent of a one inch cube.

All types of microtransparencies and microprints require some sort of viewer or reader. There are three designs which encompass most models. The first is a backscreen projector which focuses light through a transparency or off of an opaque surface, magnifies the image usually to a slightly larger size than the original to compensate for slight losses in image resolution, and projects the image on to the back of a translucent screen so that it can be viewed from the front. Backscreen projectors with their small screen sizes require only fairly low levels of illumination to permit comfortable viewing even in a fully lit room. The viewing distance is limited by the screen size, however, and the viewing position usually is restricted to a narrowed angle so that someone located off to one side of the screen sees little contrast between light and dark portions of the image.

A frontscreen projector more evenly distributes the light over the viewing surface and therefore permits a much wider viewing angle. These viewers, similar to standard slide or opaque projectors, can produce fairly large image sizes but require more intense light sources and rarely permit comfortable viewing except in a darkened room. Microscopic viewers permit the image to be seen by looking through a lens, as is the case with a true microscope. These devices require relatively little illumination for effective viewing but produce 'virtual' rather than 'real' optical images. The problem with these images is that they seem to float in space after a few seconds of viewing, which becomes critical when the image is text that must be read line by line.

For this reason, such viewers have not been very popular even though they are far less expensive to produce than either backscreen or frontscreen projectors. On the other hand, the optical system required is considerably less elaborate and, for modest magnification requirements such as the 20-power needed for microfilms, microfisches or microprints, ordinary daylight or room illumination collected by a focusing surface can be used, eliminating the need for internal lamps and sources of electricity.

Viewers for ultramicrofisches are considerably more expensive than those requiring less magnification to make the image readable. The optics are much more complex, the mechanism needed to hold the film is more complicated, and the supporting structure must be precisely rigid to maintain alignment. Furthermore, a considerably more intense light source is required in that the illumination needed is directly proportionate to the square of the magnification. Ultramicrofische images which are recorded at 1/40,000 of their projected area require one hundred times the light of a microfische image recorded at 1/400 of its original area.

The cost of using microtransparencies or prints is based both on the cost of each copy and the cost of a backscreen viewer to permit the copy to be read. Viewers can cost between $150 and $1000. Copies of a 350 page book reproduced for viewing would cost between $.25 and $1.00 each. These costs are higher per copy than for comparable quantities of printed texts in paperback or newsprint format, but lower than for clothbound or paperbound books. Particularly because of the need for a viewer, it is not likely that the cost of microcopies ever will serve as effective substitutes for books printed in large quantities. However, microcopies do have promise with respect to providing libraries and reference works to schools inexpensively. Also, some films now are being manufactured which

are nearly unaffected by climatic heat and humidity so that copies may well last substantially longer than books printed on paper.

Textbooks as Instructional Devices

The very low cost of texts permits their use in individualized instruction, but whether texts ever will be able to insure learning will depend on changes in how they are written. Earlier, it was suggested that because books expose their authors to criticism from their peers, texts more often are prepared as repositories of information than as teaching instruments. As a general rule, all textbooks tend to be too difficult to read, contain too little redundancy and incorporate too many details to teach effectively. They are reference works containing passages which must be read over and over again as a student studies. This is far from an efficient means of providing learning assistance; if the student fails to learn the first time through, it is likely he would benefit more from better prepared materials than by repeating what he already has read once. It probably is impossible to write text that is too simple. Even the very bright student, who well may be challenged by the content of a passage, does not have to be supplied with difficult reading to avoid boredom. He simply can proceed faster.

How could texts be improved? First of all, there is very little reason why texts for school use must be book length. Distributing only sections at a time would make durable bindings less necessary, exposure to loss or damage less likely, and permit only a few copies to serve the needs of an entire class if all students did not require the same sections at the same time. This approach has been pioneered, among others, by Science Research Associates and by Educational Developmental Laboratories, which both distribute texts in pamphlet form to teach reading, science and other sub-

jects. All the necessary materials for an entire class are contained in a 'kit,' or box, which includes the instructional texts for the students, a teacher's handbook, sheets to record student progress, and often audio tapes, filmstrips, visual aids or other supplementary materials. As part of an integrated system of individualized instruction, single-topic pamphlets provide the flexibility needed to permit each student to pursue his own interests and not be burdened with information that was too difficult considering his abilities or too familiar in light of his previous learning.

Another potential kind of improvement is in the legibility of the type used. Both the size of the printed letters and their design can have pronounced effects on reading speed and comprehension. Large numbers of studies seem to suggest that the shape of the letters may be more important, within limits, than the size of the letters (see Tinker, 1963). Lower case letters in particular seem to be designed without special effort to maximize the features which distinguish one letter from another. The use of color and illustrations actually may distract the reader and add difficulty to learning. Pictures frequently are used to impress the viewer but serve no particular instructional purpose. The format of most books also could be given greater attention. The size and shape of books seem more bound by tradition than by research on what format may be most convenient for the user.

The readability of most texts is another problem. Surprisingly little attention has been given to rapid reading in the schools. In fact, the highly compacted and arduously read information in most school books possibly trains students to read more slowly than they should and with less enjoyment. A literate adult normally should be able to read simple prose at a rate of between 200 and 400 words per minute or about 60 pages an hour. It theoretically is possible to be ex-

posed to considerable amounts of information this way and most adults acquire a surprising amount of knowledge each day from the newspapers, magazines and novels they may happen to read. The need for education certainly does not diminish once a student has left school and has entered the work force. However, the kinds of publications readily available to him in a convenient, readable form generally exclude those having information of lasting value. It is surprising how many adults almost effortlessly read and retain sports information or quickly grasp the details and significance of a lurid story but cannot or will not read what is meant to be instructional material after they leave school.

Improving Instruction from Textbooks

Improving the quality of textbooks is not simple. Programming the content of all the texts that might be needed for a comprehensive curriculum does not seem feasible at the present time considering the probable cost. On the other hand, investments of this kind will have to be made sooner or later and the technique even now could be applied advantageously, particularly for difficult topics or those beyond the competence of the average classroom teacher. Even without programming, much could be done to improve the instructional value of the typical textbook. Tryouts of textbooks before publication are becoming more commonplace but the procedure usually used is to collect data solely from the classroom teachers who do no more than comment on coverage, sequence and student receptivity of the text. These global observations do not provide the explicit and detailed information needed to make empirically-based revisions.

Still another way in which texts might be improved has been suggested by Rothkopf (1965). His studies of what he calls 'mathemagenic responses,' the be-

havior of the learner that results in learning, have suggested the importance of periodic tests while reading text material. Frequent testing seems to improve the learner's attention to what is being read and thereby enhances retention. The way in which key sentences are constructed also seems important in that passages prepared in such a way as to make it possible to predict questions that will appear on a later mastery test are more effective than passages which do not have this characteristic. The frequency, timing and construction of review statements also seems to be critical. One important feature appears to be the desirability of controlling which words the learner articulates to himself as he reads. Not all learners are capable of determining what is important in a passage and not all authors provide much help to the learner as to what must be practiced. Rothkopf has discovered that replacing words with blanks can provide the necessary control over the learner's 'mathemagenic' behavior and thus increase the amount he will learn. His approach may well represent a compromise between conventional texts and programmed materials.

Textbooks, reference and professional books now account for over sixty percent of the value of all books sold annually in the United States, and have a sales volume of roughly one billion dollars per year (Steckler, 1967). A market this large is sufficient to support far more research on the instructional qualities of textbooks than now occurs. The market also is vast enough to demand greater sophistication than usually is shown in the way texts are evaluated for purchase. The inclusion of questions at the end of each chapter, or suggestions for projects to be completed out of class, or detailed diagrams illustrating some point or other does not automatically convert a book into an effective instructional resource. Some children easily can learn from reading printed text and still others

can profit from text if they are willing to invest sufficient effort and diligence. The typical textbook, however, fails to provide the control over learning which is necessary to permit all students to fully master the content being presented to them. There is no more reason why a textbook should resemble a technical treatise than there is for a tutor to resemble a lecturer. The purpose of a textbook is to teach and not to store information. Sooner or later texts will assume characteristics which will permit them to serve an independent educational function and realize their potential as an inexpensive and powerful instructional tool.

11

AUDIOVISUAL AIDS

Textbooks are not the only traditional teaching resource which might be applied to individualized instruction. Audiovisual aids generally are considered materials for intact class groups, but there is no reason why individual students could not profit from them as well. The range of existing audiovisual devices and materials is broad enough to include many ways of presenting information that cannot be replicated easily by other means. On the other hand, so many types of media conventionally are grouped together as audiovisual aids that generalities are difficult to establish.

Perhaps the most important distinction is the one between classroom media, such as projected visuals or audio recordings, and broadcast media, such as instructional television or radio. From the point of view of the learner, the essential difference is that classroom media usually are under local control and broadcast media generally are not. That is, the teacher or pupil may decide when to listen to a recording or how long to look at a slide but, once scheduled, the presen-

tation of instruction over broadcast media is apt to be rigidly paced. In this sense, classroom media which could be supplied for the use of students on an individual basis may have more promise than those limited by economic considerations to very large audiences.

Classroom Visual Media

Any book on audiovisual instruction is likely to list a number of different kinds of classroom media (for example, see Kemp, 1963; Wittich & Schuller, 1967). For convenience, these can be divided into still visuals, motion visuals, audio recordings and manipulanda. Still visuals include charts, maps, displays, chalkboard drawings and various materials designed for use with a slide, filmstrip, overhead or opaque projector. Each type of presentation has its unique advantages and limitations. Slides and filmstrips are inexpensive, for example, but require a projector. Charts and similar reproductions do not depend on the availability of electricity but are more expensive to produce. Overhead visuals can be prepared locally with a minimum of equipment and require only a short projection distance so that the teacher can operate the device from the front of the room.

Much of the expense of still visuals, and many of their features, reflect the need for all students in a class to view them simultaneously during periods of conventional instruction. Charts must be large enough to read from across the room and projectors must provide a bright enough image for details to be seen without effort. Far less expensive reproductions and equipment are required when only one child is expected to view the picture at any one time. For instance, novelty devices which permit viewing a single frame of inexpensive 16mm film at a time can be purchased at many souvenir stands for less than a dollar. They use incident light, require no electricity and could, with proper

care in their production, provide an effective image for individual viewing. A few devices of this kind could serve the needs of all the students in a class far less expensively than colored illustrations in their textbooks. Individualized visuals also can be used to permit the depth effects of stereo viewing.

Motion picture equipment adaptable for individual use is becoming increasingly common. A number of cartridge loaded, 8mm projectors have reached the market, such as the one produced by Technicolor, Inc., at prices under 70 dollars. Many of these are designed specifically for 'single-concept' films lasting five or six minutes. Aside from their suitability as complements to programmed or textbook-based individualized instruction, these brief films have a format which is likely to increase the popularity of motion pictures in education because they can be selected to match the content and sequence of instruction without forcing the students to view unnecessary footage. Single-concept films also can be viewed more than once if necessary. Whether or not motion is a necessary feature of visual media, except when the motion itself is what is to be learned, is questionable. The need for color also is questionable when what is being shown has been artificially colored, such as a graph, or needs no color to help the student single out or identify certain components of the picture. On the other hand, motion and color both seem to enhance motivation at a reasonably small cost.

The addition of sound to visuals — either as recordings coupled to filmstrips so that the commentary is synchronized with the picture or optical or magnetic sound tracks on motion picture film — can enhance their communication value and, perhaps, their instructional value as well. An audio capability substantially increases the cost of the equipment needed to project visuals and, for still pictures, almost de-

stroys any opportunity for self-pacing. However, sound tracks which are prepared in advance can be tested along with the visuals and automate a teaching function which otherwise might have to be the responsibility of the classroom teacher. Then too, if equipment with an audio capability is required for any filmstrips or motion films, it already will be available in the classroom and the added cost of preparing all materials with sound accompaniment will not be very large.

Audio Media and Manipulanda

Audio materials, including both disk and tape recordings, are not used as frequently as visuals. With few exceptions, all audio materials automatically and rigidly pace the presentation for the student; several devices are designed so the presentation can be halted temporarily but it is difficult for a student to locate previously presented information he may wish to review. Language laboratories represent a special application of audio materials. The recordings prepared for language study typically are designed for individual use and self-paced learning. Even with these advantages, however, automated language instruction has not uniformly proven successful, possibly because more attention frequently is given to the equipment than to the instructional excellence of the teaching materials.

Instructional manipulanda, or physical objects designed to be handled by students for educational purposes frequently are ignored by educators who are familiar only with verbal-based academic instruction. Yet, materials which children can learn from by touching and handling often have proven successful. Perhaps the most comprehensive effort to devise materials designed specifically so that children would profit from their concrete experiences with them was the work of

an Italian, Maria Montessori, shortly after the beginning of this century. According to Saettler (1968):

> *Montessori's genius lay in her ability to anticipate what a learner was attempting to do in his informational interaction with his environment and then to develop for him a plan providing relevant experiences. . . . Each learner selected from a central room those materials he wished to use. . . . Whenever possible, the instructional materials used by the children were self-corrective, so that learners could discover their own mistakes and become progressively more independent of the teacher* [*pp. 60-61*].

Montessori's materials included objects such as a series of blocks which each would fit only in one of a corresponding series of holes, and devices to teach buttoning and other skills a child needed to dress himself.

Another very simple but useful set of materials, one which allows students to learn mathematic principles for themselves, are the proportionately sized blocks or 'rods' developed by Georges Cuisenaire, a Belgian, in the 1930's. Each length of block represents a separate integer and each length is colored differently. Thus a yellow, or 'five,' block easily is seen to be equal to one three-unit green block plus one two-unit red block, to one four-unit purple block plus one-unit white block or to five one-unit white blocks. The blocks can be used to teach principles of algebra and the mathematics of functions as well as arithmetic. Montessori schools, which emphasize the use of Montessori materials, and manufacturers of Cuisenaire rods now exist in many countries including the United States. Those interested in educational applications of materials the children themselves can manipulate and learn from would do well to review the work of Mon-

tessori (see Standing, 1968; Montessori, 1964) and Cuisenaire (see Cuisenaire & Gattegno, 1960; Davidson, 1968).

Science and Vocation Equipment

Science laboratories and vocational training equipment are other forms of manipulanda. Rarely, however, does this kind of equipment find its way into most schools. One problem seems to be that those who teach science and vocational courses are unable to devise inexpensive equipment which is capable of simulating the effects of realistic experience without costly materials and devices. Yet, the number of useful and instructive experiments and projects which can be conducted using indigenous materials and improvised apparatus is very large. A compilation of projects prepared by UNESCO gives detailed instructions on 700 science experiments concerned with plants, animals, earth materials, astronomy, physics and physiology specifically selected as feasible even for schools in extremely impoverished settings (UNESCO, 1962).

An even more encompassing effort is underway in English-speaking Africa where the Educational Development Center is attempting to improve science instruction in the primary schools (Aldrich, 1969). Guides have been prepared by teams of science and educational experts to assist the classroom teachers plan and conduct science activities in which students, through the 'discovery method,' learn to draw their own conclusions from observations and experiments. A feature of the guides is that they give the teacher detailed directions for making useful but inexpensive laboratory equipment using locally collected components. For example, a microscope is described which uses the lens from a discarded penlite bulb and can be constructed by students with less than ten cents worth of materials.

Vocational training rarely requires the elaborate equipment that often is felt necessary. Technical training in industrial and military settings has relied upon the use of simulators for some time and with considerable success (see Biel, 1962; Gagné, 1962b). Simulators can be very crude and still provide effective instruction so long as the objectives of instruction have been carefully determined and the simulator designed to provide the essential practice. Generally, this means that the student be given experience in operating the controls, levers or knobs he will manipulate, and that the consequences of his actions are revealed to him. A power plant is not required to teach someone how to be a power plant operator. All that is needed are the displays he ordinarily would see, which can be controlled artificially and even consist of no more than projected slides, and levers and switches to operate.

Simulators not only can be much less expensive than real equipment, but they can be far better instructional devices because the sequence of events can be more easily controlled. On-the-job instruction also can be a desirable substitute for classroom practice. Instructors, if necessary, can accompany students to a construction site to supervise their use of heavy equipment at considerably less expense than purchasing the same equipment specifically for educational use and having the same instructor supervise practice by the same students in a school yard.

Characteristics of Broadcast Media

Broadcast media include both television and radio. When used for group instruction, film and television can be regarded as identical (Lumsdaine & May, 1965) and so can recordings and radio. Perhaps the greatest advantage of broadcast media is that very large numbers of students can be served at a very small cost — often less than a few cents per student hour. As noted

in an earlier chapter, however, broadcast media have not yet been shown to be particularly effective in the complete absence of a live teacher. Except in very unusual applications, a teacher is needed in the classroom to maintain discipline, to provide explanations or answers to supplement the televised presentation, and to conduct those portions of the instruction not offered by television. On the other hand, educational television and radio are media capable of providing learning opportunities that otherwise might not be available in most classrooms. Remote schools, for example, may not be able to recruit or retain qualified teachers for instruction in science or foreign languages. Yet, instruction on these topics could be made available using broadcast media, and radio and television have been used in this way for some time, and broadcast instruction both in the United States and in the developing countries (see Levenson, 1945; Schramm, 1960).

Despite continued technical improvements in equipment, little real progress has been made in enhancing the instructional effectiveness of broadcast media. The transistor has made inexpensive, battery operated radios available throughout the world. Video tape has made it possible to record and reuse televised lessons far less expensively than the kinescope and other film methods it has replaced. Closed-circuit television has reduced broadcast power requirements, increased the variety of lessons which can be received at any one time and made possible the use of equipment with fewer lines per scanning cycle. ITFS (Instructional Television Fixed Service, or 2500 megahertz systems) use a narrow, directional signal to provide the advantages of CCTV without the need for cables from studios to schools. On the other hand, almost all of the emphasis in research on broadcast media, as Gropper (1966) says:

> . . . tends to be primarily concerned with the design of the message . . . 'Information' models lead to research on questions about the redundance of a message; the relevance of a message; the capacity of visual and verbal channels for transmitting the message; etc., . . . [but not to] the analytic and dimensional analysis of variables that promote the acquisition, retention, and transfer of specific behaviors [pp. 38-39].

Instruction from Broadcast Media

Educational television has achieved substantial popularity, not because it has been shown to enhance learning, but because it is a better means of presenting information. It has tremendous appeal to those who are concerned with the process of education for its own sake regardless of the efficacy of the product. Television and radio typically bring the image of the master teacher to remote classrooms. The assumption is that those who uniformly achieve success in their own classrooms will have comparable results when their presentations are broadcast to large numbers of students simultaneously. This approach, however, leads to the paradox that if the presentation were all that is important, then all there is to teaching is an instructor who supplies information and all there is to learning is listening and watching. As suggested in a previous chapter, the validity of this proposition has been found lacking by many modern learning theorists. There is reason to believe, in fact, that the quality of communication is the least significant component of what a good teacher does in the classroom. The good teacher, like a good tutor, responds differentially to the performance of each learner and it is this characteristic of a master teacher which cannot be replicated over broadcast media.

The expansion of radio reception by more powerful transmitters or of television coverage by relay facilities or even satellites will not overcome this deficit. Some progress may be in sight, on the other hand, to the extent that systems of education can be developed which make better use of broadcast media in the roles they can serve best. Radio and particularly television can present information very effectively. Both could be used to provide content which might otherwise need to be supplied by single-concept films or reference texts. During a normal six-hour school day, for example, more than 70 five-minute lesson segments could be transmitted over each available television channel on a scheduled basis. These could portray a physics demonstration, an interview with a government leader or an illustrative scene from a famous drama. Viewed just before or just after an individualized lesson presented in a programmed textbook, the telecast effectively would complement the student's learning and would do what television can do best. Similarly, radio could be used to bring experts to students so that questions beyond the capability of the classroom teacher could be answered. Two-way radio systems used in this way have been quite successful in Australia (Kinane, 1967) and to permit rural pupils access to subject matter experts over telephone lines in the United States (NEA Educational Services, 1967).

Other developments which may be useful in adapting broadcast media to the needs of individualized instruction include the 'electronic blackboard' and video transmissions with multiple audio tracks. Electronic blackboards are devices which use a television-like receiver to display a picture transmitted over the narrow channel widths of a normal radio frequency. Several seconds are required to 'build' each picture and movement cannot be shown. However, any static illustration, such as a graph or photograph, can be

transmitted. Multi-audio television permits any one of several sound tracks to be received along with a normal television picture. These sound tracks may be used to provide commentary in several different languages so that a single telecast can be used simultaneously by schools in neighboring countries. They also could be used to provide instruction at several different levels. One set of scenes filmed in a foreign location, for example, could assist students in appropriate second language classes and at the same time be used to present information on political geography for one age group, and on world customs for another.

Even before these technological developments become fully practical, more conventional radio and television broadcasts will be used to supplement inadequate instructional resources in many of the developing countries. For instance, since 1965 the Niger has used television on an experimental basis in selected primary schools. This approach was chosen to permit employing elementary-school graduates as classroom teachers for the first few grades and thus make any better qualified teachers available for higher responsibility assignments in secondary schools (UNESCO, Vol. II, 1967). An even larger effort began in El Salvador in 1969. Here, television is being used as perhaps the only feasible way of coping with very rapidly rising enrollments in the seventh through ninth grades. The aims of this project, in addition to providing for expanding numbers of middle school students, are to install a new and more relevant curriculum and to upgrade the quality of instruction in the absence of an adequate supply of teachers who themselves have the necessary educational background (Academy for Educational Development, 1969).

Although interim findings are promising in both of these countries, it is not likely that the mere use of television will achieve results any better than those

which could have been produced by reasonably competent classroom teachers. On the other hand, it is doubtful whether the students to be taught by television in these countries would receive any real instruction with the existing scarcity of, at best, minimally qualified teachers. Turning to television may be an inescapable alternative, in many parts of the world, to no education at all. But even under these circumstances, it is clear that a conventional television presentation — whether adequately tried out or not — does not embody all of what usually is characterized as good teaching. Supplementing the telecasts with additional printed materials, student activities and training for the classroom personnel who monitor the students as they watch and listen — as was done both in the Niger and El Salvador — can be helpful and, perhaps, make the most of an already difficult situation. Nevertheless, relying more or less solely on broadcast media as a solution to the enormous problems of education would eliminate even the modest amount of individualization that can be provided within the capability of almost any classroom teacher.

Research on Audiovisual Aids

Research findings on the effectiveness of audiovisual aids seem consistent with their primary utility as communications resources. A rather extensive review by Campeau (1967) summarized the results of a sizeable number of comparative effectiveness studies involving television, motion picture film, programmed instruction, transparencies and other pictorial presentations, radio and recordings, three-dimensional models and field trips. Because all of the studies were identified and evaluated by a single author, it can be presumed that the search of the literature was equally

thorough in all of these areas and that the standards applied with respect to which studies should be cited were equivalent. Campeau found 48 research studies comparing educational television with conventional instruction. Of these, eight favored televised instruction, six favored conventional instruction and thirty-four failed to reveal any differences. The findings were consistent at the university, secondary and elementary school levels and were similar to those described in previous compilations by Allen (1960) and others. Campeau located 16 recent studies comparing motion picture film and conventional instruction. Four of these favored films, one conventional instruction and eleven resulted in no meaningful differences. These studies, she reported, were consistent with those tabulated in previous reviews of the literature by Allen (1960) and Greenhill (1964).

Comparative research on programmed instruction cited by Campeau included six studies. Three of these favored programmed materials, three resulted in no differences and none favored conventional instruction. These findings, she noted, were similar to those tabulated by Schramm (Fund for the Advancement of Education, 1964) who found 18 studies that failed to produce a difference, 17 which favored programmed instruction and only one that favored conventional instruction. She also cited the review by Briggs and Angell (1964) which was somewhat unique in concluding that most studies did not result in a clear difference. In reporting on slides and other transparencies, Campeau adds only four studies to those cited by Allen (1960), who concluded filmstrips were as good as motion film, and by Wendt and Butts (1962) who found no studies which demonstrated a difference between filmstrips and conventional instruction or between transparencies and other media. Of the four additional studies, one favored transparencies over

chalkboard drawings, one favored transparencies over motion film and two indicated no difference between instruction based on transparencies and conventional instruction.

Research on radio and recordings included the two studies favoring radio over conventional instruction and the two studies indicating no difference in the two teaching methods that had been cited by Allen (1960), as well as the one study favoring tape over conventional instruction and the five comparisons suggesting no difference between the effectiveness of tape and live lectures cited by Wendt and Butts (1962). Two additional studies located by Campeau showed no difference between taped and conventional instruction and one which showed no difference between radio and conventional instruction. Language laboratory research compiled by Campeau included two studies which resulted in no demonstrable difference and one report favoring language laboratories over conventional instruction. Her survey did not include a fairly exhaustive assessment by Keating (1963) involving more than five thousand students in twenty-one separate school districts. In general, Keating's results favored the nonlaboratory groups on tests of reading comprehension and listening comprehension. Only for first year students did the language laboratory even seem to benefit speech production skills; the nonlaboratory students tended to be superior to the laboratory students in this respect in subsequent years.

Three-dimensional materials, the category Campeau uses for manipulanda as well as displays, was the basis of comparison in only three studies. One favored manipulanda, one favored no manipulanda and one favored neither. Research on the value of field trips, usually contrasting actual visits to films of visits, included three studies favoring the field trips and one with inconclusive results. Two special comparative

studies cited by Campeau also are of interest. In one, television was found to be superior to radio for instructional purposes; in the other, programmed instruction was found to be superior to film.

As many reviewers including Campeau have pointed out, comparative studies are suggestive at best. The nature of the design of most of this research necessarily precludes conclusive results. In a general sense, these studies show what may be possible depending on the quality of both the media-based and conventional instruction. Certainly any medium can be improved through tryouts and revisions. If this effort is sustained long enough, the results are almost certain to favor the students taught with the audiovisual materials. The work of Gropper, Lumsdaine and Shipman (1961) on improving instructional television and by Vandermeer, Morrison and Smith (1965) on improving films using the performance of students during preliminary tryouts supports this view. The question, then, is not whether audiovisual aids potentially are useful resources in education but how they can be prepared and applied effectively, efficiently and economically.

Limitations on Media Utilization

Better materials alone will not do much to enhance educational practices, whether the instruction is individualized or grouped. Following their analysis of a large number of media-based educational systems in both developing and affluent countries, Schramm, Coombs, Kahnert and Lyle (1967) were able to identify seventeen factors which tended to distinguish between more and less successful projects. In general, outcomes tended to fall short of expectations wherever new media were supplied without sufficient attention to integrating the use of the new media into the overall educational process. The need to focus attention on

more than the devices themselves is illustrated by Oettinger and Marks (1968), who comment on the use of equipment which, in this instance, already was located in the schools:

> *A visit to a place we shall call Small City provided an example of this phenomenon. Overhead projectors were introduced into a brand new high school . . .because blackboards had not been delivered before the opening of school. School officials provided enough overhead projectors to have approximately one for every two classrooms. These remained even after the blackboards came, but older teachers who had complained all along that they needed a pilot's license to use these gadgets, promptly abandoned their use. Although we were told that the younger teachers had been enthusiastic about the new devices, we saw no evidence of anyone using them in any classroom* [*p. 704*].

The problem is not only one of more relevent teacher training. School buildings, for example, seriously can constrain the advantages of audiovisual aids. Rectangular rooms are not particularly well suited to any visual presentation due to the highly variable distance between student and screen and the angle at which many students must look at the picture. Windows often must be shuttered and unshuttered several times each day. Sound systems, even those with minor distortions, can be painful to those in the first row if turned loud enough to reach those at the back of the room. Most school rooms are designed for conventional teachers who present information in conventional ways. Thus, despite the development of several concepts which do make media-based instruction feasible through the better design of school and classroom space (see De Bernardis et al., 1961; Educational

Facilities Laboratories, 1960), still more effort is required in this direction.

Media-Based Individualized Instruction

One example of how school facilities can be designed to meet the needs of individualized, media-based instruction is the new Nova Educational Park in Fort Lauderdale, Florida. This set of schools, which eventually will encompass preschool through post-graduate university education, were constructed, organized and staffed in accordance with the Trump Plan, a comprehensive framework for school planning which emphasizes the relationship between school buildings, teacher utilization, curriculum sequences and media resources (see Trump & Baynham, 1961). Most classrooms have movable walls to permit various sizes of groups to receive instruction at particular hours. Room rearrangements are used to facilitate team teaching opportunities and to allow one teacher to lecture or show visuals to all of the students while other teachers devote their time to preparing future presentations. Closed-circuit television which also can distribute broadcast television is supplied to each room. Several 'resource centers' are designed for individual student study and are equipped with desks, texts, references and audiovisual equipment. Consistent with the Trump Plan, considerable emphasis has been placed on flexibility in student programs and teaching methods. Small group discussions can be used to supplement lectures or individualized instruction. Each day is divided into brief periods to accommodate instructional units of various lengths. Teachers are provided with offices and with workshops to prepare audiovisual materials.

The success of the Nova schools, and others like them which have attempted to combine a number of innovative practices into a workable system, has been

limited. Not all of the flexibility or resource capability can be used effectively. Management of the school day when each student sometimes is expected to attend group sessions and sometimes work on his own is difficult. Students occasionally are overwhelmed by the options available to them. Most teachers are ill prepared to develop or use media wisely. Yet, there is no evidence that any of these schools do a poorer job of educating students than conventional schools and the experience gained from their open and flexible attitude toward experimentation and innovation certainly will be beneficial to all involved.

12

EDUCATIONAL SYSTEMS

Education is only one of the many fields in which the availability of potentially useful technology is considerably ahead of the development of practical applications of the technology. The vast variety of devices, methods and media that have been devised to support and supplement classroom teaching permits far more sophisticated educational practices than have been introduced anywhere. The growing gap between what is done and what might be done in providing effective education is not due to any shortage of promising techniques but to their diversity and the lack of familiarity with them. No one person today can acquire the expertise necessary to be an authority in each and all of the technologies which could be assembled to improve education. Furthermore, education is a dynamic entity. The implementation of any change is likely to have unplanned as well as planned effects. Education is too complex, and its components too interrelated, to permit isolating the consequences of any action only to its intended outcome.

The Systems Approach in Education

Composites made up of many interacting constituent parts are called systems. While the origin of systems thinking may be very old, the application of systems concepts to education is a fairly recent development. According to Silvern (1965b), the earliest known description of instructional practices in systems form was contained in a book on pedogogy written by Herbart in 1806. Through the following years, various systems engineering concepts such as 'block-diagraming' and 'flow-charting' were introduced into education. Yet, it was not until after the Second World War that serious efforts were made to develop procedures for analyzing educational policies and organizations from a systems point of view. Much of the impetus for this surge of interest resulted from the success of systems approaches in anticipating and overcoming problems during the development of complex military equipment, and many of the advocates of systems thinking in education were individuals who had experience with the development of missile, aircraft and similar systems during the war years.

The success of systems concepts in education has, to this point, been very limited. One very crucial reason has been suggested by Oettinger and Marks (1968):

> *If we compare the organizational structure of the schools with the structure of organizations which have successfully integrated advanced technology into their functioning, it becomes obvious that the educational system is far more complex than anything we have hitherto tackled — air defense systems, moon shots, and air, rail, or communication networks notwithstanding — and that, in addition, we have far less knowledge of its component parts* [*p. 705*].

Another, perhaps equally important, reason is that too few educators have a reasonable grasp of the systems approach. As explained in an earlier chapter, the systems approach is used to identify and define the requirements which must be met for an overall objective to be achieved; to specify the characteristics of resources which must be assembled to fulfill these requirements; and to provide a detailed plan which permits the resulting product to be evaluated, revised and updated with minimum waste. The systems approach is not itself a procedure, and there are no rules or recipes which, if followed, will guarantee the success of a planned system. As Pfeiffer explains (1968):

> *As the systems approach comes into prominence, educators and others will have increasing occasion to consider it in somewhat greater detail. We have already emphasized that they will not find a clear-cut set of rules or a step-by-step framework constructed along do-it-yourself lines. We would be proceeding under false pretenses if we presented the approach as other than a thing in process, rather fuzzy at the edges perhaps, but embodying a core of procedures which can be identified and used to good effect* [p. 21].

In practice, then, the systems approach is nothing more than a logical way of going about solving a problem. For this reason, most explanations of what is meant by the systems approach are no more than conceptualizations or models which describe an abstract system. The real difficulty is not in understanding what to do but in turning to particulars and applying the approach to improve the operation and success of an actual system.

Steps in the Systems Approach

Most authors who have described the characteristics of the systems approach as it might be applied to education agree on its principal characteristics (see Pfeiffer, 1968; Brown & Norberg, 1965; Briggs, 1967; and Tucker, 1965). The first step is the recognition and definition of the problem in terms of the desired outcome of any system action. Determining the goal of a system change is not always easy. Too often the aim is stated in terms of introducing a process rather than attaining a product. Improved guidance, for instance, may be a reasonable method for accomplishing some objective but it is not itself a legitimate goal, because it is a means and not an end. The second step is to establish the criteria to be used in assessing the success of a change. Typically, evaluation may include not only increments in the quality of instruction or the quantity of students enrolled, but measures of cost, acceptance and ease of administration as well. The purpose of this step is to reach agreement on what constitutes an acceptable solution beforehand so that developmental efforts are not wasted.

The third step is the identification of potential solutions to the problem. During this step two important findings are bound to emerge. One is that no one technology or innovation in education alone is likely to be capable of achieving any goal by itself. Content, facilities, talent and many other factors ordinarily must be combined to arrive at a workable solution. The other is that no single innovation which may be considered will be supported by past evidence to demonstrate that it will succeed in its intended application. A solution may have been effective elsewhere as a component of another system; but even if the solution is the same, the new system context in which it will be operating may make past findings almost irrelevant.

The fourth step, which reflects these inevitable findings, is a period of feasibility testing for each promising solution. Prototype materials, equipment or schedules have to be tried out to determine the conditions which must be met to permit each solution to succeed. Very often, this step can be accomplished on paper or by using a mock layout. The purpose of this step is not to inspect the plans for the solution but to work through a series of events comparable to what would happen in real life. This effort will reveal at least the more obvious flaws and indicate which other aspects of the system are likely to be affected by the change that is being introduced. The fifth step is to begin the assembly of the new system based on the adoption of one or more of the solutions. Because any solution is likely to affect many components of an existing system, it usually is necessary to make at least modest changes in a number of areas simultaneously. Finally, the sixth step is to provide procedures for improving the system as experience is gained with the impact and limitations of the innovation. Flaws almost certainly will appear in spite of diligent efforts to anticipate them, and these deficiencies must be identified and corrected as rapidly as possible.

This process is illustrated in Figure 13. The blocks and arrows in the diagram show the sequence of events which should occur as an innovation is introduced into an ongoing system. The dashed arrow is a very important component. It represents the use of system-generated information to define residual problems which then can be the aim of a subsequent cycle of system improvement. In other words, the refinement of an educational system is really a continuous process with each new action followed by the collection of system feedback to determine the priority of further improvement efforts. This is the essence of the systems approach, a series of steps which describe what

is to be done in order to establish or, more often, revise a system. This overall approach has been applied to education in two distinct ways. One of these has been in terms of the structure of an educational capability. The other has been in terms of the instructional process itself. Each application reflects a different kind of system and a different kind of approach.

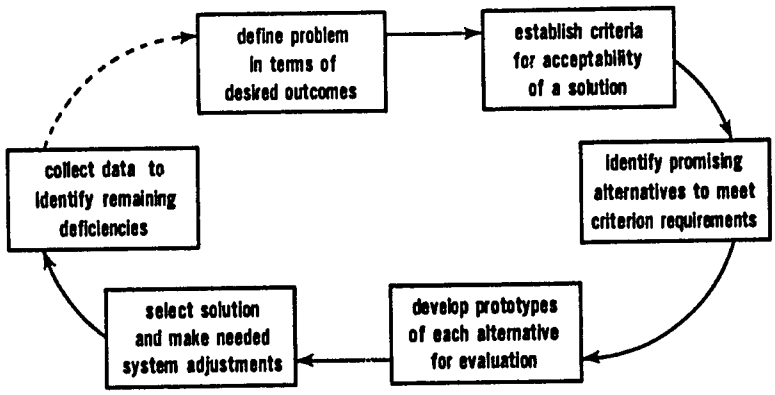

Figure 13. Six steps in the systems approach cycle.

Structural Models of Education

A model of the possible structure of an educational system is shown in Figure 14. It identifies, in block diagram form, the various components that are almost universally relevant to an educational system. This is not a necessary or complete list; one of the difficulties in applying the systems approach, in fact, is the enumeration of system components. Even with this gross model, it is easy to see that a change in any one component is likely to affect most or all of the others. For example, a decision to provide vocational education to meet demands for more skilled electronics technicians requires an adjustment in curriculum standards. New teachers and special materials may be needed. Classes would have to be scheduled. Training equipment may

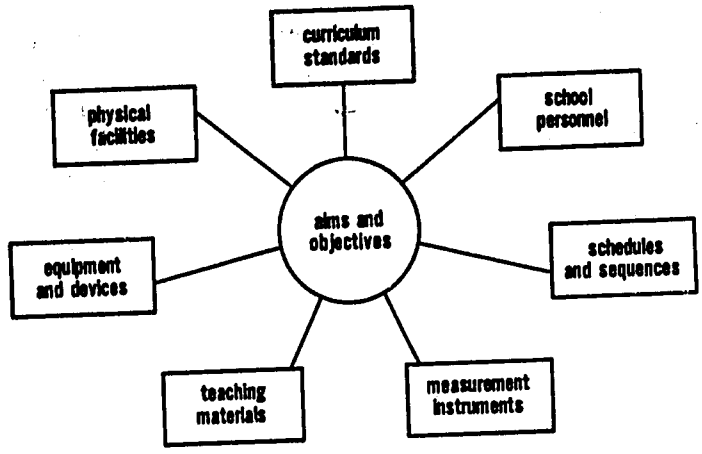

Figure 14. Structural model of a typical educational system.

have to be purchased and classroom space made available so that the equipment can be installed. New aptitude tests to select students and new measures of proficiency may have to be developed.

This particular model describes an educational system as a whole. The components, however, each can be viewed as smaller systems with interrelated, constituent parts. For instance, Figure 15 is a model of a school personnel subsystem. Again, a change in the responsibilities, assignment or quality of the individuals in any subgroup is likely to have repercussions on the others. Each function must be related to the other functions for the smooth operation of the school. The model may be made larger as well as smaller. Curle (1963) and others view education itself as a component of a larger system of national economic development. Here again, any change in the entire system is likely to impose new constraints and requirements on the education component or, if education is changed, the effects are likely to be felt in many other areas. One series of examples of the sometimes unexpected outcomes which educators may experience as a

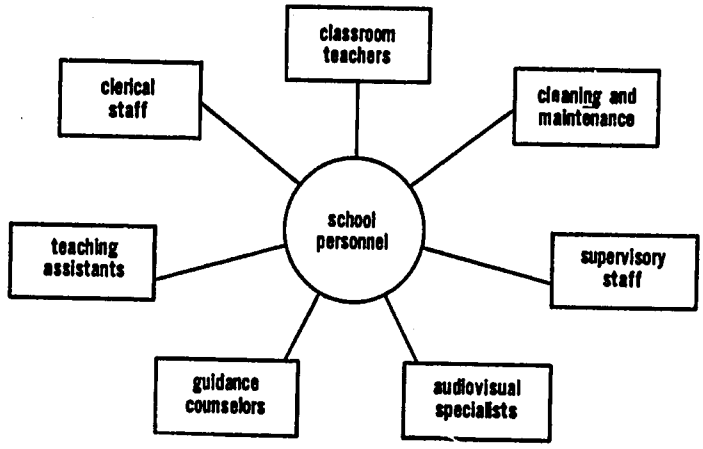

Figure 15. Structural model of a school personnel subsystem.

result of changes in school policies has been provided by Oettinger and Marks (1968):

> *A change in the school hours affects not only pupils and school personnel but every child's mother. You introduce the 'new math' and shake up every parent in town. Ability grouping invites federal court decisions prohibiting it. If part of the high school burns down, it may be cheaper for local taxpayers to build a new one because the state contributes toward costs of new construction but not of renovation. An experiment with new curricula raises the specter of low performance on college [entrance examinations] . . . [p. 703].*

Process Models of Education

Models of instructional process systems regard the student as a product of education. These models illustrate how the student enters the system, how he proceeds through it and how he is changed by it. An ex-

ample of this kind of model, similar to ones proposed by Glaser (1962a) and Stolurow (1966), is shown in Figure 16. The format of this model is a flow chart rather than a block diagram; it illustrates a process instead of a structure. As a student enters the system at the left, his entering behavior is assessed. The results of this step may indicate a need for differential placement to the extent that different students may require unequal amounts of instruction or instruction which is adapted to each student's background and style of learning. Normally, the student then proceeds to instructional methods, although the efficiency control loop shown at the top indicates that he might enter instruction at various points depending on the skills he already has attained, or skip instruction entirely. The last step is proficiency testing. He leaves the system if his proficiency is acceptable or he may return for further instruction or to have his present performance diagnosed again, perhaps for placement in a different course. The effectiveness control loop is a form of quality control both on the progress made by individual learners and on the capability of the system itself.

Evaluating Educational Systems

The overall perfection of these two kinds of systems is assessed differently. When a structural model is used, the excellence of the system is measured in terms of its capacities. These, in turn, reflect the quantity of students who can be taught at one time and the quality of the education they receive. A system is structured optimally when all of its components are in balance so that the quantitative and qualitative capacities of the system are as large as possible for the investment made in it. Unused school buildings, for example, represent a surplus capacity and, therefore, a system weakness. Outdated textbooks mean that the additional classroom time, teacher resources and in-

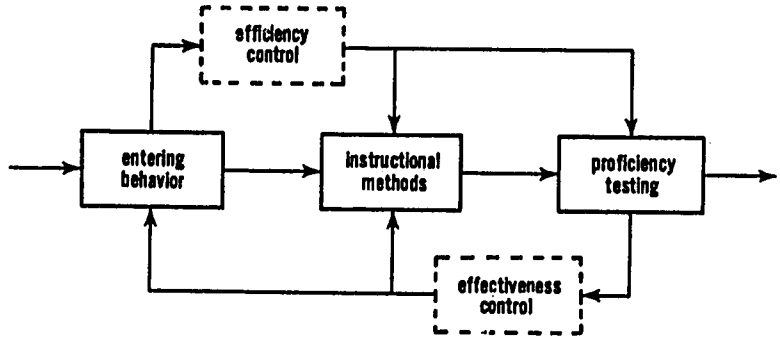

Figure 16. Process model of a representative instructional system.

structional aids must be used to compensate for the deficiency or else the system will suffer a loss in the quality of its output.

The efficacy of a system represented by a process model is measured by the amount of behavioral change that occurs as a function of instruction and by the amount of time required to produce that level of attainment. An improvement in the system would be evidenced by increased quality, reduced time or both. Some actions taken on a process model system may affect the performance of the system only at a later time. For example, methods which teach decimal arithmetic by rote in the early grades may be very efficient, but they also may result in time wasted later on when the student encounters difficulty in learning binary arithmetic.

Interactions in System Components

When the systems approach is applied to a practical problem, both the collection of alternate solutions and the identification of the possible ramifications of each one require time-consuming, inductive efforts and often considerable creativity. Suppose, for instance,

that a particular social studies course seems weak. Students finishing the course do not do well on criterion-referenced examinations, and they are felt to be poorly prepared for subsequent courses which depend on content they should have mastered. Perhaps the teachers could be improved or better textbooks could be obtained. Perhaps more time could be scheduled for each lesson or better audiovisual aids supplied to complement teacher lectures. Perhaps the class size could be reduced or aptitude measures could be applied to eliminate those entrants who are likely to do poorly. The ramifications of each of these solutions are likely to be extensive. Visual aids, for instance, would require projectors, screens, electricity and blinds for the windows. The visuals would have to be distributed and stored. The projectors will require maintenance and the teachers may have to be trained to operate them.

As another example, suppose far larger numbers of students have been electing a college preparatory program in secondary school than possibly could be accepted considering available university openings. One solution to this problem might be to institute a guidance program. The success of this action is likely to depend upon recruiting new kinds of school personnel, the purchase of test instruments, provisions for offices where the counselors can meet with students, changes in schedules to provide time for testing and counseling, explanations of the program to parents, investigations of promising job opportunities, revisions in course offerings to permit guidance recommendations to be utilized, and perhaps much more. Each of these consequences then may need to be analyzed in detail. What would happen, for instance, if the planned recruitment program failed or if the test instruments were too costly or if the office space could not be created for several years? In many cases, research will be needed to devise a solution where none exists or a

new product will have to be developed to bring the cost of an essential component within the available budget.

An Example of New System Defects

Because of the complexity of most educational systems and the number of options which are likely to exist, it rarely is possible to plan an action which will have the desired effect from the moment it is introduced. In retrospect it always will seem incredible that the problems which are encountered during implementation were not anticipated beforehand. A by no means atypical example was the recent tryout of the English Language Services' automated Teacher Education Program, or TEP (American Institutes for Research, 1969). This experimental course provides instruction on the teaching of English as a second language. The lessons are self-instructional and utilize written programs as well as films and tapes designed for individual study. The entire package consists of 26 volumes of text and practice exercises; 163 cartridges of 8mm sound movie film; 140 cartridge-loaded audio tapes; worksheets for students to use in recording their responses; a 28 volume reference library; and, finally, the TEP console, a fiberglass shell which contains a movie projector, tape recorder, headset, study lamp and work space. The course is designed for use by individuals who will become teachers of English at the primary, secondary or university level. Between 275 and 300 hours of self-paced study usually is required to complete the course.

An initial version of the course was completed in 1965 and was administered by its developers to a sample of seven trainees in the United States for tryout purposes. A number of needed modifications were detected and the appropriate revisions were made. The course then was administered to a group of six trainees in Enugu, Nigeria (Van Syoc & Schwarz, 1968). Several new problems were identified, including the lack of a

suitable orientation segment to introduce the course and a substantial discrepancy between estimated completion times and the longer times these trainees actually required. Further revisions and modifications were made to correct these and other problems that were observed. A third tryout was then conducted in Ibadan, Nigeria, this time with eight trainees. A detailed record was kept of some of the unexpected events which occurred. The first was the failure of some equipment to arrive by the starting date, making it necessary to shorten the planned daily schedule so as to spread access to the equipment, and to reuse instructional materials from the previous tryout. When the shipment did arrive, 16 tape cartridges had been broken in transit. One projector failed and the needed parts were unavailable in Nigeria. The trainees at one point reported they needed a rest and elected to take a three-day holiday. A total of 157 film cartridges jammed at some time during the tryout and almost all of these had to be opened and the film spliced. The coding system used to identify films was ineffective and trainees spent considerable time searching for the cartridge they needed. Typographical problems in the printed materials continued to cause confusion, although the substitution of detachable bindings for the permanent bindings used in the first tryout permitted corrections to be made.

Three further tryouts were then undertaken, one in Hyderabad, India, one in Singapore and one in Caracas, Venezuela (American Institutes for Research, 1969). Despite modifications that had been made in the film cartridges, the jamming and burning of film remained a problem. Although not reported in the previous tryouts, the audio tapes now tended not to rewind properly. Several tapes were ruined because cartridges were inserted incorrectly so that the master track was erased. Control knobs malfunctioned and fuses could not be located when needed at two of the three sites. The ori-

entation segment, which seemed successful in Ibadan, turned out to be less than adequate in these more recent tryouts. Labeling of materials continued to be a problem, as did typographical errors in the workbooks. At one site, the level of English used in teaching the course was too high. American instead of British pronunciation, not a great problem in Nigeria, suddenly became one at all the three tryout sites. Some lessons required such expert mastery that conscientious students repeated them over and over without meeting the criterion. The absence of a live teacher to answer questions was regarded as a deficiency by some trainees.

While sometimes irritating, none of these problems was serious enough to make the system ineffective or prevent the trainees from learning the intended content. Looking back, it may seem that better and more thorough planning could have prevented most of the difficulties that were observed from happening. Yet, as many as thousands of other problems undoubtedly were anticipated and overcome by the developers of the system even prior to the first tryout. Few systems incorporating as many innovations as this one would be likely to succeed as well in similar field tests. At the present time, further tryouts of the TEP system are in progress, and it can be expected that the number and importance of problems will be reduced as successive revisions, additions and corrections are made.

System Planning Techniques

With the advantage of hindsight, it is evident that each step in the systems approach has its own perils. The first step, defining the problem, is perhaps the most difficult. One of the most likely causes of failures in innovation is trying to find a problem to fit an innovative solution which already has been selected, and endless examples can be cited where focusing attention on some attractive technique has led to unhappy re-

sults. For example, perhaps millions of dollars worth of closed-circuit television equipment sits unused because personnel competent to produce lessons for television are unavailable. Curriculum revision projects, as another example, often are aimless in their conception because the deficiencies in the old curriculum have not been specified. It also is essential to avoid unnecessary constraints on potential solutions. Improved textbooks, newer buildings, better guidance and smaller classes all seem desirable, but they are no more than a few of the choices of the means by which education might be improved. They are not ends in themselves.

Focus on the product is stressed by the systems approach. For example, if permitted by the scope of the undertaking, it would be far better to propose an investment in 'teaching' than in 'teachers.' It may be no more difficult or expensive to develop instructional materials which reliably produce learning in the classroom than it would be to train teachers to accomplish similar results. Instead of automating teacher training, as was done for the TEP project, materials could be prepared for use by the students themselves under the supervision of a relatively untrained monitor. Better teachers should be viewed as only one of the ways in which classroom teaching can be enhanced; it may be more feasible or even less expensive to consider alternatives such as audiovisual aids or improved texts instead of limiting the solution only to higher quality personnel.

During the second step, considerable time usually is required to identify the characteristics of an acceptable solution. For instance, even the design of an ordinary classroom may demand weeks or months of study to identify the questions which should be asked, such as how many chalkboards are needed and will the doors be wide enough to move a desk in or out. And, as much time or more may be needed to obtain reliable answers.

An important consideration in this step is that all relevant criteria cannot be given equal importance. Cost, level of mastery, number of students affected and time to reach the goal all are valid concerns, but it generally will be impossible to satisfy every one simultaneously. Instead, some hierarchy of priority must be established among the criteria adopted. If cost is the primary consideration, for instance, then mastery level may have to be relegated to secondary importance, and the remaining criteria may have to be assigned even lower priority.

The third step, identifying plausible alternates, generally requires assistance from experts representing a number of disciplines. Few ideas are really new. And, for this reason, there is not much point in spending months on questions which already have been studied intensively, such as finding substitutes for electric lighting, selecting a core vocabulary for second language learning or rediscovering the value of projecting images of specimens on a screen before asking students to observe the behavior of specific one-celled organisms through a microscope for themselves. What can be new are procedures for making old ideas practical and useful. Binet's notions of intelligence measurement were not widely applied to education, for instance, until Otis developed simplified test instruments which were feasible for group administration. When hypothetical systems are devised, it is easiest to begin each one with a key concept and construct the remaining system around that innovation. For instance, one approach to improving the quality of medical education may begin with a change in student selection standards while another may be based upon more extensive supervised experience. Once the key concept is suggested, a system can be built around that concept to make it practicable. Several new concepts can be combined

only if a system can be devised which makes all of these features compatible.

The fourth step again requires time and effort. There is no other way to assess potential solutions except through simulated or actual tryouts. The outcomes of many attempts to simplify teaching responsibilities by increasing specialization are good examples of this point. Very often, narrowing the scope of a teacher's instructional tasks has led to reduced quality, even though more preparation time was available, because of the teacher's boredom and lack of feelings of accomplishment. New textbooks frequently are tried out in draft form before they are published to determine whether they may be unusable because they are too long or too short to fit the schedule of the school term. Frequently, tryouts will reveal that a solution deserves further consideration only if other changes are made within the system to accommodate the innovation. It is important to recognize that all essential components of the solution must be simulated during the tryout step. Bright was quoted in an earlier chapter as suggesting the use of a human to replicate the functions of a computer at early stages during the development of computer aided instruction. This is a very useful illustration of simulation but, for example, it must be complemented by durability tryouts of the proposed equipment terminals as well, even though this can be done separately and need not involve the same instructional materials.

System Implementation Techniques

The fifth step is the assembly of the new system and the orderly implementation of the innovation. Several new techniques, variously known as PERT, or Program Review and Evaluation Technique, and CPM, or Critical Path Method, are of help in establishing the priority and time sequence of steps needed to reach a

complex goal. These techniques are based on analytic network models such as the very simple one shown in Figure 17. The scheduable subobjectives which must be

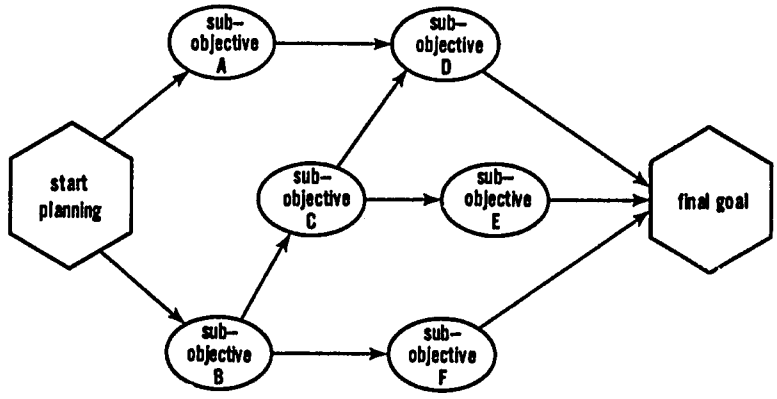

Figure 17. Analytic network model of system development.

reached are designated by ovals. These usually are determined by working backwards from the final objective. For example, a program which has adult literacy as its goal might require students, materials, and teachers. Teachers cannot be recruited, however, until

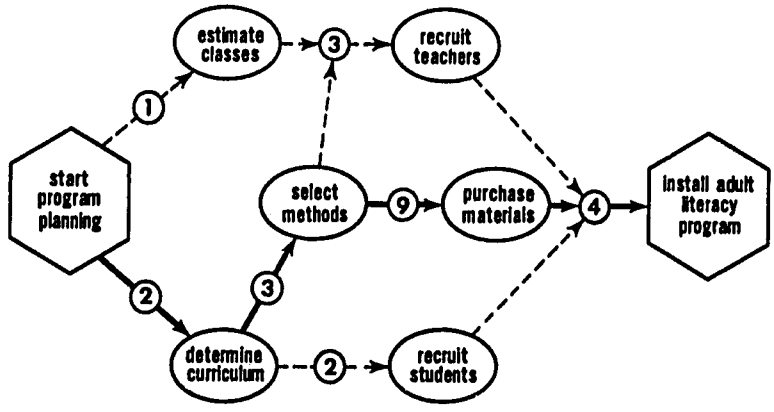

Figure 18. Example of a PERT/CPM time analysis.

the instructional methods have been selected and the number of classes to be offered have been estimated. Similarly, the classroom materials cannot be chosen until the methods to be used have been determined. The sequence of steps for this example is shown in Figure 18.

A further refinement of PERT and CPM methods is to estimate the time required to accomplish each activity, represented in the diagram by the numbers in the arrows. Some of the arrows have been redrawn to represent the convergence of more than one activity to reach a single objective. The minimum total time required, from planning to the installation of the program, is ten time units as shown by the path designated by the heavy arrows. An inspection of the network reveals the priority of activities. If the development effort is to succeed in no more than the estimated number of time units, work on the curriculum must begin immediately. In contrast, the start of work on estimating the number of classes can be delayed as long as four units without affecting the date classes begin. Thus, resources to be devoted to this latter effort can be transferred temporarily to the more critical activities. Further information on PERT and CPM and their uses to isolate potential problems, to serve as a basis for management control reports and to determine the shortest time in which a goal can be reached can be found in several books on the subject (Baker & Eris, 1964; Evarts, 1964; Horowitz, 1967; Levin & Kirkpatrick, 1966; Moder & Phillips, 1964).

Determining priorities in such a way as to minimize developmental time is not always the best strategy. The same general approach can be applied with cost figures replacing time estimates. For instance, Figure 19 shows hypothetical unit cost estimates for the same activity. In this example, the critical steps turn out to be almost the same ones, except that the purchase of the materials

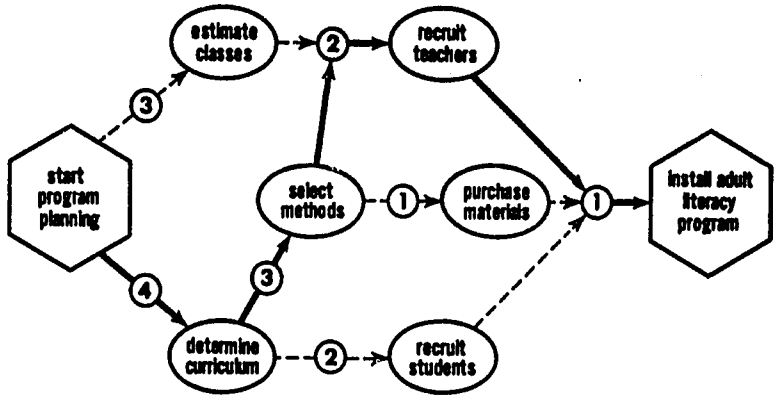

Figure 19. Example of a PERT/CPM cost analysis.

at a high initial expense is anticipated. From the point of view of cost, it may be desirable to delay teacher and student recruitment, even if this meant a subsequent delay in initiating the program, to give additional attention to the problem of selecting the materials. Sometimes, a cost analysis of this kind will suggest the need for a review of all the steps leading to a particularly high cost activity. It may be, for example, that a change in methods would reduce the need for a substantial investment in materials. Identifying the steps leading to high cost activities in advance of implementation even may entail establishing new criteria for that activity which would result in a different cost outcome.

System Feedback Techniques

The last step in the systems approach was described in terms of the introduction of feedback mechanisms into the system. Every system at a minimum should include some method of formal evaluation capable of revealing the effectiveness of the system relative both to the criteria established for it and to any system it may be replacing. The system also must have inspection points arranged to reveal deficiencies in its

design before these defects become overwhelming. Preferably, there should be measures of the status of each component so that the kind of remedy, as well as the need for one, can be identified.

It will not be possible, in many instances, to limit feedback to objective results alone. As Brown and Norberg point out (1965):

> *Obviously, we cannot produce a technology of instruction while specifying its goals intuitively. But is it possible to specify educational goals with absolute precision? In some fields, it may not be too difficult; in others, there are serious obstacles, to say the least. . . . It is often much simpler to establish a system performance criterion when the output is readily specified in quantitative terms; but it should not be assumed that perfect quantitative specifications of all factors is always the absolute requirement* [p. 349].

Qualitative reports, if timely, can be of considerable value in detecting and diagnosing system flaws. These may include comments from the students or their parents on the acceptability of an approach, reports from teachers on their own classroom observations, and evaluations of a new program by its first graduates, their employers or their subsequent instructors. Even if only qualitative, feedback is required to insure that all necessary components have been identified, that each component contributes effectively to the overall outcome and that no component represents an expenditure of time, money or resources disproportionate to its unique contribution within the system. Insistence on stating measurable outcomes differentiates a systems approach from other approaches to educational betterment. That educational progress is

difficult to measure makes frequent and informative feedback no less imperative. Change based upon no firmer a justification than hopelessness over existing practices easily could be a change for the worse.

13

SYSTEM DESIGN*

Knowledge about the systems approach can be helpful in planning an educational innovation or solving an existing problem, but it is no substitute for actual experience in system design. Unfortunately, most published descriptions of the evolution of either existing or hypothetical systems tend to oversimplify the systems approach process. The reason is that these descriptions are intended to be instructive only as to how problems were solved; they do not provide practice on how to solve future problems. Nevertheless, seeing the process applied to achieve realistic educational goals might usefully illustrate the way in which the systems approach is employed.

An Example of a Systems Approach Problem

Perhaps one of the most pressing educational needs in the developing countries is the problem of adult lit-

* The example of adult literacy was introduced at the Regional Seminar on Educational Innovation and Technology and convened by the Southeast Asia Ministers of Education Organization (SEAMEO) in Singapore in May, 1969, and many of the suggestions from that meeting have been incorporated into this chapter.

eracy, particularly in rural areas. As Coombs points out in introducing the concept of an educational system (1968):

> *In the early 1950's educational systems the world over began a process of expansion without precedent in human history. Student enrollments more than doubled in many places, expenditures on education rose at an even faster rate, and education emerged as the largest local industry. . . . Despite this great educational expansion, a parallel population growth has led to an increase in the aggregate number of adult illiterates in the world. The figure for Unesco's member states currently exceeds 460 million illiterate adults, or almost 60 per cent of their active population* [*p. 3*].

A nation faced with an adult literacy problem of this magnitude might well find the systems approach advantageous to increase the likelihood of success for a solution and minimize the potentially enormous waste which might result from plans which were not carefully devised and thoroughly tested.

The first step in applying the systems approach to meet these needs, as described in the preceding chapter, is to define the problem. This can be done through the process of answering a number of specific questions. What is literacy — does it include writing as well as the comprehension of text? What is the prevalence of illiteracy — what numbers of people are involved, where are they located, what languages do they speak? An unavoidable question is why teach literacy at all — everyone usually agrees literacy is desirable, but what are the social and economic expectations of a literacy program? Answers to questions such as these necessarily will vary from one nation to another but, for purposes of this example, it might be assumed that literacy should include writing and simple arithmetic,

that up to sixty percent of an adult population of ten million might be involved, that they are located mostly on farms or in small villages without electricity and that two distinctly different languages are represented, one written using roman characters and the other written in a form of sanscrit. It might be assumed, too, that literacy is a valid and realistic national goal and that its attainment is imperative for further national growth. By defining the problem this way, certain solutions are precluded, such as the use of scribes and readers or the development of telephone and radio systems to permit the needed communications to occur without recourse to literacy instruction. It might be assumed, however, that these alternatives do not reflect national needs and preferences accurately and that literacy realistically is required to fulfill national aims.

Establishing Criteria of Success

The second step in using the systems approach is to establish criteria for the success of any proposed system solution. Some of the questions which might be asked during this step are how much skill is required for adequate literacy and how are these abilities to be measured? What percentage of the adult rural population must learn literacy from the program for it to have achieved its purpose? By what date should the program be completed? And, what is the limit on how much money or other resources can be devoted to this effort? Generally, the questions to be asked during this step — as well as the answers — will vary depending upon the problem. Almost always, however, they will reflect at least the determination of proficiency, numbers, time and cost criteria. As indicated in the previous chapter, no final answer to questions such as these are possible until a hierarchy of priorities is established. For instance, it may be possible to produce adequate literacy in an entire population in a short time period, but only

at an extreme cost. Priorities are needed to indicate which of the criteria are of greatest importance in the system and which only need to be approximated as closely as possible. This does not mean that the less important criteria are to be ignored but only that they can be subordinated if not all criteria can be met simultaneously.

Returning to the example, assume that cost has been determined to be the crucial consideration and that no more than ten million dollars could be made available for the program each year. Next, it might be assumed that only those men and women between the ages of 15 or 50 would be recruited as students. Children younger than 15 would be eligible for instruction as part of an accelerated basic education effort in existing village schools, and those adults who were over 50 years of age would not be emphasized although they would not be excluded from participation. Adequate literacy skills in at least eighty percent of the adult population might be selected as the desired goal. This figure may be somewhat arbitrary, but it might be assumed that it was agreed upon as the lowest percentage likely to insure that literacy would be self-sustaining without further efforts.

Next, it might be assumed that the general standard of literacy to be attained is one generally favored by UNESCO (Burnet, 1965), that literacy is:

> *. . . a great deal more than just being able to make out the words on a page or copy them from dictation. It means reading and writing with enough ease to use these skills for practical purposes — to read a newspaper, for instance, or write a letter. It implies being able to handle figures well enough to do simple accounts. . . . a man [is] functionally literate if he can use reading and writing to communicate*

> *with the educated majority of his own social group* [*p.* 14].

This definition only approximates a usable criterion, however, in that it is no more specific than deciding that the cost of the program should not be 'large' or that it is expected that 'many' adults should achieve literacy as a result of the effort. Quantifying literacy is more difficult than deciding upon a dollar value or a percent, but it can and must be done.

At this point in system planning, then, work might already begin on the development of a test of literacy constructed according to proficiency measurement standards. The test might require a potential student to read a passage comparable in difficulty to a typical newspaper article, compose a brief letter which was to contain some specific details and calculate both the total cost of an assortment of merchandise and the total price of some quantity of commodities which the learner might sell. Actually, at least two tests would be required, one for each language, and parallel forms of each test might be produced to simplify the security of test answers and the problems of repeated testing before, during and after instruction. Some method would have to be devised for reliably scoring the test in the field, particularly the composition segment, and some minimum score would have to be selected as representative of acceptable literacy. Sufficient time should be allowed for test tryouts and for using the test or some simpler version of it to determine the level of literacy which already exists among a sample of adult villagers. This information will be needed later in planning the instruction to predict the probable number of individuals who will need instruction in various districts, to identify the probable number of villagers who already were literate and who might be recruited to help during the instruction and to estimate the existing variability

among potential students with respect to their entering skills.

Finally, it might be assumed that the government hopes to achieve literacy during the next five years. Less time, of course, would be desirable, but this criterion may be the one felt to be least critical. When these criteria are reviewed, it might be decided that proficiency was more important than the numbers of adults instructed in that the standard for proficiency already was minimal and that any further reduction would not make the program worthwhile at all. Thus, the order of criteria finally specified might be:

1. a developmental and operating cost as low as possible but in any case not to exceed ten million dollars per year;
2. a level of proficiency achieved which is as high as possible but desirably not less than some specific score on a test which will be constructed;
3. a proportion of the age 15 to 50 rural population achieving literacy which is as large as possible but preferably no lower than eighty percent;
4. a time limitation on the entire program which is as brief as possible but hopefully no longer than five years.

Identifying Alternative Solutions

Once the criteria and their relative importance are established, work can begin on the third step of system planning, identifying possible alternative solutions. It is at this point in the systems approach that a broad range of background knowledge is needed to profit from what already has been done, and creativity is required to invent what has not yet been done. One of the more useful techniques that can be applied during this step is the principles of 'brainstorming' (see Osborn, 1963; Parnes. 1967). This procedure has been satirized

widely, but its fundamental notions that creativity is at least partially the product of a free flow of ideas cannot be dismissed. Every encouragement should be given to the expression and pursuit of as many ideas as possible in a nonaversive, group setting. One idea may facilitate another and the more ideas there are, the more likely it is that at least one will turn out to be effective. Another technique is the successive use of 'analysis' and 'synthesis' as described by Silvern (1965a). The process he suggests is to begin with an analysis of the functions to be fulfilled by the system and, as each is identified, to begin the synthesis, or assembling of system elements, to meet these requirements.

Three other concepts may be helpful during this step. One is that no system can be designed around a core of good, but incompatible, components. It is better to consider the central feature of each suggested solution independently and build a system around it than it is to try to devise a system which incorporates many or all of the innovations suggested. Thus, when solutions are first proposed they should be in terms of a single system element, such as the use of radio or the use of the military as teachers or the use of existing school buildings, and not in terms of a complete system. The second concept is that it sometimes is helpful, when an adequate solution is not readily apparent, to identify what to avoid and why. If there simply are not enough teachers to make a teacher-based system feasible, this should be noted so that alternate ways of doing what a live teacher might do can be explored. The third concept is that the collection of possible alternatives might well begin with a survey of existing resources, particularly those which are not now being used. It may be, for example, that village police posts already equipped with two-way radios could be the nucleus of a system or that a core of students could be recruited as teachers and equipped with battery oper-

ated filmstrip projectors and phonographs so they can offer literacy instruction during vacations.

Suggestions for how to provide effective reading, writing and arithmetic instruction to adults can come from many sources. Books on the subject may be of some help, but the fact that the problem still is an enormous one implies that no existing solution has been particularly successful. Nevertheless, descriptions of other programs often identify their weaknesses as well as their strengths and may lead to the discovery of some way of correcting previously observed defects to improve upon an old idea. In the case of literacy, various UNESCO publications (such as Burnet, 1965 and du Sautoy, 1966), bibliographies (see Mezirow & Epley, 1965) and discussions of particular approaches (such as Medary, 1954 or Laubach & Laubach, 1961) may be helpful. Some of the suggestions contained in these books include the use of radio combined with primers, the use of word games, the recruitment of retired literate adults as part-time teachers, the use of films containing text to enhance reading motivation, and even the use of a special flag or a gong to signal everyone in a clockless village when lessons are about to begin. Many of the problems are summarized, too. Irregular student attendance can prove disasterous, some attrition can be expected among teachers regardless of pay or other inducements, more students may appear than there are texts and regional dialects may be too different to consider them members of a single language.

As an illustration of what has been done, one of the more successful approaches has been the use of radio, apparently first applied for the teaching of adult literacy by Father José Salcedo in Colombia in 1948 (Burnet, 1965). His Sutatenza program has been widely used since then (see Burnet, 1965 and UNESCO, 1967). In brief, this system is based on the student's use of

primers and lesson exercise material following directions and auditory instruction supplied over radio. Each voluntarily organized class is complemented by a monitor who is literate but untrained as a teacher. The monitor corrects the classroom exercises, supplies supplemental assistance and distributes materials. Even radio is not without its problems, however. Batteries may fail during a lesson, atmospheric disturbances may make reception difficult, students who do not have supervision may turn to broadcasts of popular music when they should be listening to a lesson, and indifferent learners may cease to participate as soon as they experience some difficulty. Even when an instructional system is effective, the overall objective may not be reached because of unforeseen circumstances. For instance, literacy can be expected to have little value or permanence without a concurrent effort to insure that books, newspapers and other reading material which is both relevant and simple will be available to the newly literate villagers.

Developing Prototype Components

The next step in the systems approach is to develop prototypes or simulations of suggested solutions. What ought to be effective sometimes will not. For instance, up to 400 hours of instruction may be required to develop minimal literacy (du Sautoy, 1966, p. 117) which means that two years or more may be required to complete one cycle of the course when the schedule of instruction is part-time. This, in turn, means that many students are likely to drop out of the program before they complete it, which is a substantial waste of resources, and that nearly double the amount of resources will be required if new cycles were to begin even as frequently as one year apart. Tryouts, even if condensed into a few months, would reveal how many hours of instruction really were required and how these

might best be scheduled. Similarly, the Laubachs suggest very brief lessons of perhaps only 15 minutes (Laubach & Laubach, 1961), yet du Sautoy (1966) reports that most literacy programs using radio have class sessions one to two hours in length. A simple experimental comparison of these two positions on a trial basis should contribute much to the eventual success of a system plan. Tryouts certainly are in order before equipment is purchased or lesson materials are produced and probably are essential whenever a system is likely to depend on the capabilities of volunteer teachers or monitors.

Reaching at least partial agreement on a system to adopt following the collection of tryout results usually is not difficult. However, as attention becomes focused on a particular solution, many suggestions can be expected on ways of refining the system before it is installed. These changes often are helpful, especially when they are directed at defects in the system detected during the early tryouts. For example, are the skills and spare parts available to permit equipment to be repaired locally? Are the desired textbooks available, and at what price? Are workbooks needed and can a workbook prepared for one of the languages easily be translated into the other? Are different kinds of teachers needed to fulfill different system functions? Then, too, there may be discrepancies between the component subsystems. Some responsibilities, such as transporting materials, may have been overlooked. The gradual refinement of a system is an expected part of its development.

It is at this point in the systems approach, when the principal features of the system have been identified, that the PERT/CPM network procedures described in the previous chapter can be used to schedule system development activities, assuming that sufficient progress had been made in preparing instructional materials

and methods during the tryout period to determine the amount of effort remaining. There is no necessary reason why the system should be complete before implementation efforts begin. It is only important that a framework exists which specifies the components of the system, how functions are distributed among these components, and the criteria applicable to each component. Because continued modifications in the complete system almost invariably will be required once it is introduced, efforts to be too precise during prototype tryouts often will be wasteful. Tryouts and changes can and should continue during system implementation based on those components which already are fixed. Any system always can be refined and improved. However, waiting unnecessarily while trying to achieve perfection in the system suggests that the goal, in this case functional adult literacy, has been subordinated to the means.

Measuring System Functioning

The final step in the systems approach is the creation of accurate and frequent measures of system functioning. Gagné (1962a), among others, considers this characteristic of a system as one of the most important:

> *The process of putting a system into operation is seldom done all at once. Rather, this process itself is composed of several stages . . . two major kinds of effort can be distinguished; they usually proceed simultaneously, and are mutually interdependent. The first of these is the exercise of the system, to establish and refine the interrelationships of its subsystems. . . . The second comprises the set of procedures used to determine what the system can do and how well it performs the operations implied by its purposes; this is sytem testing or, more generally, system evaluation* [p. 8].

Gagné views feedback as evaluative and diagnostic information which reflects both the functions to be performed somewhere in the system and the allocation of these functions among components of subsystems.

The kinds of feedback which might be desirable from a system of instruction for adult literacy, particularly because of the lengthy and cumulative teaching process, would relate to the conditions which must be present for success to be achieved. Do the students who have been recruited make themselves available for instruction? If they do appear, do they respond correctly to instructions and directions? Have the necessary materials reached them on time and in usable condition? Interim measures of proficiency can be collected at least from a sample of learners to see if the progress being made matches expectations; if not, some adaptation may be required to improve the excellence of the system even during the first cycle.

Whenever defects are detected, it usually is necessary to make a speedy decision as to whether or not some change is required and, if one is needed, whether or not it can be made soon enough and with sufficient certainty to overcome the problem. It may be, for example, that the instruction for learners in one district has been badly scheduled with respect to seasonal crop requirements in that area. If the schedule cannot be corrected, thought should be given to canceling the program in that district temporarily until a better solution can be identified. Any appreciable reliance on informal, spontaneous changes in the system at the local level generally will prove to be less than satisfactory. Too many and too varied changes in the planned system, even when well intended, can destroy the diagnostic value of subsequent feedback. For this reason, all locally produced modifications and their effects should be communicated promptly to the system developers so they can be assessed and possibly adopted for the sys-

tem as a whole. Those difficulties which cannot readily be overcome would then become the problems for a future cycle of system planning and development.

System Design and Individualized Instruction

The application of a systems approach is particularly necessary when individualized instruction is contemplated. Rather special instructional systems need to be devised when it is expected that each student will proceed at his own pace. For instance, one unique problem associated with individualized instruction is that not all students will complete a course at the same time. And, unless previously collected data are available on each student's rate of learning, it is not possible to predict accurately which students will finish early and which will finish late. This problem is noticeably acute in technical training when a precise number of graduates may be required each month to fill job vacancies or enter a nonindividualized advanced course. In the academic setting, the problem can be solved to some degree by permitting those students who finish early to leave early and requiring those who work slowly to remain late. It also can be dealt with by assigning more units to the fast learners so that all students spend equal amounts of time in school but learn different amounts of content. Where a substantial investment has been made in training equipment, on the other hand, that equipment must be utilized fully at all available times to maximize the capacity of the system and reduce costs. In this setting, a 'pipeline' concept may have to be applied; sooner or later a constant flow of students will fill the 'pipeline' and a steady rate of graduates will be produced even though those completing the course together probably will not be those who entered the course together.

Special kinds of system models have been developed to handle several of the unique problems of indi-

vidualized instruction, including some which use a computer to simulate system functioning (see Cogswell, 1966b). One problem which can be considered by such a model is the optimization of quantities of self-instructional materials, laboratory facilities, audiovisual equipment and other constituent resources. Obviously, it is not necessary to provide materials, space and equipment in the quantities that might be needed if all students were to work on the same unit of the course at the same time. Too ample resources would not be a prudent use of funds while too little would make it necessary for some students to wait until the resources he needed were available. Careful planning and systematic tryouts can optimize the amount of resources furnished for a group of a given size. For instance, fewer resources probably are needed for short units than long ones and more resources may be required to support early units than units which appear later in the course when the students are likely to be spread apart in their progress.

The potential ramifications of individualized instruction are not limited to what adjustments may be needed within the classroom; they may include a substantial restructuring of the total educational system. As an example, an experienced systems planner would question the appropriateness of today's schools for individualized, media-based teaching. Classrooms typically are designed for intact classes with all students engaged in the same activity. Perhaps individual study areas are required, or perhaps individualization would be enhanced by facilities which resemble libraries. For that matter, perhaps school buildings are not really required at all except to store materials and equipment which could be loaned to students as needed for them to use in their own homes. Certainly working at home would not be any more distracting then work-

ing in a room with thirty or forty other pupils all doing different things.

If school buildings are not needed, perhaps classroom teachers are not needed either unless they must serve some essential function in the system. The human component generally is by far the most expensive link in the educational process. In many developing nations and regions, sparse resources may be more productively devoted to devising instructional methods which are not contingent on the presence and participation of a trained teacher than to attempting to replicate systems which evolved long ago in countries with more affluent economies. Even if the goal of reducing or eliminating teachers seems unattainable at this time, changes in the role of the classroom teacher may be possible. For instance, a class of forty students may be seen as an impossible challenge by teachers who normally teach only thirty pupils at a time, but that same number of pupils may be welcomed by a teacher who regularly faces fifty or so pupils in each class. With some adjustment in the training and expectations of the teachers, elementary school classes comprised of up to one hundred students each have been taught successfully in Seoul, Korea (Shin, 1969). And the television teacher, who might be disappointed by a smaller audience, does not seem to object to teaching thousands of students at one time.

The Systems Approach and New Media

The systems approach is a way of looking at a problem. It differs in many respects from the kinds of planning unfortunately characteristic of most educational undertakings. It is all too common, for example, to select textbooks by committee rather than by tryout and to plan teacher training by analyzing existing curricula than by analyzing the exact functions those teachers will be responsible for fulfilling. Similarly, as much effort sometimes is expended in getting teach-

ers to use filmstrips or slides or televised lessons as was spent in creating them. It is likely that these aids were produced, not to meet a need, but because someone felt it was important to produce filmstrips and slides and televised lessons. As Schramm, Coombs, Kahnert and Lyle point out (1967), the new media of instruction alone will not result in meaningful educational improvement; a systems approach to the use of these media is essential:

> *. . . if we had to name only one prerequisite of effectiveness of a new-educational-media project, we would say, let it begin with a problem. Let it not begin with a piece of new technology, but with a recognized and significant problem for which the most appropriate technology could be selected. . . . the new media are not miracle drugs for an ailing educational system. Rather they are potentially efficient system components which may be used effectively or ineffectively to strengthen an educational system* [*p. 117*].

As was noted earlier, the systems approach is far from a specific procedure. Although some exceptions undoubtedly exist, it is unlikely that any application of instructional technology has, at one extreme, totally ignored the integration of the innovation with ongoing practices or, at the other extreme, resulted in an instance where perfect planning produced a flawless outcome. Systems planning is a matter of degree. It also should be obvious that the systems approach will not itself eliminate the substantial discrepancy between the present way education is provided and the way it could or even should be provided. A systems orientation, on the other hand, offers those willing to experiment with education new tools that may make changes more feasible and success more predictable.

14

COMPUTER MANAGEMENT

One outgrowth of applications of the systems approach in education has been a recognition that education should have the administrative competence and efficiency of a modern business firm. Schools endeavoring to offer comprehensive instruction are responsible for collecting, processing and analyzing surprising amounts of data on student enrollment, attendance, grades, progress and health. Examinations must be scored, and assignments have to be processed. Class schedules have to be arranged so that maximum utilization is made of teachers, equipment and space. Compiling and maintaining school and student records can be and often is a sizable and expensive clerical task. Even more important, the magnitude of data may seem so overwhelming that no real effort is made to use the information that is or could be collected. Yet, an accurate statistical representation of the status of a school system is essential in order to determine where the system is and to plan where it should be going.

Data Processing in Education

The dramatic growth of computer technology has led many school systems to acquire computerized data processing equipment in order to gather and tabulate administrative and fiscal information, forecast needs and changes in trends, schedule students and classes, score and report objective test results and perform other clerical routines. At the present time, perhaps ten to twenty percent of all schools in the United States make some administrative use of high-speed computer systems, and this number is growing quite rapidly. Still further growth can be anticipated as a function of the ever increasing availability of computer services on a part-time rental basis from private data-processing organizations. These firms eliminate the need for capital expenditures by schools, can supply the personnel needed to 'program' the computer and still make it possible for a school to have a terminal within the building for data input and print out.

The use of computers also is likely to increase as greater numbers of individuals trained in data processing techniques accept careers in schools. Educators and educational administrators rarely have the background needed to recognize how computers can be used advantageously in the management of educational systems. Because the operation of computers largely has been in the hands of mathematicians, there has tended to be a disparity between the needs of users and the often elaborate treatment given these needs by computer specialists. For this reason, the educator should make an effort to learn the language used in discussing electronic computers and something about their components and principles of operation. A number of texts have been prepared which can be used for this purpose, including one by Gregory and Van Horn (1963) on general business applications, one by Borko

(1962) on computers in the behavioral sciences, and books by Grossman and Howe (1965) and by Haga (1967) on electronic data processing in education.

Tabulating School Data

Statistical tabulations of data to describe the current status of an educational system represent one of the simpler administrative uses of computers by school authorities, but one which has shown considerable promise. Kendall (1968) proposes the following as the basic information needed to evaluate the extent and operation of educational services in any developing country:

1. School facility data, by level or stream, indicating the number, size and location of all school buildings, and the equipment available at each one.
2. Classroom teacher data, reporting the numbers of teachers by sex, qualifications, experience and assignment.
3. Other personnel data, describing the kind, location and assignment of individuals who are not engaged in classroom teaching.
4. Pupil enrollment data, showing the numbers and characteristics of the students in each grade or level together with records on years repeated and attendance.
5. Financial budget data, disclosing the initial capital expenditure and recurring annual costs for each building, teacher and pupil in the system.

These statistics should be collected, Kendall feels, to:

> *. . . provide quantitative answers to such questions as how large is the system, what kinds of education is it providing, how rapidly is it growing, in which regions is it lagging, what use is being made of the teachers and of the schools. Adequate answers to these questions are necessary to justify the budgeting expen-*

> *diture and to make possible sound estimates of future expenditure; to give the educator an idea of what is happening and a firm basis for considering future development; and to provide the politician and public in general with a precise impression of the nature and extent of one of the major social services [p. 10].*

On a more local level, data processing equipment can be used with equal success to reduce the cost and errors of clerical operations which are now performed, if at all, by hand. Some of the more recent applications of computers for educational analysis and planning within a single school or school district have been to summarize information needed to equalize teaching loads throughout a school system (Farner, 1966a); to analyze optional course preferences across students in order to reduce scheduling conflicts (Farner, 1966a); to project probable school enrollment for planning staffing, construction and equipment requirements (Farner, 1966c); to compare alternate suggestions for weighting teacher experience and education in revising salary scales (Farner, 1966c); and to adjust the organization of school districts so as to provide comparable sources of tax revenues (Farner, 1966b). These and similar uses of computers can be expected to grow as educational management becomes increasingly sophisticated, and as progress in communications permits a more rapid response by school system administrators to problems and trends which now can be identified sufficiently in advance to be dealt with in a systematic way.

Planning and Prediction Techniques

When programmed to accept sophisticated mathematical models, computers also can have considerable impact on long-range educational decision making by

permitting evaluations of suggested changes far in advance of implementation in order to study their probable impact. For example, the Colorado State Department of Education has simulated an entire community called "Capsburg" to permit forecasting the effects of educational changes (Pfeiffer, 1968). The advantage of such a model is that it yields an overall prediction of the results of any number of changes all operating jointly. Models of this kind grow in accuracy and value as additional data on actual events and outcomes are collected and integrated into the model. Over a period of time, they will enable a shift in the focus of educational administration away from a crisis-to-crisis schedule and toward the kinds of planning emphasized by the systems approach.

School administration is not the only area within educational management where computers have proven useful. Goodlad, O'Toole and Tyler, for example, have suggested the potential advantages of a computer to permit teachers to 'call up' audiovisual materials, reference documents and other teaching aids based on information stored and indexed in computer memory (1966). They also recommend that a computer be considered as a means of selecting training programs for individual teacher candidates to make better use of their backgrounds and experience and to better prepare them for specific educational positions such as a member of a teaching team, a teacher of nongraded classes or a teacher of specialized courses in which subject-matter expertness is required. Hayes (1967) envisions libraries which store documents centrally, index content by automatically analyzing the full text and permit retrieval at remote points by transmitting images or facsimiles.

Cogswell (1966b) has reported identifying needed changes in the organization and structure of school systems by using a computer supplied with appropri-

ate mathematical models to study the flow of students through the school. Emphasis is given to the steps which represent decision points, such as when a student is accepted into the school and when his program of studies is determined. One improvement he has proposed is the creation of a 'surveillance and detection' function which automatically analyzes student performance data and, if a student appears to be having trouble, alerts appropriate school personnel who then can take action to remedy the difficulty. Another highly promising use of computers in managing the educational process has been in providing students and teachers with authoritative school and career guidance information (see Cooley & Lohnes, 1968; Cogswell, 1966a; and Grossman, 1966). The computer can analyze the results of aptitude and interest tests; consider past student performance, and then combine this information to make predictions based on patterns of success and failure and manpower planning data. One of the projects in this area has been to place the counseling interview itself on a computer (Cogswell, 1966a). By answering much the same questions as he would during an actual interview, the student can obtain the guidance he needs but avoid the often aversive experience of reporting his difficulties and problems to another person. A computer terminal reserved for this purpose also is considerably less expensive than a permanently employed, highly trained counselor.

Test Scoring and Analysis

Scoring objective tests and preparing examination results is still another clerical routine for which computers are well suited. Several optical reading and mark sense scoring machines are available which automatically score, item analyze, tabulate and record test data on punched cards or magnetic tape for processing by a computer. National testing programs designed to

control the quality of instruction, to select students for secondary and vocational training, or to provide basic career guidance would be impossible without machines such as the IBM Series 1230 devices or the Iowa Electric Test Scoring Machine which can score up to 13 tests per student answer sheet and 5000 answer sheets per hour (Flanagan et al., 1962). A more recent development has been the use of computers to score essay tests and correct student compositions. Page at the University of Connecticut is one of the researchers who has arranged a computer to analyze written content (Education USA., 1968a):

> *In 30 seconds the computer can 'read' an essay and analyze it for ideas, organization, style, mechanics, and creativity. On a trial run, using 256 papers written at a Wisconsin high school, the computer's judgments were practically indistinguishable from those of English teachers* [pp. 16-17].

This system not only assigns grades but prints out comments similar to those a teacher would write on the student's errors in grammar, spelling, sentence structure, usage and punctuation. At the moment, student essays must be punched onto cards or typed before they can be analyzed. However, it is quite possible that having the student prepare his composition directly in machine usable form or the further development of optical readers which can interpret handwriting will vastly reduce the need for trained teachers to grade student productions by hand.

Managing Individualized Instruction

Perhaps one of the most important applications of computers in education has evolved from various plans to individualize student progress by permitting each student to learn on his own and to adjust the time he spends on any one topic in accordance with his ability,

background and interests. Early efforts in this direction, such as the Winnetka plan of the 1920's (Washburne & Marland, 1963), were very difficult to sustain because of the sheer number of instructional management decisions that had to be made, one or more each time a student completed a unit and was ready to move on to the next. Computerized systems have considerable potential as a practical means of implementing individualized student progress schemes, however, and substantial progress has been made in this direction in the past few years (see Brudner, 1968).

To appreciate the impact which computers may have on managing instruction, it is necessary to understand the logic of individually prescribed instruction systems or their predecessors, continuous progress plans. These systems of education are designed to overcome the problems inherent in trying to offer uniform classroom instruction to thirty or more students at one time. Because of ability differences, a presentation at the level of the average student is likely to be too slow to maintain the interest of a superior student while the same presentation is apt to be too fast to permit the poorest students in the class to grasp all the essential concepts being taught. Individually paced instruction permits everyone to learn at his own, self-selected speed by providing study materials that can be used by the student without direct assistance from a teacher. In various plans, this approach may be applied to the entire curriculum or to only parts of it; it may entirely replace traditional classroom teaching or do so only during certain periods within a school day.

To simplify administrative practices, the content to be learned by self-study methods usually is divided into segments or units. At the beginning of each unit, the student receives a set of study materials, including texts and other instructional aids, and often an outline

of topics to be covered. The student is expected to stop at the end of each unit to have his progress assessed by a test of what he was to have learned. Depending on the results of the examination, the student is permitted to continue on to the next lesson or is required to undertake remedial work. This corrective work may consist of returning to the original materials for further study, assignments in parallel or supplemental materials, a conference and tutorial assistance from the teacher, or some combination of these remedies. Units vary considerably in size depending on the intent of the program. Very often, however, they include about five or six hours of work. The average student usually is encouraged to work on a range of subjects simultaneously so that roughly equal time is spent in each curriculum area such as science, mathematics, language arts, social studies and, possibly, a foreign language. This means he will complete an average of about five units each week, one in each area.

Typically, then, in even the most simply organized plans each student will take about five examinations each week, and a teacher with thirty students in the class must grade and review the results of perhaps 150 tests every five days. In addition, the teacher must keep track of each student's progress to be sure he takes the correct examination each time and that he maintains reasonable diligence in every area. This amount of record keeping not only is tangential to the interests and capabilities of most teachers, but leaves little if any time for the student-teacher interactions needed to overcome the always present minor defects and inadequacies in the study materials typically developed for individually prescribed instruction plans which otherwise would prevent these systems from succeeding.

Data processing equipment not only can keep track of each student, but also can be used to identify the

more common weaknesses in specific units, based on the performance of large numbers of students, so that these units can be improved. Various terminal devices can be installed to process student quiz results automatically. The student can record his answers on punched cards or tape, use a stylus to complete a partially punched hole, or operate some simple keypunch device. Mark sensing and optical reading equipment developed for test scoring purposes can be used both to collect test information and to convert documentary data to data processing cards or tape.

Once individualized instruction is computer managed, a number of variations and elaborations on the basic approach is possible. For example, a much wider curriculum can be offered with many more options to the student than is possible when a teacher must be responsible for record keeping and decision making. If desired, an entire sequence can be planned for each student based on his own interests, talents and goals, a sequence which may be uniquely different from the one prepared for any other student. As another example, a number of parallel units can be devised which differ slightly in emphasis, reading difficulty, use of instructional aids or number of practice exercises. Which of these alternative units should be begun by any one student can be a decision based on the student's past experience and success with comparable materials. This degree of thoroughness in offering individually prescribed instruction is beyond the information storage, retrieval and analysis capabilities of a human teacher, but is no problem at all to modern computers.

Computer managed individualized instruction plans have been adopted in a number of trial applications. Several of these have been described by Cogswell (1966b) and by Pfeiffer (1968), including those at the Brigham Young University Laboratory School

in Utah, the Theodore High School in Alabama, and the Garber High School in Michigan. Still other applications are now in progress or under development. One of the largest of these, Project PLAN, is described in detail in a later chapter. Not all of the attempts to develop systems of individually prescribed instruction, even with the assistance of modern computers, have been successful. Problems almost invariably occur in trying to isolate suitable units of content, in keeping students fully motivated with only minimal attention from a teacher and in smoothing the difficulties of students who may transfer between the experimental school and either a traditional school or some other experimental program. Even more crucial is the problem of the degree to which students can teach themselves using various self-study materials.

An Example of Individualized Instruction

Perhaps one of the most widely visited projects employing individually prescribed instruction is at the Oakleaf Elementary School near Pittsburgh, Pennsylvania. This project began in 1964 as one of several innovative efforts undertaken by the University of Pittsburgh's Learning Research and Development Center under the direction of Glaser. As explained in a recent report on this project (Education USA, 1968b), the participating students are at the primary level, from kindergarten through grade six. Individually prescribed instruction is used at all grades for mathematics and reading and recently was introduced to teach spelling and science as well. Not all of the student's time is spent in self-study; instead, the school day is divided into periods with some set aside for individual work and others devoted to more traditional classroom activities.

Although the developers of the system have recognized the desirability of integrating instruction across

subjects, each subject matter has its own, independent sequence at the present time. Each sequence is divided into 'levels' which correspond roughly to the content of one year of normal classroom instruction. The levels are further divided into 'units' corresponding to about two weeks, or ten hours, of traditional teaching. Each 'unit' consists of several 'objectives' organized so that the instruction relevant to any one objective ordinarily can be completed in one regular class period.

On some typical day, a student will refer to his 'prescription' sheet which indicates the lesson he is to begin next. The student himself collects the necessary lesson materials from a storage area in the classroom. The materials for a specific unit, for example, may consist of an audio recording, some printed pages and a worksheet the student is to fill out as he progresses through the lesson. The student places the record on a phonograph equipped with earphones and the recorded voice tells him what he is supposed to do. He can stop the recording to complete an activity or he can repeat a portion of it if he did not understand the directions the first time through. At the end of the lesson, the student takes the completed worksheet to a teacher aide, or assistant teacher, who reviews it for him and tells him to continue with the next lesson if everything is satisfactory. If the teacher aide is not satisfied with the student's achievement from the lesson or is uncertain about it, the student's worksheet will be reviewed by the classroom teacher who also will furnish supplementary help if it is needed. Because each lesson is brief, and because the performance expected of the student at the end of the lesson is clear, misunderstandings and incomplete learning can be detected easily and corrected before these weaknesses are compounded in future lessons.

While the student at Oakleaf works on his own, he is able to ask for assistance from the teacher by

raising a small flag at his desk. Even with a teacher and several teacher aides in the room, help may be several minutes off, however. As a result, the students are expected gradually to become more independent, ask less questions and try to puzzle out problems for themselves. At any one time, it is more than likely that every student in the room will be working on a different lesson. This limits opportunities to combine several students with similar problems into one tutorial group, but it also means that only one or two copies of each set of lesson materials are required.

At the end of each unit, the student is administered a comprehensive posttest which may require both oral and written answers. A student who had failed to achieve 85 percent of the specific objectives for that unit is required to return to the unit for further work on lessons he has not fully mastered. These remedial assignments also may include tutorial sessions with the classroom teacher. Students who pass the examination are then given a pretest for the next unit and, on the basis of the results of this test, a new prescription is prepared which specifies which subsequent lessons the student is to work on. Students who already demonstrate mastery of specific objectives are not required to study the corresponding lessons. Supplemental prescriptions may be prepared as the student proceeds through the unit to modify the student's assignments based on the progress he has shown.

The results of three years of experience with this system at Oakleaf have been very encouraging. Individual differences in student learning ability are fully reflected in rates of student progress. For example, while the average student would complete the equivalent of 37 units in mathematics in three years of traditional teaching, one very able Oakleaf student completed 73 units, or more than five years of content, while the slowest student finished only 13 units, just

as much as normally is expected following only one year of instruction. Revisions of the instructional materiels based on deficiencies identified from records of student performance on tests and exercises have led to generally better average achievement each year.

The use of a computer in this project has been only marginal up to the present time. Teacher aides are needed to assess student progress because the system now depends heavily on evaluating oral and handwritten answers. A far better understanding of how to prepare instructional materials will be required before student errors will be reduced to the point where these examinations no longer will be necessary, or new techniques will have to be devised which make it possible to evaluate a student's oral and handwritten responses electromechanically. A computer is being used at Oakleaf, however, to compile the data needed to revise lessons and to assist the classroom teachers in preparing prescriptions by matching student difficulties with alternate ways of overcoming them. One of the problems being faced is deciding what information is relevant. Little has been done on this problem until recently because of the magnitude of the task of keeping detailed records on the daily or hourly performance of every student; this clerical task literally is impossible without electronic data processing equipment. Were teachers to be given the responsibility of integrating the large amounts of detailed student information needed to make decisions regarding student assignments, they at best would be able to utilize only a small fraction of the pertinent data.

The Prospects for Computer Management

Returning to the more general question of the probable role of computers in education, it seems quite likely that electronic data processing equipment installed to serve the administrative needs of schools

and school districts will become increasingly popular and productive over the next several years. The extent of waste in any highly diverse organization, including almost every educational system, probably is much greater than most administrators would be willing to believe. The use of computers to make better use of existing resources, to maintain quality standards and to intelligently plan for the future almost necessarily will more than recover the costs involved. The use of a computer as an aid to educational administration requires only a few centrally located input and output devices. Even current information, such as attendance records, need not be processed immediately and there is ample time to transport the information to a central facility when this would be less expensive than having terminals located at each school and connected to the central processing equipment by communication lines.

Computer managed classroom instruction also seems to have promise, but only for the more distant future. One problem is the much greater amount of equipment that would be required. Computer supervised instruction is far more sensitive to time delays than computer based educational administration. Even a system of individualized instruction designed to permit a delay in assignment decisions for as long as a day by having students engage in multiple, concurrent tasks would depend on a volume of input and output data so large as to require at least one terminal in every school or, perhaps, one for the use of each classroom teacher.

The cost of the equipment necessary to support a system of individualized instruction is difficult to estimate because of three reasons. First, the frequency of data transmission called for in different systems of computer managed instruction is highly variable. Second, the costs of the central computer equipment that might be required to provide the needed data process-

ing and storage capability are changing rapidly. And third, the distance separating the terminals from the central computer, which must be bridged by transmission lines, will differ considerably from one location to the next. The overall cost might be in the order of $10 to $25 per student, per year, a figure beyond the reach of many developing countries but actually less than the $30 it presently costs to give any one student a single day of computer aided instruction.

The expense of a computer installation is not necessarily a permanent deterrent to individualized instruction, however. Frequent assessments of student progress may well seem impractical on a large scale without assistance from a computer but, when necessary, the work could be done by hand. In the Oakleaf project, for instance, the bulk of the clerical effort is performed by teacher aides and not by data processing equipment. There is hope, too, that sooner or later the problem itself will be eliminated by further improvements in instructional methodology. For example, techniques which completely eliminate the need for remedial work by insuring that learning invariably will occur also would eliminate the need for collecting very large quantities of student information and, in turn, would abolish most data processing requirements entirely. This approach would represent a more desirable, more permanent and more efficient long term solution, although the necessary techniques still remain to be devised.

15

DIAL ACCESS SYSTEMS*

One of the very first applications of individualized instruction within an ongoing school program was the 'language laboratory.' The earliest of these language laboratories were no more than audio devices which allowed students to hear the voices of native speakers. According to Hocking (1967), the first device of this kind was developed for use in teaching conversational French in 1904. Successively, projected visuals and sound motion pictures were added to the capabilities of language study equipment. Hocking reports that, as early as 1924, students were learning Spanish at the Ohio State University with individualized equipment which permitted recording responses for comparison with the native speaker's voice. The growth in popularity of conversational language instruction in the United States during the 1950's led to installations with increasingly large numbers of stations and varieties of lesson materials.

* Mr. Garrett Mitchel, Director of the West Hartford project, and Dr. Stafford North, Dean of Instruction at Oklahoma Christian College, were very helpful in supplying detailed information about the dial access systems being used in these two locations.

The Growth of Dial Access Systems

Centralized playback mechanisms operated by a laboratory assistant became increasingly necessary to simplify student use of the equipment and to prevent damage to tapes. These systems were unwieldy, however, when large numbers of stations and, consequently, large numbers of requests for specific tapes were involved. The first laboratory which made it possible for students to automatically select individual tapes was installed at the University of Michigan in 1961 (Ofiesh, 1968). This installation permitted each student station access to any one of 108 separate audio channels by dialing a code using a telephone-like device. Remotely controlled language laboratory equipment based on dial principles also was described in 1961 by Brubaker (Hocking, 1967, p. 193) and by De Bernardis and his associates (1961).

The application of dial access principles to a full range of audiovisual equipment and for presenting instruction on a variety of academic courses other than foreign languages was an expectable development. Broad purpose installations appeared almost simultaneously in 1965 at the Ohio State University, Oklahoma Christian College, Oral Roberts University and Grand Valley State College (Ofiesh, 1968). By early 1968, Ofiesh was able to identify 121 dial access systems already in use; 43 of these were limited to language teaching but 78 were designed for multi-subject teaching. Another 56 institutions were in the process of planning a dial access system (Ofiesh, 1968, p. 25). Of those in use, 58 were at colleges or universities, 13 at junior colleges, and 50 in primary and secondary schools. The typical installation contained about 35 student stations, although two universities reported capacities of 160 students each. The cost averaged about $1,000 per station including central playback equipment (Ofiesh, 1968, pp. 92-95).

Dial Access at Ohio State

The very rapid proliferation of the dial access concept suggests these systems are fulfilling an important educational need. Clues to what this need is, and to how successfully dial access systems overcome it can be found in an examination of some typical installations. One of the pioneering schools was the Ohio State University. This system, which is limited to audio instruction only, utilizes the university's regular telephone service to give college students at each of the 267 booths located around the campus access to any of 60 separate channels (College and University Business, 1966). To use the equipment, a student locates an empty booth, puts on the earphones, turns a switch and then dials a number corresponding to the lesson he wishes to hear. Most of the lessons provide instruction on conversational skills in modern languages although about 25 percent support music courses and some use of the equipment is made to play recordings of dramatic performances and provide speech therapy to stutterers. Language lessons are about 10 minutes in length, music tapes 30 to 50 minutes and plays, which are recorded by acts, may be several hours long.

When a student dials the access number to a channel, a computer automatically switches him to the proper playback unit. If that lesson is not being used at the time, the computer will start the tape. When the lesson is complete, the tape will rewind and begin again. If the student 'hangs up,' the tape will rewind so that it is ready for the next call. If the tape a student wants to hear already is in use, the computer will add that student to the channel. He will hear the lesson from the middle, but it will continue playing over and over until there no longer is any student on that line. Very long presentations, such as entire sympho-

nies, are begun at specific times under the command of the computer so that students wishing to hear several tapes in order can schedule their use of the booths accordingly. The Ohio State system, which now operates 95 hours weekly, is used between 35,000 and 40,000 times each week, or more than once for every student enrolled in courses on the campus (College and University Business, 1966).

Dial Access at Grand Valley

A far more elaborate dial access system was developed by the Educational Facilities Laboratories for Grand Valley State College, near Grand Rapids, Michigan. This college, which was first opened to students in 1963, has 256 carrels housed in the library building. About half of the booths have access to any one of eight closed circuit television channels; these and most of the remaining carrels also have access to any one of 120 audio channels (Wisniewski, 1967). Four of the classrooms at the school contain terminals which provide access to all video and audio channels and, in addition, have a speaker system which permits the playback of any library tape from the central control room on the request of the classroom instructor. Similar units in the three auditoriums have all of these features plus a capability for displaying live or taped lessons from the television studio. Together with the recording equipment, studio and related facilities, the cost of the system has been more than $250,000 (Potter, 1968).

At Grand Valley State College, the dial access system is meant as a supplement to, rather than as a replacement for, regular classroom instruction. Most of the use of the audio components of the system is for language skill, music and similar self-study materials. The television capability has been used more broadly to present a variety of lessons in physics,

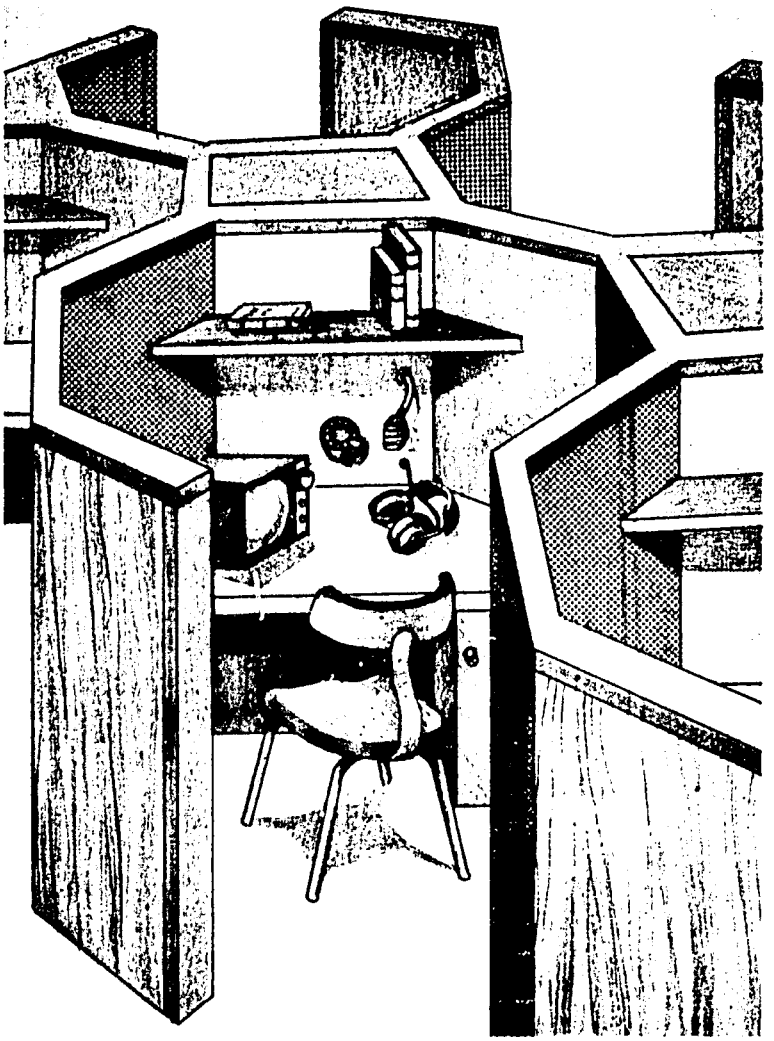

Figure 20. Carrel used at Grand Valley State College.

anthropology, political science, English, psychology and teacher preparation (Broadcast Management/Engineering, 1967). Several difficulties with the system already have been observed. One of these is that earphones had to be substituted for the loudspeakers in

the carrels because the booths could not be satisfactorily soundproofed. Another problem is that no equipment is available at a reasonable cost to merge the video and audio systems. A student may turn to any of the eight video channels but this is done without the aid of the dial mechanism. Still a third difficulty is with the 4-track audio equipment which was installed as an economy measure. Although all four tracks play simultaneously and each can be accessed independently, when a student listening to one track initiates a rewind cycle, he interrupts the listening of all students connected to his or any of the other three tracks (Potter, 1968).

Dial Access at Oklahoma Christian

Perhaps the most comprehensive use of a dial access system is at Oklahoma Christian College in Oklahoma City. This is a small, privately supported school with a strong religious affiliation. Following fifteen years of operation using traditional instructional methods, the college planned an entirely new campus. A key concept for this new campus was that independent study was to be encouraged by providing every student with a well designed study carrel for his own personal use. An important feature of each carrel was to be a dial access audio system which would form an integral part of the resources available to the instructor of each course. As explained in the guide distributed to the students:

> *For a three semester-hour course, then, a teacher can work with about eight or nine hours of student time a week and a wide variety of teaching methods. He may combine these in whatever patterns he believes will be most effective. The teacher of one three-hour class may want to meet in person with a class two hours a week, have students spend two*

> hours working with tapes and workbooks, and assign about five hours of work in reading, writing, and study. Another teacher may want to meet with a large group once a week, a small group once a week, have one tape a week, one movie a week, an individual session once a month, and some assigned reading and writing [Oklahoma Christian College, 1968; Appendix: Student Guide, p. 4].

The system was installed in 1966 on the second and third floors of the student library. There are 1024 individual carrels for an enrollment of approximately 1000 students. Each carrel includes earphones, a dial to select from among 136 audio channels, space for books and a typewriter if the student wants to use his individually assigned booth for all of his studying, and space and connections for projectors which may be borrowed as needed to view slides, filmstrips or motion pictures. The carrels are available for student use about 100 hours each week. Because a booth is reserved for each student, he may decorate it as he wishes, eat snacks while studying and, if he wants to, bring in a radio equipped with an earphone or turn a switch on his console to listen to a local radio station while studying. Administrative controls over the use of the carrels are designed to minimize possible disturbances and maintain the area as a quiet place for serious study.

At Oklahoma Christian College, the dial access system is an integral part of regular instruction, not a supplement to it. The self-study lessons, which average 30 minutes in length, may consist of taped lectures prepared by faculty members, taped exercises designed as drills to help students memorize factual information, and aural study material including recorded music, dramas and speeches. To the extent possible, every lesson is accompanied by a workbook which is

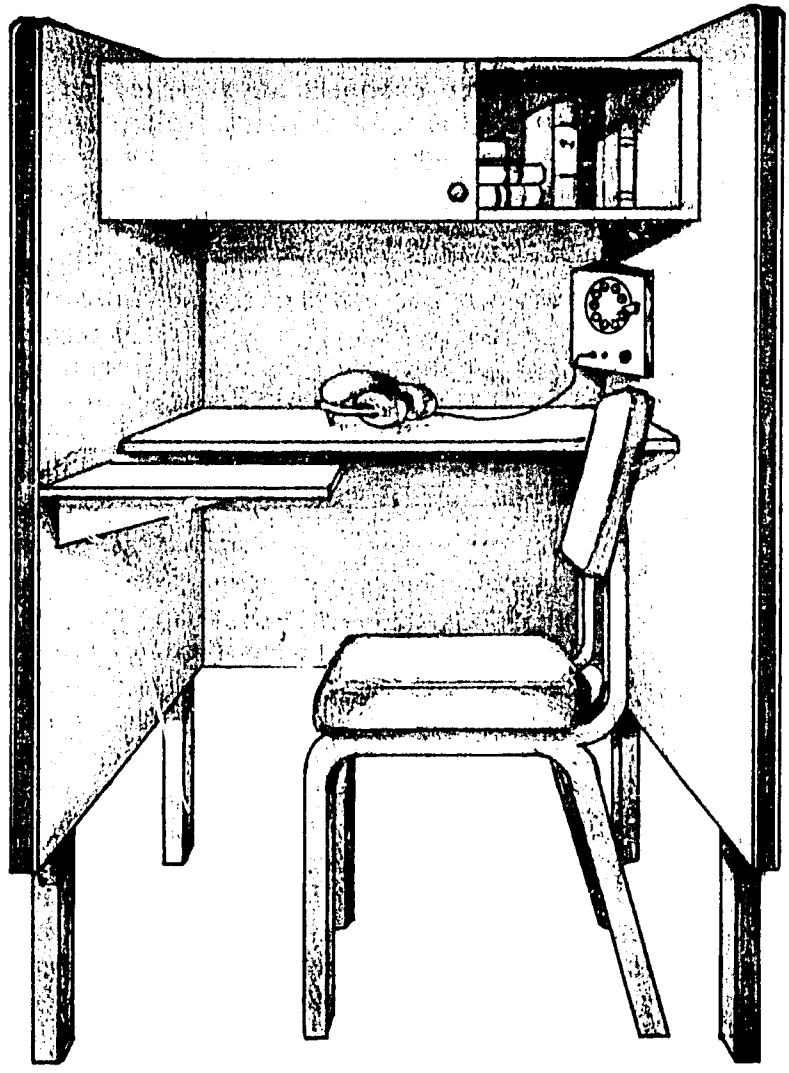

Figure 21. Carrel used at Oklahoma Christian College.

keyed to the taped lectures and contains questions for the student to answer, space for notes, charts and maps, and outlines of the recorded material. The workbooks for each course are purchased by the students

at the beginning of each term along with their textbooks. A student may plan his own time in the carrel. About 35 of the audio channels are reserved for recordings presented at scheduled times during the day while the remaining 100 or so channels operate only on command from a student. The system uses 4-track tapes and playback units which operate very similarly to the system installed at Grand Valley State College. The cost of the system so far has averaged about $400 for each carrel including the cost of all central recording, playback and dial access equipment (North, 1966). Further carrels could be added to the existing selection and playback system for about $100 each.

A survey of student study habits before the system was installed indicated that 56 percent of the students did most of their studying in their dormitory rooms. Now, 60 percent do most of their studying in their carrels. The average student spends three or four hours a day in his carrel, although some students make very little use of it and others study there as many as ten hours a day. The developers of the system recognized that each booth might be used only a few hours each day but felt that insuring the availability of a booth for each student's exclusive use more than made up for the extra cost of additional carrels. One implication of this approach is that dormitory rooms no longer must contain study areas or desks. As North points out (1966), if the dormitory room no longer is considered the prime study area, substantial savings might be realized in the design of new dormitory facilities.

From the college's point of view, the system can be more economical than regular classroom teaching. Because they do not have to repeat lectures to several different classes each term, the faculty has more time for other functions such as holding discussions with groups of students or preparing new recorded materials. Courses offered to several sections of students

each year, as might be done for history or French, may require only half as many instructors if ordinary lecture material is presented by means of the dial access system. The school also believes that less classroom space may be required because classes now meet only once or twice a week instead of three times or more. Maintenance of the system is the responsibility of one full-time technician.

Research results on the effectiveness of the system are limited, but one study compared the performance of students conventionally taught a beginning speech course with the performance of students who learned the principles of effective public speaking from 16 taped lectures and accompanying workbook materials. Improvement within the two groups was about equal and both substantially surpassed a control group which received no instruction between pretest and posttest. Of the 31 students who learned principally from tapes, 26 preferred self-study, 3 felt they rather would have had conventional instruction and 2 indicated no preference (North, 1965).

The system at Oklahoma Christian College also is not without problems. When mechanical breakdowns do occur, they sometimes require parts which are difficult to obtain and the system can be out of service for two or three days at a time. The design of the carrels generally is felt to be satisfactory although further soundproofing, particularly through the addition of carpeting throughout the carrel area, has been recognized as almost essential. Very little instructional material for the system is available commercially and most of the tapes have to be produced by the faculty. Approximately two full days are required to prepare and record each taped lesson although the time varies considerably depending on the lesson content and the skill of the instructor responsible for it.

Another carrel area for the use of upper class students has been planned. Unlike the existing booths, these will not be equipped with a dial access system; instead, each one will contain a cassette tape playback unit. The reason for the change is not a reappraisal of the value of dial access but rather that it will be less expensive to provide every student with a copy of the tapes when, as is typical of advanced courses, less than thirty students are enrolled. The central control and switching equipment needed for dial access represents about three-fourths of the total cost of the system and this expense is felt to be practical only when large numbers of students need to listen to the same tapes at approximately the same time.

Dial Access at West Hartford

The emphasis on independent study at Oklahoma Christian College may be more difficult to implement for younger learners, but several dial access systems have been installed for use at the secondary and primary school levels. One of these is a pilot project in West Hartford, Connecticut, which includes dial access facilities installed at two senior high schools, two junior high schools and five elementary schools. Each school is equipped with at least one classroom access unit and two individual carrels, but some schools have larger numbers of terminals and there are ten classroom units and eight carrels in one of the buildings. The various schools are connected to the central control and playback equipment by communication cables.

At the present time, there are 8 video channels and 32 audio channels to select from. Preference in the use of these channels is given to the teachers in classrooms equipped with monitor units. The teacher submits an advance request to have one of 4000 films, 3000 filmstrips or other audiovisual materials stored at the central control point shown at a particular time. These

materials all have been converted to video tape to simplify transmission. At the scheduled time, the teacher dials the number of the 'Program Channel' which shows the dial access number of all scheduled presentations on the remaining audio and visual channels. The correct number then can be dialed so that the class can view or listen to the proper tape. Students at the carrels may dial into the system at any time to view scheduled transmissions over a television receiver in their booths, or listen to an audio channel. They also may call the center and request an unlisted program. That lesson will be supplied if a vacant channel is available.

One disappointment experienced so far at West Hartford has been the absence of the kinds of lesson materials that the majority of teachers want to use. Most commercially available films either are too long, 30 to 45 minutes, or too short, 3 to 5 minutes, to be consistent with the aims of the system. The longer films usually were intended to be very broad in scope and were planned to contain enough background and generality to be useful everywhere. The short films, usually single concept films, frequently have too little introductory information to be appropriate for individual study. The most successful lessons now being presented are those illustrating procedures — the conduct of a chemistry experiment, for instance — which can be used year after year. The use of the system by students in individual carrels for review and enrichment has not been given much attention up to now, both because of the limited number of carrels that have been installed and the difficulty in scheduling their use at the same time as classes are in session.

The present experimental system, which was installed at a cost of about $60,000, is being expanded following the completion of a new high school building which was designed to provide space for a fully equipped transmission center. The new equipment,

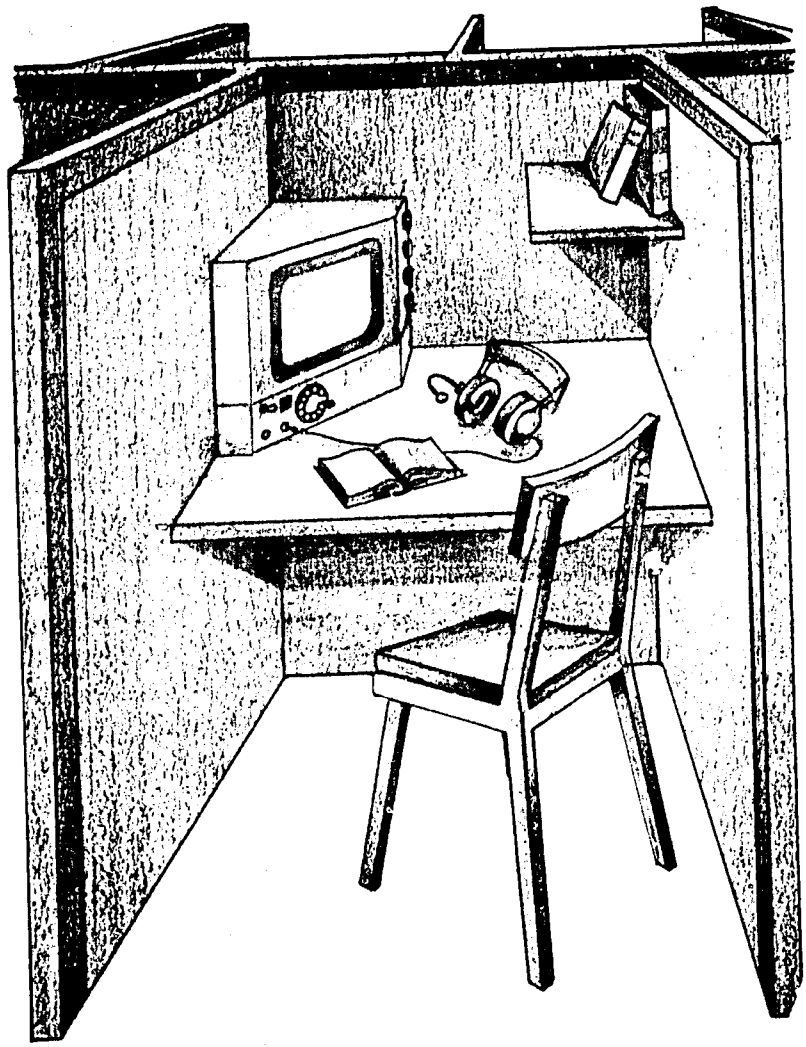

Figure 22. Carrel used at West Hartford, Connecticut.

which has a capacity of 20 video channels and 100 audio channels, is being installed at an expected cost of $250,000 (Towne, 1967). In addition, 50 classrooms in that building are being provided with dial access monitors and 100 dial select carrels will be installed to

serve the 1500 students at the school. The flexibility of the new West Hartford system is evident from the number of lessons that can be transmitted. If the lessons average twenty minutes each, the system has a capacity of 360 programs per hour, 1800 per five-hour day, and 9000 per five-day week (Towne, 1967). It is hoped that the new system will have components less likely to break down than those presently used. The developers also hope that substitutes will be found for the 4-track playback units which, as in other systems where they are used, fail to give each user full control over the recycling of lesson materials.

Dial Access at Oak Park

The problem of full random access to stored lessons from every carrel has been partially solved by a very elaborate dial access system installed at the high school in Oak Park, Illinois. This system, like the ones at West Hartford and Grand Valley State College, has both audio and video capabilities. The central equipment has up to 224 fifteen-minute audio lessons stored in it. However, instead of transmitting a taped lesson directly to the student's carrel, a buffer tape unit is used to duplicate the master tape at 40 times normal listening speed. To hear a lesson, the student presses a 'clear' button and then presses a sequence of buttons corresponding to the dial code number of a desired lesson tape. In about 30 seconds, the requested lesson will have been transferred from the master tape to the student's own buffer unit and playback of the lesson will begin. He never has to begin a lesson in the middle because another user already initiated playback of that tape or receive a busy signal if all channels to that lesson already are in use. The student's duplicate of the master tape can be stopped or recycled whenever he wishes without affecting another listener. When a stu-

dent is finished with the lesson, a new master tape can be selected and copied on to the tape in his buffer unit.

The video aspects of the system at Oak Park, which currently are being installed, will operate without a buffer. As many students as want to will be able to ac-

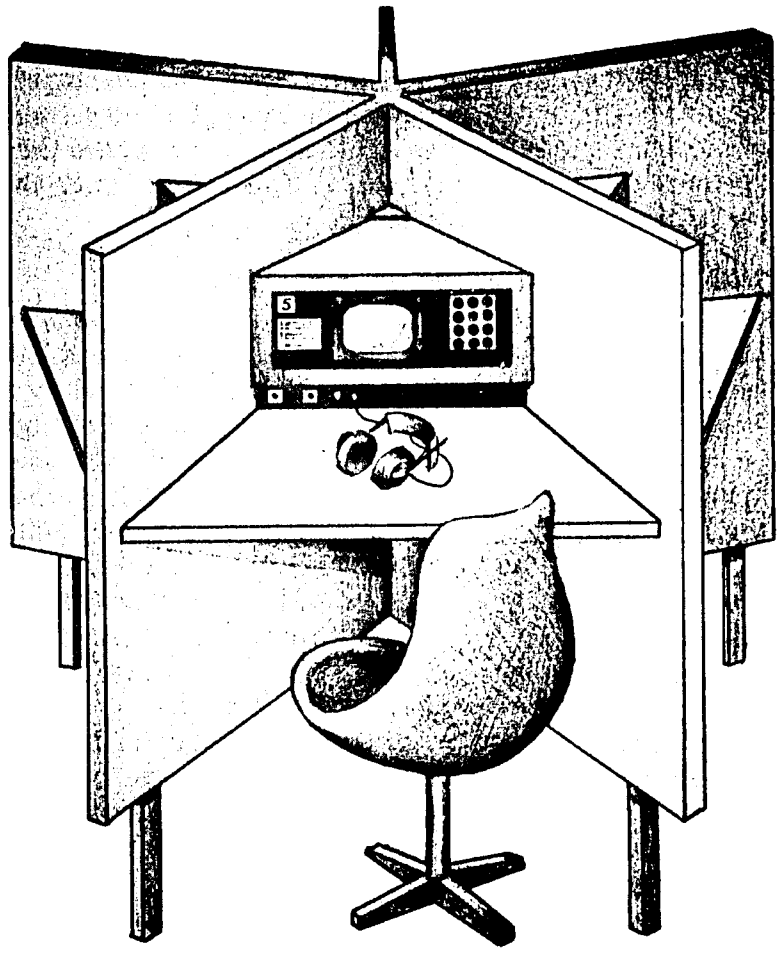

Figure 23. Carrel used at Oak Park, Illinois.

cess a television lesson but, once begun, the lesson will continue until it is completed. A student who happens

to enter a lesson in the middle would have to call up that lesson again to see the first half. The video components also will have a capability for transmitting still pictures to complement an audio lesson and will permit the reception of live telecasts. At the present time, 25 student carrels are in use and work has begun on expanding the system to 75 carrels. The entire installation is expected to cost approximately one million dollars, or roughly $13,300 per student station (Educational Media, 1969).

The Prospects for Dial Access Systems

The potential impact of dial access systems on educational practices cannot yet be evaluated. Most systems are relatively small and relatively new. Several tentative conclusions seem to stand out, however. First, dial access systems have been used in three distinct ways. At most schools, such as Ohio State or Oak Park, the equipment serves as a combination language laboratory and audio or audiovisual library. These systems are supplemental to conventional instruction. A second use, at both West Hartford and Grand Valley, is to supply audio and visual materials to classrooms for use during conventional instruction. Access to these lessons by individual students from their own carrels is a somewhat incidental feature. The third pattern of use, the one at Oklahoma Christian College, is the only kind which attempts to integrate individualized instruction and more conventional methods in a systematic way. Because this system emphasizes self-paced learning, it is the one most likely to stimulate any fundamental change in educational practices. Oklahoma Christian College, incidentally, is perhaps unique in offering visitors an orientation to the system using a student carrel. This lesson is complete with taped instructions, a workbook guide and accompanying exercises to be completed while listening to

the tape, and a filmstrip that is used to illustrate concepts introduced on the tape.

The overall cost of a dial access system depends on the type of equipment used and the number of stations. According to Ofiesh (1968), the median total equipment cost of 94 installations on which data were available was $56,000. The cost of developing lesson materials locally for a typical dial access system has been estimated to be about half of the cost of the equipment (Stewart, 1967), or perhaps an additional $28,000. This ratio reflects the higher lesson production costs when a system is equipped with a video capability and the larger number of lessons that could be appropriate for a system with many channels and many student carrels. Ofiesh points out that a large amount of materials is commercially available which could be converted for use in dial access systems (1968). Yet, most schools now using dial access equipment report that commercially available lesson materials rarely fit their needs and that most of the materials they do use have had to be developed locally. Neither the exchange of materials among dial access centers nor the connecting of several together with transmission lines is likely to solve this problem. There are too many differences among otherwise independent school districts for them to comfortably share lesson materials on a large scale.

Whether or not content can be provided, an important question remains. Is dial access worth the cost? So far, the answer seems to be a clear no, at least for the numbers of stations and channels typically planned. As Oklahoma Christian College discovered, it may be far less expensive to supply each student with his own cassette recorder than to connect him to a central playback unit. Projectors for individual use which show color sound film from cartridges can be obtained for less than the cost of the colorless television monitors usually needed in a dial access carrel

to give it a video capability. Only when fairly sizeable numbers of students would be expected to want to learn from the same lesson at the same time would remote playback seem warranted. And, even then, it would be far less costly to use a simple selector switch to choose the appropriate audio or visual channel than an expensive dial network arrangement, particularly for systems intended for classroom use.

It is clear, too, that one of the prime arguments in favor of a dial access system, that of permitting instruction from a variety of media sources without the need for vast quantities of various film projectors, individual audio units, and so forth, could be remedied equally as well by single devices capable of presenting media in various modes. The commercial producers of film and recorded material seem unable to agree on standardized presentation equipment. Yet, materials produced locally to meet instructional needs at least could be designed for a single multiple-purpose device installed in each classroom or carrel.

Finally, it is clear that most existing dial access systems are not really individualized at all. Only at Oak Park can a student stop the presentation or repeat a segment from it without interfering with the progress of other students. The novelty of dial access seems to be a high price to pay for the loss of self-paced instruction. These systems do allow students to repeat entire lessons, but this approach seems to be an unwieldy way of overcoming learner difficulties. Even if dial access systems are tied into a regular telephone system so that students can hear lessons of their choice in the comfort of their own homes (see Potter, 1968), the fixed pace of the instruction will continue to limit its potential value.

On the other hand, dial access systems are a significant development in terms of getting instruction out of the classroom, with its traditional constraints. These systems also make it clear that a taped lecture

can be as good, or even better, than a parallel live lecture which cannot be planned, prepared or presented with equal care. The automation of instruction becomes a reality when students can be remote from their instructors both in time and space, and the growing need to economize on instruction is likely to encourage more and more automation. Once this trend becomes inevitable, it is likely that much needed efforts to improve on the quality of the presentations will occur as well.

16

PARTIAL INDIVIDUALIZATION*

A number of complete systems of instruction have been devised which combine several innovative approaches to meet learner needs. One of the most encompassing of these is the dramatic, television-based system at American Samoa in the South Pacific. The project began as the core component of a major developmental program for the islands initiated in 1961 by the newly appointed governor, H. Rex Lee. The problem Lee faced, one which unfortunately is typical of most developing regions, was that less than half of all school age children were enrolled in school and, of those who were enrolled, less than one percent met minimum achievement standards for their age and grade level (Harold, 1966).

The Basic Plan

Lee felt that evolutional improvement of Samoan education would be too slow a process. His alternatives were few: to staff the schools entirely with fully

* Mr. Roy D. Cobb, Director of Education for American Samoa, was extremely helpful in supplying background information and specifics on the operation of the educational system in American Samoa.

qualified teachers recruited from the United States, to provide a nucleus of U. S. teachers to support the existing staff, to furnish teacher training and retraining on a large scale or to somehow enhance the effectiveness of existing teachers. For both economic and cultural reasons, Lee chose this last approach, and he initiated a study of the feasibility of using educational television to carry the principal burden of classroom instruction. This study, conducted by Vernon Bronson of the National Association of Educational Broadcasters and completed early in 1962, identified a sizeable number of deficiencies in the existing system including poorly defined goals, inadequate school buildings, low standards of attainment, poorly trained teachers, inadequate skills in English, and instruction which emphasized rote practice (Bronson, 1968).

Bronson's principal recommendation was to provide a six channel television capability to be used to transmit basic instructional content. He also proposed that classroom teachers should conduct classroom activities before and after each televised lesson, based on centrally prepared written materials. His additional recommendations suggested a revised curriculum better oriented to the Samoan culture, the use of the Samoan language — which was then prohibited — in the schools, an emphasis on oral English, and replacing rote memorization with questioning, discussions and problem-solving. The Bronson proposal was adopted and construction of the new schools and television facilities was begun in 1963. The first lessons were telecast in October 1964 and the system was completed in September 1967 when TV service was provided to the last of the schools in the coverage area. Some 8,000 students are now included in the system at 26 elementary and 3 secondary schools.

The cost of constructing and equipping the studios and transmission facilities for the six channels was ap-

proximately $2.3 million. This cost was higher than it might have to be in some other locations due to terrain problems, but was less than might be required if relay stations had been needed to expand the coverage area beyond the required 80 miles. The annual operating cost of the TV system, not including any school building or classroom teacher costs, is about $1.2 million. Although this represents an expenditure of almost $200 per student per year, the very small number of students has been the determining factor. Far larger numbers of pupils could be handled, were they within transmission range, with only small increments in the total yearly operating cost.

Operation of the System

The operation of the system has been described numerous times (in particular, see Schramm, 1967). Very briefly, each class consists of twenty to thirty pupils of about the same age, although much smaller classes are common at the more remote schools. Periodically during the day, as determined from a master schedule, the teacher turns on the television monitor in the classroom and all the students view an instructional lesson. Each televised lesson may be five to twenty minutes long. Before and after the lesson, the Samoan classroom teacher is expected to prepare the children for what they will see and hear, provide supplementary help, and supervise the completion of worksheets which are designed to give the students practice with the content of that lesson. The method used, then, is a form of 'team' teaching. The television teacher is responsible for introducing new facts and principles, for providing explanations and examples, and for organizing and scheduling the sequence of instruction in any particular course. The classroom teacher is responsible for maintaining discipline, for administering the use of the

worksheets, and for leading discussions or answering questions.

Instructional television is the heart of the system but, as Bronson (1968) points out:

> *The system is not a television system. It is a cooperative system of instruction making maximum use of television. The core of all instruction in this system is the teaching done by means of television and supported by [rehearsal] activities that take place in the classrooms. . . . This is 'team teaching' in its broadest and very best sense [p. 9].*

Although the classroom teacher is regarded as part of the team, it nevertheless is clear that these teachers have a fairly minor role in planning and preparing the lessons. This is not a reflection on the Samoans, who have been participating in ever increasing numbers as television teachers, subject-matter specialists and television technicians but, instead, a reliance upon well organized communication as the principal characteristic of effective teaching. As Schramm (1967) has described the system:

> *The function of television is to make it possible for a skilled teacher to teach a standardized curriculum in all classrooms, and by so doing to raise and to equalize the standards of instruction throughout the system, as well as to contribute to teacher training by furnishing an example. . . . Television promised a solution [to the problem of utilizing poorly prepared teachers effectively] because it spread the influence of the best teachers, and permitted the less well-trained teachers to handle duties that placed less strain on their mastery of content and method [pp. 18-19].*

A paradox is immediately evident in this description of the use of instructional television in American

Samoa. The television teacher is responsible for presenting information and, in many cases, for conducting choral drill. But, this is rarely what a skilled teacher is expected to do in the classroom. Good teaching seems to be characterized by its adaptiveness to individual learners, yet this responsibility is left to the less well-trained classroom teacher. If television can be expected to bring excellence to education, then reserving the most difficult and least procedural portions of the instruction for the classroom teacher is a strategy that is difficult to defend. This is particularly important in American Samoa where the classroom teachers have, as intended, adopted the teaching model they routinely see on their TV screens. There is considerable choral drill and very little individualized recitation or discussion.

The Role of Supplemental Materials

In this light, it may be that the apparent effectiveness of television-based instruction in American Samoa rests more substantially on the materials distributed to the students than on the contributions of the television or classroom teachers. The introduction of these materials into the system originally was proposed to make up for a lack of appropriate textbooks, but the materials go far beyond what usually is found in a traditional text. Every lesson is accompanied by two kinds of materials: directions to the classroom teacher and a set of student worksheets. Standard textbooks are not used. A typical set of instructions to a teacher is shown in Figure 24. It is expected that the teacher will have read these directions the day before and will have collected any special materials that are required. Suggestions are made as to what to do before the telecast, the content of the telecast is summarized, and directions are given for what to do after the telecast is over.

General Science
Unit 11 - Lesson 19

Main Idea: Green plants must have several things to make food.
Materials:
After: Reading sheet for lesson 19
Worksheet for lesson 19

BEFORE THE TELECAST:

1. Ask: What must we have to make a basket for taro? (a coconut leaf)
   Ask: What must we have to make palusami?
   Say: Kel will show us what green plants must have to make food.

THE TELECAST:

Green plants must have air to make food.
Green plants must have water to make food.
Green plants must have minerals to make food.
Green plants must have sunlight to make food.

AFTER THE TELECAST:

1. Pass out the reading sheet for lesson 19.
   Let the students read about the things that green plants must have to make food.

   Let students read different paragraphs aloud.
   Discuss any paragraphs that give them difficulty.

2. Pass out the worksheet for lesson 19.
   Let the students read the questions on the worksheet.
   Let them find the answers on the reading sheet.
   Let them copy the answers on the worksheet.

   DO NOT pass out the worksheet if your class needs more time with the reading sheet.

3. Call on students to read their answers from the worksheet.

Note to the teacher: You must have four small plants to use in lesson 20. Carefully dig up each plant (don't break the root). Put each plant in a different can or jar with some wet soil.

Figure 24. Typical instructions to a Samoan classroom teacher.

This particular lesson, part of a course on general science for students nearing the completion of elementary school, was scheduled for fifty-five minutes beginning at eleven in the morning. The telecast was

presented between 11:05 and 11:25, providing five minutes beforehand for the teacher to orient the class and allowing thirty minutes after the telecast for the students to complete the reading passage and the worksheet. The content of these individually distributed materials is reproduced in Figures 25 and 26. Other kinds of activities and materials are being used as well.

Reading Sheet for Lesson 19 — General Science Unit 11 - Lesson 19

Green Plants Must Have Four Things To Make Food

Green plants must have air to make food. The air goes into the leaf. The leaf cells use the air to make food. If a green plant has no leaves then it won't get air. If a green plant doesn't get air then it won't make food.

Green plants must have water to make food. The water goes into the roots. The water goes to the leaves. The leaf cells use the water to make food. If a green plant has no water then it won't make food.

Green plants must have soil to make food. The roots get minerals from the soil. The minerals go into the roots. The minerals go to the leaves. The leaf cells use the minerals to make food. If a green plant has no soil then it won't make food.

Green plants must have sunlight to make food. The sunlight goes into the leaves. The leaf cells use the sunlight to make food. If a green plant has no sunlight then it won't make food.

A green plant uses all these things in the leaf. The leaf cells use all these things to make food. This is photosynthesis.

Figure 25. Sample classroom reading passage for a Samoan student.

For example, Figure 27 shows a page of a brief, locally produced reader used during the early grades and Figure 28 is a copy of the teacher's instructions for an

Worksheet for Lesson 19

General Science
Unit 11 - Lesson 19

Name: _____

Copy the sentence from the reading sheet that gives the answer to these questions.

1. What must green plants have to make food?

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

2. Where does the air go?

   _____

3. Where does the water go?

   _____

4. Where do the minerals go?

   _____

5. Where does the sunlight go?

   _____

6. Where does a green plant make food?

   _____

Figure 26. Sample classroom worksheet for a Samoan student.

elementary school lesson on personal hygiene. The picture the teacher is to show the students is reproduced in Figure 29.

These printed materials, although regarded as supplemental to the televised presentations, probably carry much more of the teaching load than the actual

This is Tomi and Mele's house.

It has a big roof.

It has no walls.

Father and Mother are sitting

by the house.

Mother is playing with Pusi.

Figure 27. Sample page from an elementary Samoan textbook.

telecasts. However, they represent only a small fraction of the total cost of the system. According to Schramm (1967), the annual cost of instruction, after excluding instructional and administrative expenses attributable

Play and Learn - Level 1
Unit 1 - Lesson 17

Main Idea: Soap makes us clean and makes bubbles.
Materials:
After: a small container of soapy water for each child
use liquid detergent or mix soap and water the day before so the soapy water is thick
paper straws, or bamboo
old papers for desks
2 dirty rags
picture sheet for teacher

BEFORE THE TELECAST:
Ask the children to look at their hands.
Ask, Are they clean?
How can you get your hands clean?
Tell the children they will learn about soap and how to blow bubbles.

THE TELECAST:
We see that soap removes dirt.
We see how to blow bubbles.

AFTER THE TELECAST:
1. Show the picture sheet to the children.
Ask: What is this boy doing?
What is he using?
Why is he using soap?

2. Show the children the 2 dirty rags.
Pick two children.
Have 1 child wash 1 rag in water.
Have 1 child wash 1 rag in water that has soap.

When they have finished ask: and show the rags.
Which rag is cleaner?
Is it easier to wash a rag in water or water with soap?

3. Give each child old paper to cover their desks.
Give each child a container of soapy water and a straw.

Let the children blow soap bubbles.

Figure 28. Instructions for a classroom activity in a Samoan school.

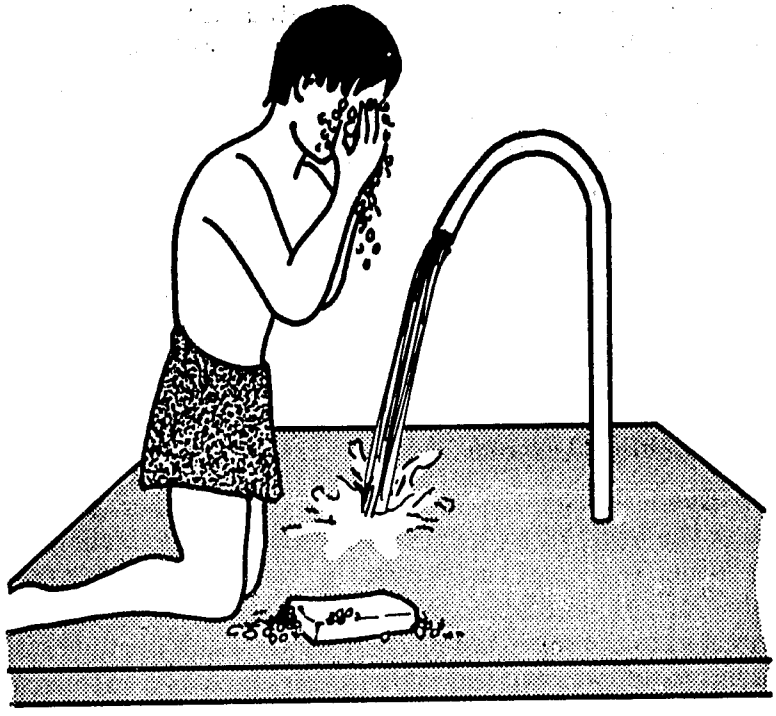

Figure 29. Picture to be shown to children in class by their Samoan teacher.

to a special school which operates independently of the system, is $393 per pupil. This cost is divided as follows:

classroom instruction			$195
general administration			16
television system:			
TV teachers and staff		34	
printing of materials		9	
TV transmission:			
parts and supplies	32		
technicians	84		
electricity	17		
other	6		
		139	
			182
Total annual operating cost (per pupil)			$393

If the time of the television teachers and other staff members who prepare lessons is apportioned two-thirds to the telecasts and one-third to the supplemental materials, the entire cost of these materials, including all printing charges, is only about $20 per pupil per year. This is only a slight fraction of the remaining total of $162 spent annually per pupil solely to prepare and transmit the televised lessons. Incidently, the amount of printing is rather substantial. Approximately one million sheets of paper are distributed each month to the 8,000 students and 300 teachers in the schools.

The Televised Lessons

Even though the worksheets and teacher guides form the basis of over half of the student's instruction by time, that part not spent in watching television, most of the emphasis in planning and scheduling is devoted to the televised presentations. Each production team, usually consisting of a studio teacher, a resource person and a producer-director, prepares an average of about ten to fifteen lessons a week. While this load is three to five times that generally expected of a similar television group in the United States (Schramm, 1967), it nevertheless means that the teacher is exposed to the students less than four hours per week. The remaining time is available for lesson planning and gathering materials. This is roughly one-tenth of what is expected of an ordinary classroom teacher in a school where television is not used. Thus, the television teacher in the Samoan system has at least ten times more preparation opportunity than more typical, and perhaps less expert, teachers. In this sense, the instructional value of each televised lesson should be considerable indeed.

In practice, however, the televised lessons are not very different at all from the conventional instruction

they were designed to replace. Schramm (1967) describes Samoan education before television this way:

> *Most of the class-room activity, as a matter of fact, was taken up by the class chanting in unison a set of responses learned by rote — the kind of teaching . . . producing students who can define a past participle but not use one, and . . . the only kind of instruction feasible for teachers who themselves do not really understand the subject-matter* [p. 13].

Although somewhat of an exception to the lecture of format of most televised lessons, a passage from a current English language course, the only one presently being preserved on tape for use from one year to the next, proceeds as follows:

> *Teacher:* 'This is a bottle.'
> *Pupils:* 'This is a bottle.'
> *Teacher:* 'This is a bottle.'
> *Pupils:* 'This is a bottle.'
> *Teacher:* 'These are bottles.'
> *Pupils:* 'These are bottles.'
> *Teacher:* 'This is a bottle.'
> *Pupils:* 'This is a bottle.'
> *Teacher:* 'These are bottles.'
> *Pupils:* 'These are bottles.' [Kaser, 1965, p. 73].

This would be a difficult lesson for a native Samoan teacher to present, with his own deficiencies in English pronunciation. Yet, he must judge during the telecast whether the children are responding correctly or, in many instances, even responding at all.

The use of television would be enhanced considerably in American Samoa if steps were taken to recognize limitations inherent in the telecasts as well as their potential. The effectiveness of a skilled classroom teacher quite likely depends upon regular interactions with the students. However, television realistically is only one-way communication and there is no particular

reason why traditional classroom practices should be any more effective when presented this way. On the other hand, television can make use of techniques rarely seen or even possible in the classroom. Its potential in this respect is evidenced by the subordinate use of the system in Samoa for community education, entertainment and enlightenment:

> *At night, the new schools become community centers, packed to the standing-room-only stage with older Samoans eagerly imbibing lessons in farming, home beautification, sanitation, the principles of government and democracy. Newscasts in both Samoan and English are featured nightly, as are travelogues showing how other people live and solve their problems* [*Hall, 1965, p. 5*].

The telecasts transmitted to the schools could be improved substantially by devoting more of the available time to presenting and illustrating content, and less to tiresome explanations and repetitions. Television has capabilities for imaginative and vivid demonstrations far beyond the diffusion of what ordinarily could be seen by any student seated in the third row of a conventional classroom. On the other hand, the worksheets permit the kind of practice that is needed for effective learning and retention. Were an investment made in them comparable to what is presently spent on television, it is quite possible that the need for the telecasts would be reduced substantially.

Deficiencies in the System

The present system in American Samoa has other deficiencies as well. When Schramm visited the islands in early 1966, he noted a number of problems, including frequent discrepancies between the printed materials distributed to the students and the actual content of the lessons, and well intended but not always correct

deviations by the teachers from their lesson instructions. These problems were still evident to other observers in late 1968. During a one-day visit to an elementary school, one classroom teacher was observed who had failed to write a list of words on the blackboard that were referred to as being there during the televised lesson and, when he did write them, he took the initiative of adding the misspelled words "coustom" and "coustoms" to the list. Another teacher conducted a drill to emphasize the need to clearly pronounce the final s in "A dog eats meats."

Another problem with the system is the conviction among its planners that the curriculum is ungraded. In place of the usual twelve grades of elementary and secondary school, there are eight 'levels' which exhaustively define the instructional program. All students in Level II, for example, receive the televised lessons, exercise materials and classroom instruction uniformly offered at that level. Thus, instead of the continuum commonly implied by the term 'ungraded,' Samoan students are lockstepped into a progression scheme which has even fewer compartments than representative 'graded' schools, particularly those which have multiple aptitude tracks, alternative curriculum sequences with elective courses, or classrooms subdivided by ability levels.

A third difficulty is one built into the system by an unnecessary stress on the currentness of the televised lessons. Because educational standards are changing so rapidly as a result of the system, it was feared that over- or underestimating the ability of the students would be likely if the lessons were prepared too far in advance of use. Television tapes now are prepared about one week before they are presented. However, this schedule places heavy demands on all concerned. A better approach might be to permit the recording of most routine lessons well ahead of when they are

needed — these lessons always can be rescheduled or revised if necessary — and to reserve one lesson each week specifically for review, correction and elaboration. This review lesson could be prepared only a few hours in advance of when it is to be used and be based on the feedback now collected routinely from the classroom teachers.

Technical problems have not interfered with the operation of the system to any great degree. The availability of six channels was wisely planned. Only five are used routinely and the sixth is set aside to replace any channel that might fail temporarily. About one percent of the receivers break down each day. This is not surprising considering the very high humidity, but spare receivers are not provided in the classrooms and lessons easily are missed.

An Analysis of System Effectiveness

Despite these deficiencies, the system seems to have resulted in a very sizeable improvement in the quality of education in American Samoa (Jacobs, 1969; Schramm, 1967). Attendance is very high, improvements in English grammar and pronunciation are very noticeable, and acceptance of the system by Samoan teachers is satisfactory. It should be noted, too, that simply having prevented a deterioration in the quality of education as a result of a rapidly expanding school age population must be regarded as an achievement in itself. In part, these gains may be attributed to the very significant changes which have been made in the instructional curriculum and in the standardization of content among classrooms. Furthermore, education was only one part of the encompassing accelerated development program initiated by Lee in 1961, which included paved roads, revitalizing experimental farms, school lunches to combat malnutrition, and vastly expanded commerce and tourism. Under these circumstances,

school attendance is bound to rise even without improved instruction, as will skills in oral English, world affairs and a willingness to tolerate controversy.

It undoubtedly is true, on the other hand, that much of the improvement that has been observed is due to the vitality and confidence of the staff. Had the usual amounts of time been spent on repetitive evaluations of plans and meetings by various committees, the project not only would have been delayed unnecessarily but the probable magnitude of the task might well have been recognized, judged to be overwhelming and its inception indefinitely postponed. The willingness of the staff to experiment, to welcome criticism, and to deal with practical issues as they occur has permitted the system to grow in effectiveness while at the same time providing much needed instruction.

Whether or not the use of television as the basis of instruction has been crucial to the success of the system is questionable. The skilled teachers recruited to present the telecasts clearly have made valuable contributions in planning the curriculum, sequencing the instruction, selecting appropriate examples to illustrate content and anticipating concepts which may be difficult to master. Several have been very effective as television performers by adopting styles of presentation which are far different from those usually seen in an ordinary classroom. Nevertheless, the worksheets and teacher guides very fortunately have complemented a method of instruction which well may have been a failure without them. Television can be a very potent way of informing a student what he is to learn, but individualized practice and guidance probably is necessary to insure that the desired learning will occur. In this system, partial individualization has been used to provide the tutorial assistance which, as much as depth in content, was not obtainable prior to the introduction of instructional television.

17

PROJECT PLAN*

A very ambitious effort directed specifically at individualizing education was begun recently in the United States under the direction of John C. Flanagan. Known as Project PLAN, this system is intended to provide comprehensive, but individually designed and paced instruction for all twelve years of elementary and secondary school. Fourteen independent school districts, the American Institutes for Research and the Westinghouse Learning Corporation are cooperating in carrying out the project.

The Planned Approach

The goal of Project PLAN is to use knowledge about each student's aptitudes, interests, and learning ability to help him formulate and pursue a personalized educational program which fully reflects his potential, ambitions, and probable opportunities. Accomplishing

* Dr. John C. Flanagan, Director of Project PLAN, was very helpful in supplying details about this system, its operation and its future plans.

this goal in a traditional educational framework probably is impossible for several reasons (Flanagan, 1967). First, the present structure of education inadequately provides for the wide range of individual differences and resulting variability in achievement that is characteristic of any age or grade group. Second, schools generally ignore the development of a sense of responsibility among students which they need to make their own educational and career decisions. Third, the usual objectives of education fail to fully prepare students for productive occupations, responsible citizenship or satisfying adulthood. And, fourth, current teaching methods lack the effectiveness, efficiency and flexibility needed to reach levels of skill, understanding and competence known to be attainable.

The development of a system which could overcome these deficiencies necessarily had to be concerned with a number of practical realities. The technology which could be brought to bear had to be within the budget capabilities of most school units and any changes required by the system had to be operationally feasible. It also was recognized that present knowledge about individual differences, the learning process, teaching aids and materials, curriculum design, the management of educational resources and other likely components of an optimal system is far from complete. To wait for detailed solutions to all expected problems, on the other hand, would cause needless delays in the application of all that is known. For this reason, an approach was devised which permitted continuous improvements in the system after its introduction. No changes in physical space, classroom personnel or administrative responsibility were contemplated and a decision was made to limit the selection of instructional materials for student use to what was commercially available. Significant steps were planned, however, in the establishment of educational objectives, in the organization of

instructional sequences, in the use of evaluative data and in the way in which a typical classroom would operate.

Assembling Teaching-Learning Units

Work on Project PLAN began early in 1967 with the development of sets of comprehensive and integrated educational objectives for language arts, science, social studies and mathematics. These objectives were prepared by committees of teachers, school administrators and subject matter experts whose goal was a continuous learning sequence that was independent of any framework suggested by specific course titles. Detailed subobjectives were prepared at the beginning of the project for those segments of each curriculum corresponding to grades 1, 5 and 9; by starting at three separate points in a standard twelve year program, the project could be completed in only four years. Each behaviorally oriented objective was sufficiently specific for assessment purposes and for the selection of instructional materials. The objectives in each area were grouped into 'modules' each representing about 10 to 15 hours of instruction for an average student and designed to be used over two-week periods. Any one module contained approximately five objectives. The modules then were used to identify the 'teaching-learning units' or TLU's that would be used to instruct the students.

At least three, and sometimes four or five TLU's were assembled corresponding to the objectives contained in each module. This array of alternatives was designed to provide both students and teachers with a choice among instructional materials that were equivalent in content but varied in reading difficulty, amount of visuals included, style of teaching and other characteristics. All TLU's were designed to be largely self-instructional, although limited participation by a teach-

er sometimes was expected within a unit to verify progress on complex assignments or to overcome particular difficulties. The materials themselves were selected from among commercially available text and reference books, films and other audiovisual aids, programmed instruction sequences, and workbooks containing seatwork exercises or laboratory experiments. Audio tapes and visuals were considered important components of the instructional materials and, for this reason, the classrooms were expected to contain sufficient tape players and viewers for individual use. Each TLU was structured with a four-page guide that identified the objectives of that unit, itemized the corresponding instructional materials and presented exercises to help the student evaluate his own progress.

A comprehensive, diagnostic test also was prepared to assess student mastery at the end of each module. Each of the objectives in the module was represented by several test items to make it possible to differentiate between objectives which were and were not fully achieved. In this way, the student and teacher can pinpoint the remedial instruction required whenever learning has not been completely satisfactory. Other, long-range examinations also have been prepared for use in the system. These tests are designed to assess progress in generalized skills, such as reading comprehension, and to update stored information on each student's abilities, interests and areas of likely success. These long-range assessments also are designed to measure growth with respect to objectives that might require more than a few weeks to achieve as well as to review previously studied objectives.

Developing Instructional Programs

When a student first enters the system he is tested extensively to determine his abilities, interests and previously acquired knowledge. This information is ana-

lyzed and the results are reported to the teacher. At this point, the teacher, the student and perhaps the student's parents as well, meet to discuss the student's plans. At the present time, any of twelve curriculum patterns can be used to structure an instructional program appropriate for an individual student. These patterns are designed to reflect the kinds of goals that might be agreed upon during the initial guidance sessions. One pattern, such as engineering-chemistry-mathematics, or business-sales, or mechanics is chosen by the student on the basis of his own aspirations and after he has had an opportunity to consider guidance information supplied by the teacher regarding his potential success in that field.

On the basis of this interim decision, tentative instructional goals for the year are selected in each of the four areas represented by modules. The program for one student might emphasize language arts, either to overcome a significant deficit or to expand his capabilities in that area, while the program for another student might emphasize the sampling of a wide range of modules to allow vague interests to mature and uncertain skills to develop. Students can and do redesign their own instructional programs as they gain experience and perspective. There is considerable overlap among the curriculum patterns, particularly at the primary level, so that a student easily might change from one overall pattern to another should his interests shift with experience and exposure to new fields.

The instructional plan indicates which modules the student should take during the year and identifies which of the corresponding TLU's are best suited to his rate of learning, special aptitudes and learning style. Very often, two or more alternative TLU's may be suggested to provide the student a choice among authors of equivalent texts or among projects requiring different amounts of time. The student then is given the

guide for each TLU he has selected. The guide specifies the objectives and the instructional materials to be used for each unit. He then will begin on these units following the study outline given in the guide which suggests the reading to be done, the audiovisual materials to be used, the workbook exercises to be completed and the group instruction to be attended. At the same time, the teacher is provided with suggestions on how and when to check student progress during the unit and on what difficulties are likely to arise that may require intervention.

Considerable flexibility is built into the selection of TLU's and their sequencing. Some modules, for example, are optional and can be studied at any time during the year. Other modules are represented by parallel TLU's which differ in emphasis but result in learning the same skill; algebraic equations, for instance, can be practiced on problems which reflect mechanical, scientific or commercial interests. It also is possible for a series of modules to be used in different sequences; for example, world history can be learned in a chronological, geographical or inverse order. The overall plan for each student assumes he will learn both in and outside of school. Students enrolled in Project PLAN classes are expected to spend an amount of time on homework equivalent to what normally would be required of other students at that grade level.

The Instructional Process

Most of the learning is paced and scheduled by the student himself. Because he knows exactly what objectives are to be achieved, he can spend as much or as little time as necessary on each one. He is free to use reference materials to pursue topics of immediate interest, to review difficult segments as often as he wishes and to ask the teacher for assistance whenever he feels he needs help. Because he typically is assigned three or

four units in different subject matter areas to work on simultaneously, he can distribute his efforts on any one day among several topics or concentrate on just one. By sharing in the responsibility for planning his school day, the student receives practice in making decisions relevant to his own career and educational development. And, by pacing his own instruction, the student has an opportunity to progress in accordance with his individual talents and needs.

After about two weeks, when the student has reached the end of a unit, he is given the examination for that module. The test is scored and, on the basis of the student's performance relative to each objective, a summary recommendation is prepared. If the student learned all that was expected of him, he is informed that his work on that unit is complete. If he missed some items relating to particular objectives, he may be asked to review certain segments of the instructional material either from the TLU he already used or, possibly, from another TLU which may cover the missed content from a slightly different perspective. In those occasional instances when the student has done poorly on the entire test, a conference between the student and teacher will take place to identify the difficulty. It may be that the student was ill-prepared for that module or that he selected a TLU which was particularly ineffective for him. Appropriate remedial action will be planned by the teacher and the student together. This may include a restructuring of the student's instructional program or, possibly, just redoing the unit. When desirable, an alternate version of the module test can be used to assess mastery following additional study. The assignment of marks or grades to students on the basis of their performance has been left to the individual schools.

An important feature of the Project PLAN system is that each module is based on what its developers call

the "success principle." As Flanagan (1967) describes it:

> *It is intended that each student be assigned only objectives which he can achieve at his present stage of development or learning in each field and that he be assisted in selecting, from the different types of teaching-learning units available, one which is well-suited to his learning style so as to enable him to attain the objective within the prescribed period of time. Failure on a unit test represents a breakdown in the system and will be the source of immediate investigation to identify and remedy the observed deficiency in methods and materials assigned* [p. 29].

It is fully recognized that the burden of learning rests with the system. For this reason, remedial recommendations contingent upon less than satisfactory test performance are interim solutions secondary to the more important use of test information to avoid future failures. As results from greater and greater numbers of participating students are compiled, increasingly positive predictions will be possible as to which curriculum patterns hold the most promise for any one student and which TLU's can be relied upon to most certainly produce satisfactory levels of learning.

Computer Functions in the System

The efficient management of the system depends heavily upon a computer to collect, organize and analyze the considerable quantities of information generated on the performance of every student. A terminal located in each participating school is connected to a single central processing unit capable of serving very

large numbers of pupils by long distance telephone lines. The terminal is used to enter student data, to receive recommendations for use in counseling and to aid in selecting appropriate TLU's for individual students. Information destined for the computer is prepared on mark sense data-processing cards which can be read by the terminal equipment. These cards are designed as miniature answer sheets for the unit tests and other examinations; the student can enter information on a card himself simply by darkening in the area corresponding to his answer choice. The teacher collects these cards and inserts them into the terminal device. The tests then are scored automatically by the computer.

In addition to scoring and reporting on module and long-range achievement tests, the computer updates each student's file or record of progress and goals, provides the teacher with a weekly summary report on the status of each student, monitors each student in terms of schedule commitments, and prepares guidance information which can be used to recommend refinements in a student's curriculum pattern. The computer also furnishes data to the system's planners on the effectiveness of individual TLU's and on the overall status of system operations. Teachers can request stored information on a particular student at any time. In Project PLAN, the computers serve a management rather than an instructional function. There is little urgency to the communications between the teacher and the central computer because students can proceed on other modules already assigned while waiting for test results. For this reason, transmission requirements are not heavy and one terminal can serve a fairly large number of students. Typically, schools collect module test answer cards during the day, transmit the data to the computer in the evening and receive printed results from the computer before school opens in the morning.

Early Experience with the System

Not unexpectedly, a number of problems were encountered when the system first was introduced on a trial basis in September 1967, in that only seven months separated the beginning of the project and its first use in participating schools. Technical difficulties and occasional breakdowns were experienced with the computer terminals which prevented teachers from obtaining needed student information and recommendations. Even though the first tryout year was limited to grades 1, 5 and 9, there were delays in getting all of the needed test and instructional materials to the experimental classrooms before the first day of the school term. Clerical errors in coding data cards resulted in some students being assigned a module not intended to be in their program or a test for a module they had not taken.

Many of the problems encountered could be overcome only by innovations. During the first year of the system, unit tests for children in the first grades had to be hand processed by the teachers before they could be entered into the computer, but this problem now has been solved by redesigned cards which very young children rapidly can learn to mark correctly. Color coding the instructional materials, guides and tests belonging to each module simplified both the student's task and the supervision required. Revisions in the format of the guides based on tryout experience substantially reduced sequencing and other procedural errors. Modules were added to the system to orient students to its use, to give them guidance in making academic and career plans, and to provide remedial instruction to make up background deficiencies. Still other modules were added to provide enrichment opportunities for those students who had made rapid progress and were interested in broadening their education.

In September 1968, Project PLAN was extended to grades 2, 6 and 10. Essential revisions were made in the materials for grades 1, 5 and 9 and work was begun on the development of modules for grades 3, 7 and 11. The entire system is scheduled to be in use beginning in the autumn of 1970. It is never expected to be "complete," however. Tryout results are being collected on approximately 2,000 students at each grade level during each year to permit continuous refinements in the selection and sequencing of instructional materials. Teachers and curriculum experts have repeatedly reviewed the content, order and grade placement of each module. And, plans are being made to expand and adjust the present twelve curriculum patterns to provide students with better opportunities for an education that is tailored as closely as possible to their ultimate career goals.

Information that has been collected so far suggests that the use of commercially available instructional materials as content for the TLU's is feasible for a system of this kind although several difficulties in choosing materials have been experienced. First, it has not always been possible to identify materials which concisely parallel the objectives that were established for each module. This means that students sometimes must depend on a large number of instructional resources and spend more time on a unit than would be necessary if more succinct and better fitting materials could be found. Second, many of the initial TLU's were felt to be dull. As a result, an increased emphasis has been given to audiovisual materials and practical exercises in devising subsequent or revised units.

Third, it has been found that the more difficult and exacting instructional materials are not chosen frequently even by the superior students. One possible interpretation of this observation is that most students

are interested in learning what is expected of them as quickly and as directly as possible. Students would rather use easier materials than those they might be capable of using and seem more inclined to complete many assignments than to be challenged by difficult instruction. Fourth, locating materials suitably easy for slow learners has been a major task. The detail and reading comprehension level of most texts is simply too demanding to be satisfactory for some students who, by their age and interests, otherwise are prepared to learn new content of potential value. Finally, there seems to be no clear-cut tendency for any particular kind of instruction to be more suitable for one student than another in terms of learning style. There is no evidence as yet that certain kinds of learning activities enable certain kinds of students to learn more effectively than others.

Teacher training has been an essential part of the system. In implementing Project PLAN, the participating teachers have had to assume a very different role in the instructional process than they traditionally have held. Instead of performing in front of an intact class, the teachers have become educational managers for a number of students who all may be engaged in distinctly different activities at any one time. Most participating teachers, even with the present inefficiencies in the system and their lack of experience with individualized instruction, find their new roles very satisfying. For many of them, this has been their first opportunity to interact with students as individuals and to observe their progress and difficulties in detail. Cooperation from participating teachers has been extremely high. Many have taken upon themselves the responsibility for revising faulty TLU's, for adjusting a student's program to meet special needs and for making the system operable.

The Prospects for the System

Until the entire system has been adequately tested at all grades and until the procedures and materials have become more stabilized than they are now, no definitive results on the overall success of the project can be expected. Tentative conclusions based upon the tryouts already completed support the need for individualization, however. During the first year, for example, some students completed all the materials available at their grade level by March, three months before the school year ended. Over the short term, this problem will be alleviated when the full range of modules has been developed and a student can continue on to objectives originally scheduled for the next grade level.

Further into the future, it will be necessary to face the problem of what to do with those children who complete a normal curriculum for grades 1 through 12 in only 8 or 9 years. Tentatively, it has been planned that the system will be expanded to the equivalent of 14 years of traditional instruction by adding to it the first two years of college or technical education. Expanding the breadth of the system to include more electives also is being considered. Another area of development being contemplated is the extension of the system to content areas other than language arts, science, social studies and mathematics. Art, music and particularly vocational training sequences may be added both to enrich the program and to meet specific career objectives.

Although much of the emphasis in Project PLAN appears to be directed at helping average and superior students reach their potential, the advantages of the system for slow learners seem especially promising. A fundamental aim of the project has been to improve the quality and relevance of education provided to the large numbers of students who now leave secondary

school unprepared either for higher education or a suitable occupation. Even at the present time, thirty percent of all students in the United States fail to complete secondary school. For these students, the most important consideration is to insure that they do learn as much as possible while they are in school. For this reason, the system permits students at the low end of the ability spectrum to concentrate on precisely those objectives which are most essential to their future success. These students are at liberty to pursue a curriculum which is free from much of the desirable but nonessential content of a conventional education and they can be encouraged toward a deliberately impoverished instructional program when this represents the limits of their abilities.

The cost of the system, when it finally is made available for routine use in schools, has not yet been determined. It is estimated, however, that the guidance program, computerized management services, module guides and tests will add approximately ten percent to the per student cost of education in a typical school. The instructional materials, audiovisual equipment and classroom storage facilities needed to hold them could add another ten percent, but these expenses should not substantially exceed existing budgets for texts, films and related items. Only a few copies of each set of materials would be more than sufficient for an entire class of students each working at his own pace and toward different goals. Project PLAN developers feel that gains in the quality and efficiency of instruction will more than offset these added costs. It also is likely that some school districts will be able to adopt the system without increased budgets by expanding the size of existing classes. The system already has been found to be feasible for classrooms containing 30 percent more pupils than the average in the United States. Still larger groups could be ac-

commodated if additional refinements in the system further reduced the teacher's present clerical and administrative burden. This solution to the cost problem has not been recommended but could be a relevant factor in the future.

The unique contribution of Project PLAN is in its emphasis on the careful and thorough assessment of each student's capabilities, on guidance which makes use of long-range predictions to select optimal and yet flexible patterns of education, and on detailed computerized records to enhance instructional management. Less attention has been given to major curriculum revisions, to the development of instructional materials to complement or replace those available from commercial sources, to modifications in school design or to changes in the utilization of school personnel. Refinements in these areas, if they occur, should add greatly to the contributions that this system may make toward producing comprehensive and workable programs of individualized education which could be implemented on a large scale.

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GRADUAL IMPLEMENTATION

One of the most important advantages of the systems approach is that it permits complex changes to evolve one increment at a time. Realistically, the amount of planning and investment required to achieve a fully effective and comprehensive system of education based on new approaches usually is too great for all planned changes to be accomplished at one time. For this reason, most efforts to implement new educational systems must be planned as a series of stages or cycles of development in which each successive stage represents a closer and closer approximation of the final system. Gradually implementing innovations is workable so long as the changes that are made are compatible with other system components both at the time they are introduced and when the final system is fully operational. This approach has the obvious advantage of producing immediate improvements in an ongoing system's instructional effectiveness or effi-

ciency without having overly taxed available resources.

An Example of Incremental Individualization

The pressures of limited developmental time have been a major factor in the adoption of evolutionary systems. An example of a system developed under these circumstances has been described by Klaus (1965b). The problem was initiated by a request to produce a programmed version of a technical training course for adults. The course, however, was several weeks in length and only a few weeks remained before it was scheduled to be offered. At that point, there was no syllabus, no textbook and no detailed list of instructional objectives upon which a program could be based. Several technical experts, each representing different content specialties, were made available to help prepare the course. These experts were neither trained teachers nor were they experienced in instructional methodology. This was an advantage, however, in that they were more than willing to have their classroom participation automated as quickly as possible so they could return to their own work.

After an exploratory attempt, any hope of having the technical experts prepare even the instructional objectives for their respective segments of the course was abandoned. It turned out to be possible, on the other hand, to secure the assistance of the experts in preparing course examinations which assessed the kind of performance expected of the students following training and which consisted, in large part, of job samples. The tactics used to insure the relevance and suitability of the test items proved rewarding. Each expert was asked to include only those items the students would be able to answer correctly following his block of instruction, with the implication that the test results would be used to assess the instructor's teach-

ing ability as well as the accomplishments of his students. This approach eliminated many unessential and tricky points, yet adequately reflected mastery, in that none of the experts were willing to suggest that their portions of the course and areas of interest were particularly simple or free from difficult problems. The tests themselves then were used as the basis for statements of objectives which informed the students what they had to know and do to pass the course.

Improving the Initial Version

These statements together with topical outlines prepared by the experts were the only materials distributed to the students for the first offering of the course. Because no text existed, thought was given to tape recording and then transcribing all of the lectures. But, an estimate of the clerical force that would be required suggested that this plan was not feasible. Instead, the students themselves were asked to take detailed notes. These notes were collected following each block of instruction, compiled and edited. Not surprisingly, the resulting composite was much shorter than a verbatim transcription would have been. Yet, the notes did cover most of the essential points in the course and were in words that had been used by the trainees themselves. An edited version of the notes was reproduced for the use of students during the second offering of the course, making it unnecessary for this second group of students to do much writing while the instructor was talking. The notes actually turned out to be satisfactory enough to permit deleting several topics from the course, topics which could be learned more readily by reading the notes than by listening to the corresponding lectures.

The efficiency of the instructors was recognized as a major problem during the first offering of the course. Even with the outlines, the technical experts frequently

diverted from the main points by presenting distracting details, irrelevant anecdotes and repetitious explanations. To prevent these incidents from occurring during the second offering of the course, the students were given generalized versions of the test questions before each lecture session. They were told the course examination would require no more than what was needed to answer these sample questions and space was provided in their notebooks for them to record answers to the questions during the lectures. Because they now knew precisely what information they were responsible for, the students in the second offering of the course did not hesitate to ask the instructor to get back to the point whenever he strayed. As Mager (1961b) had discovered, students can be quite good judges of the relevance of the instruction they are receiving. The procedure turned out to be somewhat frustrating to the instructors but quite efficient in reducing irrelevancies.

An important component of the training was the development of laboratory-like skills. These were taught, as typically is done in chemistry or biology, by demonstrating the technique and then, if there was time, by supervising student practice. It was evident, however, that the problems which the instructor selected for his own use during demonstrations were far more interesting and less difficult than those subsequently assigned for student practice. For the second offering of the course, most of the demonstrations that had been presented by the instructors were deleted and, instead, the students were given the problems which would have been used for this purpose as exercises. Printed instructions for the exercises were devised which simulated what an instructor might say if he tutored each student individually. To make it unnecessary for them to look at the instructions between each step, the students were organized in pairs. One

student read aloud as the other did an exercise; they then switched roles to work on a parallel problem. Because students generally are more patient with each other than an instructor might be, this approach resulted in very effective learning.

Further automation of this course obviously would be possible. The preprinted notes could be improved, the exercise materials could be revised on the basis of results, and the instructions for exercises could be taped to reduce the laboratory time by half. Any remaining lecture material, particularly the more difficult segments, could be prepared in programmed form. Whether or not further automation would be warranted is questionable. The real value of additional improvements, as Gilbert has pointed out (1962b), may not equal the added developmental costs. Once the objectives of a course can be achieved reliably, subsequent refinements may be dictated more by taste than by necessity. This is one of the more important arguments for gradual automation. Were materials for entire courses to be developed all at one time, it is likely that much more work would be done than was essential.

The Technique of Gradual Automation

This general approach to course development more recently was applied to a course on basic electricity and electronics offered to telephone technicians (Short et al., 1968). Several cycles of course development again were used, with increasing automation and individualization during each cycle. The resulting materials included demonstration films, lecture tapes, explanatory texts, practice exercises, programmed segments and activities with specially designed circuit simulators. This mix of media was not originally an aim of the project. Nor was it the result of any theoretical position on which media might be best suited

to teaching certain kinds of skills. Instead, the need for these various media grew out of practical efforts to produce the necessary learning. Films were used, for example, when motion had to be shown and audio tapes were prepared when the student had to look at schematics or illustrations while an explanation was being presented. This project reduced training time from the nine weeks that previously had been scheduled for the course to an average of only nine days. Trainee attainment and the relevance of what was learned also improved.

In these two examples of the gradual automation of courses of instruction, considerable effort was saved as well as time by implementing only a few changes during each cycle. Little was done prior to the first offering of each course except to determine instructional objectives, devise suitable proficiency tests and prepare topical outlines. Further automation was added only after test results indicated an effective teaching unit had been created and that it therefore was better to mechanize that segment of instruction than permit it to continue to vary. By automating effective sections of the course, work could be concentrated on revising the ineffective sections. Until successful approaches were found, these more difficult parts of the course intentionally were left in the hands of the instructors who helped prepare new demonstration and practice materials. Even more important, the information presented at any point during the course was not permanently fixed until it was shown to be capable of producing adequate mastery without unnecessary redundancy or extraneous details.

An Application of Gradual Automation

The gradual improvement of instruction has been applied on a larger scale at the Oakland Community College in Michigan. Here again the approach was de-

termined by a need to institute an educational program, in this case roughly equivalent to the first two years of college, in the shortest possible time. When OCC was founded in 1964, John Tirrell, its first president, was encouraged to develop a new kind of educational institution which stressed the individualization of instruction and independent learning. However, classes were to begin only fifteen months later. This left too little time to develop programmed instruction materials even for the more important courses. Tirrell turned to a group of systems specialists who had been working on the development of military equipment. Their recommendation was to approximate the learning conditions that would be present if courses were programmed, but to leave the detailed programming for later.

The most pressing need, as newly recruited faculty began joining the school, was to block out the terminal objectives for each course. In many cases these would be the same objectives as were aimed for in traditional courses at other colleges and in popularly used textbooks. However, by making the objectives explicit it became evident that not all of the necessary learning could be accomplished by the students themselves solely through individual reading. Additional assistance was required to point out to the students which passages were particularly important, to give them practice with difficult concepts, and to provide them with audiovisual experiences to complement their reading. Furthermore, it was clear that not all of the content of any one text would contribute to the mastery of course objectives. It became evident that it was as desirable to delete some segments of a typical text as it was to supplement others with additional learning aids.

To meet the aim of self-paced instruction, it was decided that most of the student's learning would take

place in individual carrels. What would have been each classroom was equipped with thirty or forty booths, a counter where students could check out audiovisual materials and equipment, and a discussion area containing a desk and several chairs where small groups of students could meet with an instructor. Because each room represented only a single subject, such as psychology or history, an appropriate instructor could be made available to all students throughout the day. The carrels were not assigned. Preliminary studies indicated that only one booth was required for each 4.5 students when the facilities were available the scheduled fourteen hours a day. A similar ratio proved satisfactory for materials and equipment (School Management, 1966).

The avoidance of traditional lectures at OCC was explained by Tirrell this way:

> *The medieval monks were the forebears of contempory lecturers. They were the only people of their day who could read. So they read the few books available and told their students what the books said. This is still the practice in most colleges and high schools — despite the fact that most students can read — and despite the advent of television, tape recorders, films and other better means of communication. To say the least, our students do their own reading [School Management, 1966, p. 107].*

Emphasis at Oakland Community College is placed on letting the student know beforehand precisely what he is to achieve. Large group orientation sessions held during the first few weeks of each course describe the course objectives to the student. The objectives are divided into units representing roughly ten to twenty hours of assignments to be completed over a one- to two-week period. At the beginning of each unit

the student receives a list of perhaps five objectives which delimit the goals of that unit. He also receives an assignment sheet which lists, in sequence, the tapes he is to listen to, the textbook passages or study materials he is to read, the exercise sheets he is to complete, the films or slides he is to see, and the small group discussion sessions he is to attend. Guidance is given in terms of the approximate number of hours he is to spend on each assignment.

Although the students are free to schedule their own work, and adjust the hours they spend at school to correspond to their own study habits or outside employment opportunities, the unit tests are administered at scheduled times during the school year to insure that the students keep up with their assignments. Attendance has been a continuing problem, particularly among those courses where interaction with the instructor is minimal. Larger numbers of students fail to complete courses at OCC than at more traditional colleges, but this is due at least in part to the attractiveness of the approach for students who did not like the regimentation of regular classroom instruction. Not all of these students turn out to have the persistence needed to study mostly on their own.

Many modifications have been made in the instructional practices and materials at OCC based on experience. Once each course was developed to the point it could be used, increased attention could be given to improving specific units. In addition, contracts were let to several organizations capable of preparing needed programmed and audiovisual materials. An important characteristic of the approach adopted at OCC is that an overall framework was established within which continued refinements would be possible. There was no real expectation that the quality of education would be significantly better than elsewhere during the initial few years of the system's

operation. On the other hand, the opportunities for improvement afforded by individualization could not materialize unless a pattern of instruction was established which was consistent with these longer range goals.

Learner Inputs in Lesson Design

Several other approaches for developing educational materials and techniques based upon gradually evolving a solution through repeated cycles have been devised. One of these, a procedure for preparing self-instructional lessons using large steps which are divided only when shown to be too difficult, has been described by Gilbert (see Gilbert, 1962a, 1962b; Pennington & Slack, 1962). In his system of lesson development, which he calls 'mathetics,' Gilbert stresses the need for parsimony in making initial estimates of the discrepancy between mastery and entering behavior. He also tries to minimize the thoroughness of instructions given to the learner, the amount of practice that is required from him and the degree to which realism must be simulated during learning. His view of tryouts as an integral feature of lesson development, as opposed to verification, deserves emphasis:

> *First draft exercises are not expected to succeed with try-out students. . . . [The purpose of a] try-out is not to determine whether exercises succeed or fail, but to discover what changes are necessary to make them succeed [Gilbert, 1962b, p. 56].*

Student control of not only the pace, but also the content of instruction has been emphasized by Mager (see Mager & Clark, 1964). In one study already described, students were given complete control over the curriculum for a course in electronics. They indicated which topics they wanted to have discussed and in which order and to what depth. The resulting course

was quite different from one which had been prepared by experienced electronics instructors, and it also was significantly shorter. In a second study described by Mager and Clark, learners were supplied with detailed objectives for a six-month training program before individual tutorial instruction began. The students themselves then selected the content and sequence of the instruction they received. This approach reduced training time by 65 percent and, at the same time, improved achievement.

In still another one of Mager and Clark's studies, the proficiency of untrained housewives on a meter-reading task was shown to be much lower than the skill of experts but it nevertheless was substantially different from zero. Had instructional development been begun without this knowledge, considerable time would have been spent on skills and information which the learners already possessed. This finding was more than verified in yet another experiment in which experts performed no better on test problems than individuals who had received no training whatsoever. The advantages of gradual automation and course development are in avoiding the tendency Mager has identified of traditionally teaching too much of what the student, even without being aware of it, already knows.

Student Controlled Course Content

Giving the student greater voice in determining instructional practices has become particularly important for colleges and universities. Growing discontent has been expressed over the relevance of course content, the appropriateness of traditional teaching methods and the meaningfulness of course grades. Several colleges have experimented with changes but without contagious success. Detailed student criticisms of traditional academic and technical

instruction tend to demonstrate their concern with course content that overly emphasizes petty facts, nebulous principles and unrealistic examples. These students also have recognized the need to free education from the constraints of unilateral lectures and tangential textbook assignments. Changing the fundamental objectives of a course of instruction clearly is not an answer. Not only would this raise doubts about the meaningfulness of course credits, but it would fail to provide the students with the assistance they need to achieve their own goals. Similarly, any change would have to be feasible in terms of cost, instructor competency and the use of resources.

One way in which interested students could be given greater participation in determining course content would be to allow them to meet, as a group, with the course instructor before the school year began. During the meeting detailed objectives for each week of instruction would be determined. The students would be free to propose topics which they deemed to be relevant and responsive to current issues and the instructor could suggest perhaps more orthodox topics he felt were essential to his field. Students unable to convince the instructor of the importance of a topic to them would not be required to participate in the course, nor would instructors have to agree to teach the resulting syllabus if he felt the detailed objectives distorted the aims of the course. The objectives resulting from the meeting would serve as a commitment for both student and teacher for that school term.

Comprehensive examination items then could be derived for each week of the course. For example, a sociology unit might be aimed at the answers to such questions as "What is a family?," "How are families structured?," and "What are the consequences of deviations in family structure?" The instructor then would prepare a series of suggested assignments which could

provide the students with answers to these questions. The assignments would represent a 'menu' of methodological options including, perhaps, lectures, group discussions, reading assignments, various types of practice exercises, field observations or laboratory problems. Any student could participate in as many of these options as he wished; his only responsibility would be to prepare answers to the questions that had been posed for each unit before the last day of the week. At that time the class would assemble to collectively determine the standards to be applied by the instructor when he assessed the correctness of each student's responses for grading purposes.

The instructional methodologies might vary considerably from one course to the next, and the students would soon discover which kinds of learning experiences were most effective. Substantial differences between these courses and traditional ones also would be evident in the criteria chosen to represent mastery. Students are likely to belittle routine factual information in favor of an emphasis on understanding, communication, and practical knowledge. For this reason, the atomistic specificity of many traditional course examinations and popular achievement tests probably represents only the lowest common denominator of what might have been taught or learned. It is likely that courses in which students participate in their planning will be more satisfactory than those presently offered in the sense of preparing students for future independent learning. At the same time, they would not entail undue cost or loss of administrative control.

The Strategy of Gradual Implementation

Three distinct ways have been described in which education might be improved gradually and yet systematically. The emphasis in the examples on how

courses could be automated through a series of cycles was on the development of instructional materials. The work at Oakland Community College illustrates how the individualization of instruction can be begun even without major changes in what is taught. The work of Mager and its extrapolation to a college setting suggests how the content and objectives of instruction can be strengthened gradually by giving the student more of a role during course planning. The important common ground among these examples was the provisions made in each for continued quality control through stress on systematic measurement. Automation was deferred until needed instructional content had been determined and shown to be satisfactory through test results. In all instances, the total developmental investment was spread over a period of time rather than spent all at once.

A major conclusion which can be derived from these efforts is that too early a decision about the ultimate characteristics of a system of instruction can prove to be quite costly. On the one hand, these studies suggest that the content of traditional instruction rarely is directly transferrable to instruction which is both automated and individualized. The developmental cycles described in the first two examples were needed not so much for automating these courses as for determining what content had to be automated. On the other hand, these studies also illustrate how most, if not all, of the advantages of lengthy programming efforts or expensive equipment purchases can be achieved without any of these ingredients. While not as fetching as the dial access systems described earlier, the approach at Oakland Community College probably is close to being as effective. A decision to introduce dial access at this point would be based on a realistic assessment of the need for further automation, an assessment that would be impossible

to make accurately without knowing what materials were essential and what requirements had to be met.

Another and perhaps more important conclusion from these studies is that even with minimum advance planning, almost any efforts to improve instruction which include emphasis on diagnostic testing as a means of quality control are likely to succeed. The probability of any change from traditional instructional practices being a change for the better is far greater than chance alone would dictate. Once the need for change is recognized, any systematic effort which is based on the increments in knowledge about instruction which have materialized in recent years is more than likely to be successful. The outcome can be in doubt only when the proposed change is so radical as to require profound modifications in all components of instruction at one time. Even then, however, present technology with its emphasis on objectivity, practice and tryouts is likely to preclude any actual deterioration in the quality or efficiency of instruction.

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EDUCATIONAL INNOVATION

Although most changes in educational practices are likely to be beneficial, their impact on the overall conduct of instruction rarely will be substantial because of the dampening effects of the remainder of the system. Occasional ideas seem to stand out, however, because they ingeniously satisfy some pressing need yet fit compatibly within an existing educational framework. Some innovations have a major impact while others result only in minor changes. Both kinds, however, illustrate interesting solutions to the problems of education. Fostering the creation and adoption of these innovations has become a recognized responsibility of educational planning. But, not all innovations are useful and, even among those which are useful, few are promoted and disseminated in such a way as to be known to those who might find them valuable. It is these two aspects of educational innovation which have become the focus of long-range efforts to improve the quality of instructional systems.

Innovation in a Course Curriculum

Significant innovations can originate by chance, but most result from concerted efforts to overcome particular problems. One example of a rather successful innovation has been the spread of the secondary school physics course developed by the Physical Science Study Committee at the Massachusetts Institute of Technology between 1956 and 1961 at a cost of approximately five million dollars (Panel on Educational Research and Development, 1964). The problem recognized by the PSSC group was that the teaching of physics had failed to keep pace with scientific progress in that field. As a result, otherwise capable students were not being attracted toward a career in physics and those who did study physics in secondary school were poorly prepared for university work. In order to overcome this problem, a radically different approach was needed, one which would increase the emphasis given to the techniques and concepts used by physicists and diminished the rote learning of definitions and formulas that were the preoccupation of most existing courses.

The disparity between what was being taught and what expert physicists felt should be learned was so great that an entirely new curriculum with its own textbook, laboratory experiments, demonstrations and audiovisual materials had to be devised. Careful planning and thorough tryouts of the new course, plus the development of appropriate examinations and teacher training materials resulted in its rather rapid adoption. Within three years after the course was complete, two out of every five secondary students enrolled in physics in the United States were using the PSSC materials. So successful was the project, in fact, that the general approach was quickly adopted by similar committees

in the fields of chemistry, foreign languages, English and mathematics.

Innovation in Teaching Methods

Few innovations in education are either as encompassing or as costly to develop as those concerned with increasing the relevance of a school curriculum. The adoption of chalkboards, for instance, was predictable considering their utility and convenience as an instructional tool. Nevertheless, approximately thirty years separated the introduction of the idea and the view that a chalkboard was essential to teaching (Anderson, 1962). Other innovations seem attractive only to a few users. For example, children have been taught cooperative behavior with considerable success using specially chosen playground equipment — teeter-totters were substituted for swings and wagons were used which were so large that the strength of two children was required to move them (see Klaus, 1961), but the spread of this concept has been slow at best.

Some outstanding innovations have resulted from efforts to devise instructional routines which teach skills commonly omitted from educational goals because they have been so difficult to produce. One particularly creative example is the 'inquiry training' procedure devised by Suchman (1960). His approach was to help students learn how to discover science principles for themselves rather than memorize the words used to state them in textbooks. At the beginning of a class period, a brief film would be shown to the pupils which clearly demonstrated some scientific phenomenon but did not explain it. Following the film, the students were urged to ask questions about what they saw which could be answered by the teacher with a 'yes' or 'no.' Typically, the questions gradually pinpointed the conditions which determined whether or not the ob-

served outcome would occur and, in this way, yielded an understanding of the underlying principle.

Innovation in School Equipment

Apparatus for educational use has been a favorite goal of educational innovators, but most equipment inventions fail to be accepted because they do not meet any real need. One exception to this generalization was the 'sunlight' projector developed a number of years ago by J. Cudney, V. R. Short and M. Toufique (Hubbell, 1969). Designed to permit filmstrips to be shown in underdeveloped areas not served with electricity, the device can be manufactured easily with mostly scrap materials and the lenses from a discarded pair of eyeglasses. Sunlight is directed to the rear of the projector from outside the school building by a polished metal surface — a hand rubbed oil drum lid will do. The mirror is adjusted to reflect a beam of light through an opening in the classroom wall toward the film and lenses. The image is projected on to a light colored surface or, better yet, on to a translucent plastic cloth where it can be viewed from the other side with all the advantages of backscreen projection.

Another device, one which may have considerable utility in individualized instruction, is now under development by a leading equipment manufacturer. Up to now, most slide-sound equipment required two separate sets of materials — one for the audio portion and one for the visual portion. The new device considerably simplifies the use of audiovisual materials by imbedding slides within a transparent disk recording. By having the needle arm rather than the disk revolve, images can be projected from a stationary position. As is true of most slide-sound equipment, the images can be made to advance automatically when triggered by an inaudible signal recorded on the normal sound track. Each record will hold a lesson fifteen minutes or more

in length and the device can be operated easily even by preschool children.

Games and toys created for educational purposes have become increasingly popular educational innovations. In addition to those described previously in the chapter on teaching machines, intrinsically enjoyable materials have been prepared to teach children to listen to instructions, to learn word skills, and to practice the concepts of modern mathematics. Carefully planned science project kits often are prominently displayed at toy counters. Even traditional board games can be adapted to serve instructional needs by arranging the game's events to simulate the incidents which might occur as the result of business ownership or community planning responsibility. One of the most lasting and popular of all the innovations introduced by Washburne at Winnetka was the 'Jungle Gym,' a framework of metal bars suitable for climbing (see Washburne & Marland, 1963, pp. 136-138).

Innovation in Reading Instruction

Some of the more radical innovations in education have resulted from problems which seemingly defied solution. An interesting example is the development of the Initial Teaching Alphabet, i.t.a., by Pitman in 1961 (see Downing, 1966). The English language is almost unique among western languages in the lack of correspondence between its pronunciation and spelling. Many familiar examples exist; the vowel in the word 'my' is identical to the differently represented vowels in 'line,' 'pint,' 'buy,' 'high,' and 'eye' among others; the sound of 'g' is hard in 'gun,' soft in 'gem,' more like an 'f' in 'tough' and not pronounced at all in 'gnat.' It is no wonder that children learning to read in English seem to have a much more difficult time of it than Swedes or Italians with their far more representative orthographies. Even more unfortunate is the peculiar high den-

sity of misleading spellings among the most frequently used words in the language. It is difficult to invent even a few simple sentences in English appropriate in content for beginning readers but still uniform in the way all the letters are pronounced.

Pitman's solution was to develop a new orthography of forty-four characters, in part made up of existing letters and in part made up of new letters devised for this purpose. Pitman was careful to retain as much as possible of the standard language. For instance, he continues to use the letter 'c,' restricting its pronunciation to the sound it has in the word 'cat,' even though the letter 'k' could have been used for this purpose. As Downing (1966) explains,

> *Having learned the sounds of the i.t.a. characters, the teacher may need to be reminded of i.t.a.'s two purposes: at Stage One it is to give the beginner a simpler reading code than the traditional one, but at Stage Two it is to help the child to make an easy transfer from reading i.t.a. to reading conventionally spelled English. i.t.a. is not intended to be a system of meticulous phonetic transcription, but to provide a reading system which is both easier for the beginner and transitional to conventional print* [p.68].

Research reported by Downing on the success of i.t.a. is quite encouraging. In an experiment contrasting the performance of roughly 2000 pupils all using readers of identical content but written in the two different alphabets, the experimental students averaged about twice the progress of the students learning from traditional orthography. On a standardized reading test, the experimental pupils had an average score more than three times that of the controls. In another study, two parallel forms of a reading test were administered about the time when most students were

transferring from i.t.a. to conventional print. The first version of the test was given in i.t.a.; the second, administered two months later, was given in traditional orthography. Although less than half of the students had begun to switch from i.t.a. to conventional print by the time the second test was given, they nevertheless averaged a slight improvement in reading speed, a slight decline in accuracy and no change in reading comprehension. Even more important, these experimental students equalled or exceeded the performance of conventionally taught students on the same test, which was printed in traditional orthography (Downing, 1966).

Innovation in Building Design

Still another area in which innovation has shown considerable promise is in the design of school buildings. Not only are the costs of conventional construction prohibitive in many areas of the world, but the adequacy of the designs typically used have been questioned as well. One particular problem has been that school buildings erected years ago were designed and constructed to last indefinitely — and, unfortunately, they have. School architects of fifty years ago made the mistake of assuming that instructional requirements and design possibilities would never change, and it is likely that the same mistake is being made today. Large windows, for instance, once were the only means to provide adequate cooling and ventilation. But, today, fluorescent illumination and air conditioning provide opportunities to eliminate windows as an obvious source of distraction. The school building most desirable fifty or even twenty years from now may be difficult to predict. Yet, it is almost certain that today's designs will be inadequate. Schools can be regarded as social monuments but they need not be built, at con-

siderable expense, to be there always as a reminder to future generations that education was an important concern of a conscientious government. A far more constructive legacy would be buildings which somehow would self-destruct when their useful life had been attained.

Some of the more obvious problems likely to result from new instructional media and technologies will be the need for radically different uses of school space. The conventional classroom with neat rows of chairs to seat 30 to 40 pupils no longer is a very useful concept and it is quite possible that this one characteristic of schools, more than any other, has retarded the growth and adoption of automation, individualization and other innovations. Much of the advantage of team teaching, for example, has been unattainable because normal classrooms are ill-suited for either large group lectures or small discussion sessions. Team teaching assumes that more preparation time will improve lectures and, in turn, permit large numbers of students to learn from a single teacher at certain hours during the day. This time then can be used by other teachers on the team to prepare their own lectures or to help students individually or in small groups. Whether or not real improvements result from this division of responsibility remains in doubt. Teachers ordinarily are not well prepared either for large group or individual attention roles. This defect might be remedied by further research but too few schools have been able to experiment with team teaching due to limitations in their physical facilities. Needed refinements in team teaching are not likely to occur until suitable classroom arrangements are more common. However, designing schools to facilitate team teaching is not likely to occur until team teaching has been shown to result in genuine gains in the quality of instruction. The losers in this standoff are those children who might profit from many innova-

tive teaching techniques, including team teaching, which cannot be given a fair trial.

A number of insights into the interaction between the arrangement of school space and the opportunity to use innovative techniques have been expressed by Lehmann (1966). He also makes the point that:

> *The environment as an educative medium has been largely ignored. . . . School patrons seem to prefer to pay for shelter rather than artistry on the assumption that the teacher will work customary miracles. But the environment also teaches; the disinfectant smells from toilet rooms, the drabness of unadorned cinder block, the noisy assaults of an amalgam of extraneous sound, the glare of uncontrolled light sources, the insult of a steel locker as one's only private domain* [*Lehmann, 1966, p. 243*].

Contrast this recent impression with the description Washburne gives of changes made in Winnetka schools in the early 1920's:

> *As our educational program developed in Winnetka, we began to make more and more demands on building and equipment. We replaced the screwed-down desks in the older schools with movable furniture. We redecorated all schools with brighter, more cheerful colors. . . . The number of activities of our children and the informality of the classroom atmosphere made us conscious of the fact that most classrooms have considerable reverberation, magnifying the noise. . . . Little by little every classroom was given acoustical treatment. . . . As far as I know Winnetka was the first school system to have acoustical treatment in all its rooms. The cost, spread over the years, was inconsequential. The effects were*

almost magical . . . [Washburne & Marland, 1963, p. 136].

Conservative thinking has tended to predominate not only in the layout and comfort of school facilities but in their construction as well. Surprisingly little attention has been given to really innovative methods of constructing school buildings. If, as already suggested, changing needs are likely to render most school buildings obsolete before they physically decay, then much less expensive schools need to be designed with the idea that they will be replaced within ten or twenty years. One of the most promising materials that could be tried for this purpose is polystyrene foam, a lightweight but rigid plastic that can be sprayed on to an inflatable mold positioned at the building site. It is translucent, rotproof and would require little in the way of a supporting structure. Even less expensive materials could be tried. For example, papier-mâché made from discarded newsprint or even obsolete textbooks might be used if it were mixed with additives to make it both insect and water repellent.

Innovation in the Use of Resources

Another factor contributing to the high cost of schools is the limited use given them by many school systems. In the United States, the typical school building is used for classes only eight hours per day, five days per week, and less than 40 weeks during the year. These schools actually remain idle, except for an occasional dance, basketball game or parents' meeting, over 80 percent of the time. Innovation is needed here as well. One solution, which has been adopted in Singapore, is to schedule two complete shifts of students and teachers each day, one in the morning and early afternoon, one in the late afternoon and evening. Another solution would be to view schools as general purpose community centers, with some rooms

lined with shelves to serve as public libraries on weekends and in the evenings and other rooms equipped as theaters or for other uses.

Teachers in many parts of the world are similarly underutilized. The profitable use of their time when school is not in session would permit the higher salaries likely to attract better candidates and would provide the community with needed services from its often best educated members. The Republic of Viet Nam is now considering such a plan. Village teachers, in addition to their classroom responsibilities, would serve as a kind of local guru on problems of health, law, agriculture and so forth. The government would pay him for these added tasks and supply him with the necessary reference books and other support. In this sense, a teacher would become a prestigious resource to the community as a whole and provide much needed informal education as well as classroom instruction. Another source of economy in teaching is to establish cooperative arrangements with industry. A number of companies both in Europe and in the United States have found that supplying teachers for selected courses at no cost to the schools has improved recruiting, has provided a supply of skilled workers without salary costs during training, and has enhanced their community image.

Innovation in Teacher Guidance

The problem of the near absence of adequately trained teachers also has been considered by educational innovators. One of the most outstanding examples of a promising solution was the plan devised by Douglas Ellson for improving elementary education in rural India. The vast number of students involved almost precludes basing instruction on prepared exercises or programmed texts; present resources are

insufficient even to contemplate reproducing the tremendous quantity of printed materials that would be required. As a substitute, Ellson proposed the development of materials exclusively for the use of the teacher which would add needed organization and technique to the conduct of classroom instruction. For each lesson, the teacher would be given a detailed guide of what information to present, what questions to ask, what answers to expect, and what practice to assign. Because the materials would be thoroughly tried out, most of the contingencies likely to occur in any classroom could be anticipated and procedures could be devised for dealing with them.

The value of this approach as a way of utilizing undertrained personnel as classroom teachers is readily apparent for developing nations where competent instructors simply are unobtainable. Less apparent, but equally valid, is the use of teacher guides in economically prosperous countries to relieve temporary teacher shortages in fields such as science where too few trained individuals exist to satisfy urgent needs, or in applications such as preschool education where the necessarily high ratio of teachers to pupils precludes offering instruction using teachers salaried at professional levels. Detailed, explicit guides have been used successfully to complement programmed second language instruction with small group sessions led by native speakers untrained as teachers (Klaus, 1968). As in most cooking recipes, step-by-step instructions on how to conduct a lesson are likely to be welcomed by the novice who readily will discover their contribution to a successful outcome; even skilled teachers may adopt the suggestions so long as they are not mandatory. In either case, the guides can assure at least a minimum level of quality throughout a school system, a level substantially higher than many teachers could attain without assistance.

Other methods also have been devised to bring quality to the classroom when it cannot be provided directly. In Australia, for instance, short-wave radio is used to provide competent tutorial assistance to children living on remote farms and ranches (Kinane, 1967). Printed materials are supplied in advance and most of the routine supervision of each child's learning is left to the parents. Interestingly, these children probably have more direct interaction with their teacher than most children in a traditional classroom. Even if all of a classroom teacher's time was spent interacting with students individually, any one student in a class of thirty would receive no more than fifteen minutes of help per day. In the New England area of the U.S., the telephone is used to bring otherwise unavailable experts into the classroom. The teacher is free, during lectures or discussions, to call authorities even at long distances in order to obtain information or answer student questions. Equipment installed in the classroom permits all students to hear and participate in the conversation (NEA Educational Services, 1967).

Sources of Innovation

Not all innovations are particularly productive or worthwhile. One reason is that a number of ingenious educational innovations have been created which, unfortunately, represent solutions to nonexistent problems. Cheatproof teaching machines, as an example, were designed in large quantities before researchers pointed out that students were not at all likely to cheat if the program in the machine really was helping them learn. Various devices for displaying information in unique ways, equipment permitting students to communicate with a remote television instructor, materials that provide visual and tactile experiences in three

dimensions, and many other clever ideas have failed to have an impact because they overcame no recognized difficulty. Another reason for the failure of an innovation is because it is an innovation in name only. Large numbers of hopefully profitable concerns have devised 'systems' of instruction, complete with trademarked names, which almost invariably are promoted as a bridge between what is known about the need to present information clearly and the need to promote learner responding. The 'system' in reality consists of one or more unlikely combinations of elements from existing technologies which all too frequently fail to perform any instructional functions satisfactorily. These gimmicks rarely if ever provide the gains that could be obtained spending an equal amount of funds on systematic developmental efforts.

The dissemination of innovations is a specialized problem in itself. One difficulty is that efforts to compile worthwhile ideas rarely turn out to contain much at all which is useful elsewhere (for example, see Fallon, 1966). Picking through hundreds or thousands of ideas before finding one which might be adopted generally is an unrewarding task. Educational innovations, according to Carlson (1965), most likely are spread by direct interpersonal contacts among peers and colleagues. This finding is not at all surprising in that it probably is equally true that friends share similar problems, backgrounds and predispositions. If innovations tend to diffuse through personal communications, then how can this process be enhanced? Another of Carlson's findings is that innovations are more likely to spread from high prestige individuals to low prestige individuals than the other way around. This suggests that the speed with which an innovation is adopted will depend on its early adoption by high prestige decision makers.

The Diffusion of Innovations

The rate at which innovations are diffused has been the topic of a number of investigations and discussions (see Rogers, 1962; Miles, 1964; Roy, Waisanen & Rogers, 1969). Some innovations are adopted rapidly and others very slowly. For instance, in his study of the adoption rate of a selected group of innovations, Carlson (1965) found that the use of accelerated instructional programs reached 50 percent of the school districts in his sample within eight years of the first adoption of this innovation, while the use of a modern math curriculum achieved penetration in half of the schools in only three years, and programmed instruction in five. Foreign language instruction in elementary schools had been accepted by only 35 percent of the school districts even ten years after it was first introduced. Attempting to identify the characteristics of a rapidly diffused innovation compared with one that spreads slowly, Carlson studied the relative superiority of the idea compared to what it would replace, the compatibility of the innovation with existing values and experiences, the degree to which the innovation might be difficult to use, the extent to which the idea could be given limited trials, and the degree to which the idea would be likely to be communicated. No combination of these possible determinants adequately accounted for the variable adoption rates observed.

Efforts to induce the adoption of innovations have met with differential success. Simply knowing about an innovation seems not enough. Few school authorities appear to have the confidence in ideas they read about or hear about to use them in trying to replace the traditional programs and methods typical of their own systems. Seeing a new practice in action seems to be a considerably more powerful influence. With this possibility in mind, the Department of Audiovisual Instruc-

tion of the National Education Association collected a guide to schools in the United States making significant use of educational media in their instructional programs (Bloodworth, 1969). On the basis of questionnaires and field visits, 247 individual schools throughout the country were selected for inclusion in the guide largely because of the creativity of some program at the school and the willingness of the school to accept visitors. The guide is designed to help educators identify schools in their own localities where specific innovations can be observed in use.

Conclusive results from this project may take several years, and several of the intended biennial revisions of the guide, to compile. However, as preliminary evidence of the success of site visits as a means of promoting the spread of innovations, Bloodworth (1969) states:

> . . . [*the basis of the project was the*] *contention that observation of programs in action is the most persuasive experience an educator can have. That such observation has motivated change is now abundantly apparent in the actions and attitudes of the survey team members. Most of them indicated in their written and oral reports that they have incorporated into their own schools, and would be incorporating more in the future, various changes that they saw — some of which were new in content, others new in ways of utilization* [*p. 299*].

Constructive changes also were reported among the schools being observed as the result of attempting to explain their media program and innovative philosophy to outsiders.

20

PLANNING FOR CHANGE

Innovation may not be synonymous with educational progress, but fostering the organized creation and implementation of useful innovations is perhaps the only direct way in which a deficient educational system can expect to make rapid gains. Yet, the conditions likely to facilitate change are not at all clear. It is not even certain that change can be encouraged and promoted without drastic revisions in the way in which innovations are planned, implemented and assessed. By and large, change is not welcomed by existing educational establishments. Any suggestion of change implies criticism — that past practices are defective and that those responsible for the present system have been derelict in failing to remedy obvious deficiencies. Without adequate planning, those who deliberately set out to instigate change may succeed only in consolidating resistance to innovation and in creating an unpopular image for themselves and their ideas.

Promoting Educational Change

Few guidelines exist on how to go about producing educational change, particularly on a large scale. Agencies and foundations dedicated to educational betterment often have refrained from support of radical innovations and, through their funding practices, possibly have done more to support the continuation of established methodologies than to promote imaginative new ideas. Technical assistance, the exchange of scholars, and traditional subsidy programs may alleviate specific defects, but the underlying problems which sooner or later may cause the collapse of fundamentally weak educational systems have been cautiously ignored. One wonders whether the direction of most forms of aid to education, especially that offered to developing countries (see Tickner, 1965; Cerych, 1965; Chiappetta, 1969; Sanders, 1969 for descriptions of various programs), will in the long run prove as constructive as was intended.

The cost of producing change may be one of the principal deterrents to the adoption of educational innovations. As McCusker and Sorensen (1966) point out:

> *Perhaps one of the strongest reasons for the slow change in educational practice is that very little is invested in conscious efforts to induce change. Education's research and development budget, relative to its total expenditures, is trivial* [p. 185].

Research funds alone, however, will not accomplish any significant shift in the educational policies that have retarded meaningful breakthroughs. Sufficient basic research already is available to suggest the desirability of several profound changes in how instruction is planned and conducted. What is needed now is enough vision and conviction to overcome the ob-

stacles which have prevented these changes from being implemented.

A willingness to accept change within the educational establishment appears to be a fundamental requisite to the adoption of innovation. For this reason, genuinely constructive leadership is essential. As Griffiths (1964) points out:

> Many of the characteristics of organizations are such that they make the initiation of change difficult. When organizations are viewed in terms of the system-theory model these characteristics appear very clearly. . . . The number of innovations is inversely proportional to the tenure of the chief administrator. The longer an administrator stays in a position, the less likely he is to introduce change. . . . The more hierarchical the structure of an organization, the less the possibility of change. . . . [and] When change in an organization does occur, it will tend to occur from the top down, not from the bottom up [pp. 434-435].

The Cost of Improved Education

The presence of cooperative leadership is but one of the requirements which must exist for meaningful educational change. Adequate planning is another. Adams and Bjork (1969) identify the availability of resources as a key issue:

> . . . the analysis of educational needs without consideration of the cost involved remains merely academic; yet, a surprising amount of activity that goes on under the name of educational planning gives little attention to the constraints of a national fiscal ability. In a sense, plans are often confused with planning; for the plan is but a document, while planning

> *is a continuous process involving constant reassessment of social and economic benefits* [pp. 156-157].

Whether or not most nations can afford to create and sustain new systems of education is an unavoidable question that must be answered during the early stages of planning. The acceptance of innovation in principle may not carry enough weight to insure that a government already hard pressed to furnish any instruction at all willingly will devote the funds and resources needed to conduct the research studies, develop the materials, purchase the devices and install the programs which are likely to result. The failure of many past efforts to demonstrate that innovation can be afforded is ample evidence to convince most educators to be wary of change. And, the difficulty experienced in computing the actual cost of these innovations has not made the task of promoting new concepts any easier.

It would seem, for example, that the probable cost of a system of educational television could be determined accurately using data gathered from existing installations. Nevertheless, Schramm (1969), Carter and Walker (1969) and others have discovered that the number of parameters which must be considered make past experience almost irrelevant. Schramm calculated that the capital investment required for instructional television could vary from $50,000 to more than $5,000,000. In other words, depending on the number of channels, the type of transmission, the breadth of the coverage area and whether the equipment was purchased or rented, one system might cost at least a hundred times more than another. Annual operating costs, he estimated, could range from $90,000 to more than $3,000,000. Even actual, operating systems provide little usable guidance. According to Schramm's figures, the overall cost of educational tele-

vision can be as low as the nine cents per student hour reported for MPATI to $1.54 per student hour, or seventeen times as much, for an installation in Chicago.

Even if past costs were more consistent, the probable impact of future cost reduction efforts must be considered. Computer assisted instruction, for example, has been estimated to cost as high as $7.53 or as low as $1.77 per student hour, depending on how the equipment is used (Carter & Walker, 1969). Stolurow (1969) also calculates the present cost at about $7.50 per student hour but explains that new equipment already in production, together with better scheduling, could reduce the cost to $1.95 per hour. Because future developments in computer technology easily could reduce these costs still further, basing estimates on what has been done makes little sense.

Still a third illustration of the inconsistency of cost estimation procedures is the range of estimates reported for the development of programmed instruction materials. Independent calculations of the labor involved in preparing one hour of programmed instruction were developed by Ross, Klaus and Lumsdaine, Deutsch, Margulies, and Hickey in 1962 (see Margulies & Eigen, 1962). These estimates varied from about 30 to 75 hours of effort for each hour of instructional material. Corresponding cost figures arrived at by these authors ranged between $500 and $3000 per hour of instruction depending on both the wages of the program writer and the amount of editorial, clerical, graphic and management support he was assumed to require. When these amounts then are divided by the number of copies to be produced to arrive at an amortization cost per copy, the resulting range is so great as to make estimates other than those calculated from specific parameters utterly meaningless.

One very desirable modification that could be made would be to abandon the customary calculation

of costs on the basis of expenses per student hour. While this formulation is a convenient one, it is not a particularly meaningful way of expressing the relative costs of competing instructional systems — unless, of course, it is assumed that the primary function of education is the custodial care of the pupils. A productive innovation may cost a little more than some alternative, yet it may produce vastly greater learning. The impact of the change on the remainder of the system must be considered as well. For example, most audiovisual techniques add to rather than replace existing instructional costs. Even a few cents worth of exercise sheets can impose a considerable burden on schools if they can be used only when a teacher is standing by. On the other hand, almost any technique which replaces the teacher or at least divides his time among more pupils is likely to yield important savings.

Estimating System Costs

Although the cost of a modern educational system cannot be estimated without elaborate calculations based on the numbers of students to be served, their location and the availability and price of component equipment, it is possible to construct a framework which will insure that most of the necessary expenses will be anticipated. Too often, only 'peripheral' costs are considered — the cost of the television receivers, textbooks, film viewers or laboratory equipment that will be placed in the classroom. While these are the easiest expenses to estimate, in that the items almost invariably are competitively manufactured, considerable care must be exercised to insure that the estimates are correct. Two of the most likely errors which can occur are the failure to consider the realistic life of the item in terms of the storage and use conditions which are apt to prevail in the schools and the failure to allow for the proper number of items in each school or

classroom in terms of when, and not only how often, the equipment will be used.

The second group of costs are the one-time 'origination' expenses which are incurred in preparing televised lessons, in writing textbooks or in programming a segment of computer aided instruction. These costs are particularly difficult to estimate for a number of reasons. One is that a trade-off always is possible between quality and economy in preparing any instructional material. Almost anyone can author a textbook; only a skilled educator can write one that truly facilitates learning. Too often, expediencies resulting from limited funds are directed at the instructional value of the materials, particularly in the scope of the tryouts, while the superficial appearance of the product is maintained through costly artwork. Another reason for incorrect estimations of origination costs is because of the lack of essential talents in many parts of the world. A director of educational television may not be highly paid in an affluent country but his skills may be relatively costly in regions where this specialty does not exist. Properly skilled manpower, particularly those skilled in lesson development, is essential if any system is to achieve its purpose.

The 'process' costs of a system are those incurred in distributing and implementing the system. Some of the more frequently cited expenses in this group are the cost of transporting materials to the schools, the cost of routine equipment maintenance and the cost of whatever teacher training and supervision is necessary to insure that the system will operate as intended. Regular evaluations of the output of the system often contribute heavily to its expense, but are necessary for feedback purposes. The costs of central equipment installations are part of the process costs of a system. Because few educational institutions are in any way equipped to design or construct

television transmission, computer processors or other complex facilities, these costs are best determined with the help of competent manufacturers who are aware of both the problems and options which should be considered.

Organizing for Innovation

Cost feasibility is only one of the responsiblities of effective planning. Changes in instructional methods, curriculum plans, facility designs or teacher utilization are more certain to be successful when devised and implemented in a competent, systematic manner. Some progress is possible as the result of individuals or small groups working in isolation but the deliberate coordination of developmental activities will prevent repetitious efforts and will enhance the likelihood that any innovations which are produced will have broad applicability. In other words, an organization is required to insure that available resources, particularly the likely short supply of talent, are invested as wisely as possible.

Planning an organization which is capable of producing improvements in education is much like planning any other kind of system. Certain functions must be performed by various components and existing constraints must be recognized. Many alternate models of an organization having the necessary constituent parts could be considered but all, at a minimum, are likely to have these features:

1. a management component responsible for setting overall goals, securing funds and other resources, and controlling the operation of the system;

2. a development component responsible for planning the innovations, conducting the research, and preparing or locating materials and equipment needed to implement a change;

3. a budgeting component responsible for analyzing costs, projecting expenditures, and allocating funds and personnel;

4. an evaluation component responsible for devising measures to assess the effects of changes, for collecting pertinent data, and for reporting results; and

5. an administrative component responsible for implementing changes within the system through revised scheduling, teacher training, and the procurement of needed materials and equipment.

The pattern of organization of such a group will depend on the particular talents of its probable staff members, its size and the range of its intended activities. Several principles of organizational structure generally may be applied, however. First, rigidly defining the responsibilities of each individual or subgroup may facilitate the preparation of organizational charts but it also may preclude the flexibility needed to deal optimally with a wide range of problems. The continuous reassignment and regrouping of personnel is more likely to make efficient use of talents and produce results than the maintenance of a rigid pattern of operation. Second, the size of each component should be large enough to permit some degree of specialization and minimize the dependency of the system on one or two key persons. On the other hand, it should be small enough to insure adequate exchanges of ideas among members without the need for formal communication channels. And third, it should be part of — and not in competition with — other educational agencies. For this reason it may be desirable to draw as much staff as possible from the existing educational system on a temporary, loan basis. This will insure the relevance and suitability of innovations by having those ultimately responsible for their implementation participate in their development and evaluation and will en-

hance the dissemination of the innovations throughout the remainder of the system.

Having the right mix of capability within the innovative team will, in the long run, determine the success or failure of every project undertaken. Ideally, the team should include some people who are problem oriented, some who are technology oriented, some who are user oriented and some who are systems oriented. The problem oriented participants should be those responsible for identifying and implementing needed solutions. Without them, another step must be added to the innovative process, that of convincing the appropriate administrator that he indeed has a problem. The technology oriented participants may be engineers, economists, entertainers or others who are expert in areas in which a solution is likely. Their judgment, suggestions and knowledge cannot be replaced by any amount of undigested published information. User oriented participants generally will represent the teachers or supervisors who ultimately must implement the innovation to produce results. It is surprising how few instructional technologists have spent time teaching in a classroom. Their estimates of what is a practical change may far exceed what experience has shown to be possible. Finally, the systems oriented participants are needed to bring these components together to produce an effective and coordinated outcome.

The analytic tools, background information and developmental techniques needed by these five components to carry out their responsibilities may have to be devised to meet each national or regional situation. Although much can be learned from those who have had experience with similar problems and goals elsewhere, more effort often is required to locate and then adapt successful solutions than to devise a needed innovation from the beginning. Advisors may be of some help but, as a rule, they may be far more useful

as sources of assistance on techniques for solving problems than as participants in their solution.

The Teacher and Change

Another aspect of planning that may be critical is the development of effective procedures for implementing a proposed innovation. The pivotal ingredient here is the classroom teacher; as Travers (1962) suggests:

> *Educational research based on the assumption that teachers will change their behavior if they are told how to make their teaching more efficient is very naively undertaken . . . teacher behavior is probably the most difficult component to modify in the entire system* [p. 529].

Few obstacles to the adoption of new educational methods and media are as burdensome as a classroom teacher's past experience with hurriedly assembled systems that contain incomplete or incompatible components. Far too many ideas fail because new materials are supplied without satisfactory instructions on their use, because new equipment is installed without provisions for spare parts or maintenance, or because new routines are imposed without first adequately preparing both school personnel and pupils on what to expect.

The teacher rarely is inclined or equipped to adopt any but the most superficial innovations. Most new practices or devices for classroom use require substantial time from the teacher in reviewing materials, revising existing lesson plans, preparing new tests and mastering the new content. This generally is effort which must be accomplished after the school day, often on the teacher's own time and without recompense. Other innovations, such as television or programmed instruction may involve less added effort but they pointedly attack the teacher's prestige by replacing him as the prime source of instruction. Most teachers

are likely to accept automation only when it reduces their efforts and yet preserves their autonomy in the classroom. The frequently cited suggestion that the automation of routine activities should be welcomed by teachers who then can devote more of their time to the more creative aspects of teaching does not help much. Few teachers are prepared for any responsibilities beyond routine teaching and the threat of having to be creative could be as disturbing as automation itself.

Teacher training as a step in the introduction of an innovation is essential. Goodlad (1969), for example, describes a research study which purported to test the value of his notions of 'nongrading' as a pattern of school organization and which yielded nondifferential results:

> *I failed to predict that teachers and administrators would reach eagerly for the catchy, innovative label and that nongrading soon would be used to describe pitifully tired old practices . . . [from the report on the study] we know that some classes carried the ungraded label. If label were the only thing changed, however, we could not expect to find differences between pupil groups. The ironic sequel is that following this study, school personnel decided to return to the conventional graded organization! They returned to what they had never left, not knowing that what they had sought they never got [pp. 103-104].*

The introduction of an innovation also involves the timely procurement of instructional materials and equipment, the optimal arrangement and scheduling of facilities and space and the systematic dissemination of needed information to administrators, teachers, pupils and parents. Maintaining an environment within the school system which is conducive to the success of

innovative practices is particularly important. Parents rarely are interested in having their own children serve as the subjects in an experiment. They are more than likely to object to new methods which in any way are unfamiliar or which serve to distinguish their child from others in his age group. Possibly the best technique for overcoming these prejudices is to install a working demonstration which parents and school personnel can visit in order to decide for themselves whether the innovation is desirable.

Evaluating Innovations

The evaluation of educational change is a particularly difficult challenge for laboratory-oriented investigators. Because of the number of changes that are likely to be introduced concurrently, and because of the number of variables that are likely to be affected, no rigorous plan for assessing the results of an innovation even may be attempted. Not long ago, an education official from a developing country who was visiting the United States shortly after a similar tour of England commented that he strongly favored the American educational system because of its enthusiasm for change. His disappointment was all the more evident, then, when it was suggested to him that the two countries really are not very different in educational policy. One tended not to change practices in the absence of any data that might suggest changes would be desirable. The other tended to change in the absence of the same data, and without any concrete knowledge that the changes being made were for the better or worse.

If any change is worth making, it is worthwhile assessing its impact. Yet, the emphasis given to evaluating the effects of changes made in ongoing educational systems frequently is misplaced. In his informative discussion of techniques for measuring the results of development projects, for instance, Hayes (1959)

stresses the need to plan the assessment of an innovation to insure the isolation of cause and effect relationships. It is almost impossible, however, to conceive of an innovation which could be implemented without other, simultaneous changes in the operation of the system. Efforts to identify which change was the critical one assumes that any isolated aspect could be replicated with similar results elsewhere, but this is clearly not probable. Each country, district or school is likely to have its own peculiarities which need to be considered before adapting any innovation to fit those unique conditions. The principal utility of evaluative information is to provide diagnostic feedback which identifies weaknesses within that system so that they may be overcome. The only value in an overall evaluation is to determine whether further investments to expand or enhance the entire system are warranted.

Insuring that an innovation continues to produce results after it is first introduced and evaluated is a continuing responsibility. Quality control standards must be maintained indefinitely to insure that the local adaptations which invariably are proposed do not detract from expected results. On the other hand, just as it is probable that unforeseen events and problems will occur during the installation of a new or changed system, it also is probable that truly effective remedies will have been devised in the field. These solutions must be identified, evaluated and disseminated to enhance the utility of the innovation in other locations.

Evaluation need not be limited to student achievement measures, and content mastery should not be regarded as the only variable of interest to educational planners. Pupil dropout rates, the job satisfaction of teachers, and the attitudes of the public toward the educational system may be equally important. Similarly, the measuring instruments need not be limited to objectively scored paper-and-pencil tests. Still photographs

and motion pictures of student behavior, for instance, may reveal changes far more clearly than answers to multiple-choice questions (Hayes, 1959).

The Prospects for Educational Change

How to instigate change, especially on a large scale, is a difficult question. Generally, the impetus for change is more likely to come from outside an educational system than from within it. Much of the change in American education in the last several years, for instance, was stimulated by psychologists, industrial training experts, communications specialists and university scientists who turned their attention to the problems of education both to satisfy their own personal interests and because of the large increase in the availability of federal funds for educational research and development. Not surprisingly, very few of the federally sponsored experiments were continued by the cooperating schools once the research had been completed. Most dealt with only narrow segments of courses or school programs and the skill needed to expand these models disappeared with the research staff when the study was completed. However, many incidental effects remained. Those who participated in the research tended to be less hostile toward new media and new methods, and more willing than before to adopt subsequently proposed innovations.

Nations faced with intensifying demands for positive action to enhance their educational systems are more likely to look toward conventional solutions — bigger buildings, better salaries, and more classroom aids — then fresh approaches. Real change, if it is to occur at all, will come only from the recognition that education must be based on technology as well as tradition. Thus, creating a climate that is conducive to change is perhaps the most promising approach that

can be taken. Few problems in education will be solved by any one or two studies, even those which are carefully planned and massively supported. No single innovation is apt to overcome an existing deficit or alter a philosophy that allowed that deficit to occur. Yet, no progress will be made by standing still. Effective planning may yield not even a single useful innovation but it can create the indigenous institutions which have the energy, the enthusiasm and the imagination to challenge complacency and kindle the momentum needed to inspire meaningful change.

One simple expedient would be to insist on change as an integral part of every offer of educational support or assistance. Every plan for a new school building should in some way incorporate a design change that would be an improvement on the one before it. Every planned purchase of textbooks should be contingent on revisions, authored locally if necessary, to improve weaknesses. Every grant to support an educational program should require regular and frequent demonstrations of improvements in the efficiency or effectiveness of the program as a condition of continued funding. Concrete evidence of attempted improvement should be as rigid a requirement for educational assistance as budgetary accountability and timely administrative reports.

The changes that may be produced when innovation is required will not always be substantial or worthwhile. Initially, at least, most changes are likely to be peripheral to fundamental problems. Innovation may more readily appear in vocational subjects, for example, than in academic courses. New training programs may be suggested for guidance counselors before they are for teachers. Audiovisual aids which complement conventional lessons may be adopted when far more critical applications studiously are being avoided. Yet, an insistence on innovation sooner or later will demon-

strate that good solutions to important problems do not have to be elaborate, encompassing or expensive.

There is the danger, of course, that these policies may encourage the adoption of opportunistic fads. Innovation for its own sake is a luxury which is undesirable in even the most economically advanced nations. The alternatives, on the other hand, are far less promising. Externally imposed changes, even when amply supported by research findings, may fail to meld with the cultural expectations and historical priorities already entrenched within the system. The growth and refinement of an educational system is a continuing process which demands a continuing capability for change. Suggestions from the outside can scrape away at shortcomings but they cannot contribute to the internal competence a system needs to recognize and overcome its own defects.

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RESEARCH NEEDS

Much of the basic information needed to produce significant increments in educational practices already is available. In fact, what is known about how learning occurs and how it can be encouraged is far ahead of present applications of existing knowledge. Yet, considerable research is needed to convert fundamental principles into effective and efficient classroom procedures. Before looking at pressing research problems, however, it may be desirable to consider the functions of educational research and the ways in which the productivity of research efforts directed at improving instruction might be enhanced.

Selecting Research Problems

To begin with, a research background certainly is not required to identify significant problems. The important issues in education stand out all too clearly. It hardly is encouraging, then, to find so many researchers working on solutions to problems which are likely

to have no impact at all, even if the most optimistic outcome imaginable happened to be produced. The time and talents of a competent researcher are too valuable for him to work on studies which are of interest solely to a select number of fellow investigators and which have no meaningful implications for constructive changes in instructional practices. Perhaps the bulk of all educational research never should have been undertaken in the first place. A sampling of some recent reports, for instance, includes the findings that 75 percent of fifth and seventh grade boys prefer animal comics, that girls average almost one-half a word longer sentences than boys up to age six and that underachiever girls receive higher grades in the first five years of school than other bright girls. The researcher must have something more valuable and useful to say to the teacher than this.

The problem seems to rest in the rather dubious assumptions that all knowledge is equally valuable, that theory deserves more emphasis than technique, and that applied research — no matter how creative — is somehow less scientific than studies which yield results of no immediate utility. Ample research problems already exist in the real world of classroom teaching, more than enough to make it unnecessary for researchers to create their own questions. This same characteristic of research is reflected in the way outcomes tend to be assessed. Obviously, experimental findings will be of practical use only when the variable being manipulated is powerful enough to have an effect in spite of all other extraneous influences that might be present in the classroom. Research which systematically eliminates the consequences of extraneous factors, either through experimental control or statistical manipulation, may satisfy the standards of research journals. But, an effect which can be observed only with the aid of controls or statistics often cannot be replicated in

the typical school setting. Phenomena which can be demonstrated exclusively in artificial situations where the 'error term' has been minimized generally are not worth the time, money and trouble invested in producing them.

Far more productive research usually results from diligent efforts to make a promising idea work well in the uncontrolled, real-life world. To achieve these kinds of breakthroughs, many ideas may have to be explored before one is found which may have a truly substantial impact. This means that a number of potential solutions may fail and that even imaginative ideas may not produce meaningful gains although they are capable of providing statistically significant outcomes under laboratory conditions. The real goal of educational research should be the development of technologies that yield a real magnitude of difference, one that overwhelms the influence or random variability of pupils and conditions alike. To achieve these aims it is necessary to determine in advance of a research undertaking whether the probable impact of any conceivable solution is sufficiently great to bother with the investigation at all. A minor gain, even if demonstrable, may not justify the cost of implementing it in the classroom. For this reason, research should not be undertaken unless the success or failure of the innovation being investigated will be obvious even to those untrained in statistical methods.

Patterns of Productive Research

Another problem with research is that the process of investigation may interfere with the process of innovation. Too often, insistence on rigorous experimentation and formal assessment reduces the inventive flexibility that is essential in system development. Most successful efforts to change education were never viewed as experiments by those central to their plan-

ning. System development may depend on the freedom to manipulate many factors jointly, to pursue promising leads and abandon impotent ones, and to ignore consistency among conditions, none of which satisfy the rules of statistical inference. Contrastive research appropriately follows innovation and should not be a condition for it. Goodlad (1969) has expressed much the same idea:

> *We are not likely to have invention in educational practice, however, let alone advances in educational science, if we demand research regarding the effects of an invention as a prerequisite to its creation* [p. 97].

This is not to say that evaluation is undesirable, but only that the process of assessment cannot be permitted to interfere with the process of change. The absence of clearly objective achievement data, for instance, should not prevent the introduction of an innovation. Meaningful, relevant information can be collected through well documented observations and interviews if more precise measures are not available. Similarly, the measurement process itself should not intrude upon the aims of the innovation. Evaluation should be unobtrusive, noninterfering and devoid of influence with respect to the selection of goals and outcomes. On the other hand, evaluation should be sensitive to the unanticipated effects of any innovation. In that all components of a system are interrelated, the assessment must measure the output of the system as a whole. This is one reason why continuous, comprehensive feedback is essential to the systems approach.

If traditional educational research, whether conducted in the laboratory or the classroom, is not particularly relevant to overcoming the enormous gap between what exists in education and what is needed, then what kind of research will lead to meaningful breakthroughs? The answer appears to lie in studies

which explore radical solutions to the fundamental problems of the quality and quantity of educational opportunity. It is difficult to imagine that progress at its present pace realistically will manage to cope even with present stresses on existing school systems. To give education the capability of reaching all those who should be enrolled and to teach them all the knowledge and skill they will need to contribute positively to the world around them will require imaginative alternatives to existing practices. To devote time, energy and funds to studies which at best might yield marginal increments in the availability or scope of instruction is ignorance, negligence or both.

The evolution of present systems hardly can be expected to catch up on existing deficits, much less to overcome them. Real advances, particularly in the developing countries, will come only by leapfrogging current difficulties and by creating educational systems which have the capability needed to serve future generations. It should be clear that such a system will have to provide more and better education than is available in most economically advanced nations today. Both because of the growing number of students to be taught and the increasingly rapid rate at which teachable knowledge is expanding, much of this instruction will have to be acquired without the direct assistance of a live teacher. The solution may not be to use television, or computers, or dial-access consoles but it is impossible to imagine that a sufficiently large number of adequately trained teachers could be recruited to meet probable demands. Some form of instructional automation is inevitable.

It is equally probable that education in the future will be largely self-directed, or at least highly individualized. As larger numbers of students enter and remain in school, the homogeniety in ability attributable to limiting enrollment to the elite is more than likely to

disappear. Even further diversity will occur among students as they pursue knowledge leading to rapidly multiplying specialties in both the arts and sciences. To the extent that the identical education for each may be no education at all, instruction will have to be tailored to fit the competencies, limitations and expectations of each individual learner. Graduates will have to be mass produced but, like automobiles, with the variety of options necessary to satisfy even the most discriminating critic.

Literacy as a Research Problem

Research likely to foster the development of systems having these characteristics necessarily must be directed at components and techniques which could be useful today but which will be essential to education a generation or more from now. Within this framework, possibly the most critical problem is that of insuring widespread literacy. Learning to read is perhaps the only skill that is universally emphasized in all organized educational systems. Mastery of almost any subsequent knowledge is barely a possibility without the opportunity to learn from written text. Yet, we know surprisingly little about how children learn to read and even less about how reading might be taught more efficiently. Almost nowhere else in education does opinion count so heavily and research so little. Occasional positive contributions, such as reading readiness training, the Initial Teaching Alphabet, the carefully graded, multi-level readers developed by Parker for use in Venezuela (see Parker, 1963) and programmed reading materials of the kind prepared by Sullivan Associates (see Silberman, 1965; Pines, 1966) have not had the overall impact that might be hoped from them.

The development of an effective model for literacy instruction, one which isolates discrete objectives and

identifies techniques usable in problem areas, would be a valuable beginning. Such studies necessarily would be concerned with the vocabulary, orthography and structure of languages used both in emerging and advanced countries. Cross-cultural comparisons of the components and criteria of literacy development would give proper perspective to many of the controversies that have retarded the progressive improvement of reading instruction and the emergence of a productive technology for teaching reading either in or out of formal school settings.

The next step would be to devise systems of literacy training to meet these objectives. Emphasis probably should be given to instructional methods and materials suitable for children rather than adults; if truly effective procedures are assembled, the adult literacy problem will disappear in a generation or two. Emphasis also would have to be given to automating reading instruction using economically feasible media. Automation will have two principal advantages. First, it will permit the rapid implementation of the program where it is most needed — in countries with the least encompassing educational opportunities and the fewest literates. And, second, the explicitness required to automate instruction is likely to make a substantial contribution toward refining the issues involved in learning how to read.

Whether or not significant expenditures for equipment would be required seems immaterial. Teachers or even parents could substitute for costly audio equipment in areas where the purchase and distribution of these devices would be difficult. On the other hand, equipment and materials capable of insuring literacy could cost the equivalent of several years of formal schooling and still be less expensive in the long run than present methods of classroom instruction. As Pines (1966) points out:

> *Waiting until the age of six and then being taught ineffectively often proves disastrous for [some] children . . . they sink to the bottom of the class right from the start. There the teacher gives them even fewer sight-words to memorize than to the other children. From then on, they may never catch up. . . . Only a few youngsters succeed in overcoming such odds. The rest — even those from loving and stable homes — fall by the wayside, joining the vast pool of functional illiterates and dropouts [pp. 200-201].*

The funds now spent to produce barely enough literacy for subsequent self-initiated learning may be far greater than what would be needed to purchase even the most complicated computerized devices. Reducing the total time required to learn to read to only a few weeks — a not unreasonable goal — could shorten the entire span of education by as much as two years, or one-sixth the cost of a twelve-year program.

Undirected Learning as a Research Problem

Other research objectives seem pale in comparison to a meaningful breakthrough in literacy instruction. Even more important, much of the research that might have a sizeable impact on educational practices obviously would be contingent on reading skill as a dependable resource. For example, Coombs (1968) persuasively emphasizes the growing need for a system of self-directed 'nonformal education' in the developing countries to provide for continuing education beyond that offered within schools and to remedy deficiencies stemming from rapidly changing opportunities and responsibilities:

> *In this new context of rapid change, the prime role of formal education — as we have several times stressed — must be to 'teach people to*

> *learn for themselves' so that they can later absorb new knowledge and skills efficiently on their own. Even the greatest universities cannot hope to turn out 'educated' people — in the sense that they have 'completed' their education. Their aim and hope must be to turn out educable people, well prepared for a life of learning — which is a quite different matter* [*p. 142*].

Learning how to learn is an instructional objective usually recognized as far more important than the mastery of any specific fact or principle by competent technologists as well as educational analysts. Skinner (1968), for example, echos the same point:

> *It has been said that an education is what survives when a man has forgotten all he has been taught. Certainly few students could pass their final examinations even a year or two after leaving school or college. What has been learned of permanent value must therefore not be the facts and principles covered by examinations but certain other kinds of behavior often ascribed to special abilities* [*pp. 89-90*].

How people learn, then, may not be a basic question which is of research interest exclusively to the laboratory psychologist. If the investment usually made in formal education is to have lasting value, one of its important components must be to adequately prepare students for future learning long after they have left the classroom, reached adulthood and have assumed new careers and responsibilities.

In many respects, nonformal education is no different than the individualized, self-directed learning that is being relied upon both in the imaginative systems of instruction already described, and, even more important, in the traditional classroom as well. The child who is capable of learning from a teacher's lec-

ture, from a textbook assignment completed at home or even from a playground experience is learning in the same way he ultimately must from an explanation by a work supervisor, from a current newspaper article or from his incidental interactions with other human beings. Fostering this learning may be the essence of good teaching — arranging conditions so that the learning occurs as easily and quickly as possible.

Applying the systems approach to the process of 'learning to learn' suggests two ways in which self-directed learning might be enhanced. On the one hand, it is evident that the learner could be helped to master certain skills. For instance, he might learn where to look and when to listen. He might learn how to generate his own opportunities to practice new responses. And, he might learn to schedule the periodic reviews that are required for adequate retention. On the other hand, the need for perfection in these skills is diminished by the degree to which the presentation he learns from has controls built in which insure his attention, which give him opportunities for practice and which appropriately schedule his reviews. The extent to which these conditions are made part of the capabilities of the learner or, instead, incorporated into the instructional materials then used by the learner is one of the major decisions likely to affect the entire course of education.

If the first alternative — learning to learn — is emphasized, a considerable amount of research will be required to identify the precise skills which will facilitate learning from traditional presentations. Very little work in this area has been conducted, particularly with respect to human learning and for meaningful content. This possibly is one reason why 'Head Start,' the massive compensatory education program that has been offered in urban areas of the United States for economically disadvantaged preschool and early elementary grade children, has not shown encouraging results. In

1967, after two years of operation, the U. S. Commission on Civil Rights (1967) concluded that neither Head Start nor any other program of compensatory education appeared to raise the subsequent achievement of the participating children. In 1969, the most comprehensive report on Head Start yet available concluded that:

> *Summer programs have been ineffective in producing any persisting gains in cognitive or effective development that can be detected by the tests used in grades 1, 2, and 3. . . . Full-year programs are marginally effective in terms of producing noticeable gains in cognitive development that can be detected by the measures used in grades 1, 2, and 3, but are ineffective in promoting detectable, durable gains in affective development* [*Westinghouse Learning Corporation & Ohio University, 1969, p. 243*].

Through June 1968, 2.1 million students had participated in the summer programs and .6 million in the full-year programs; the cost of both programs to that date totaled just under one billion dollars (Comptroller General of the United States, 1969).

In commenting on the failure of enormous expenditures for Head Start to achieve any lasting improvements, Hunt (1969) questions the effectiveness of the program itself, not the concept:

> *Compensatory education has not failed. Investigations of compensatory education have now shown that traditional play school has little to offer the children of the poor, but programs which made an effort to inculcate cognitive skills, language skills, and number skills, whether they be taught directly or incorporated into games, show fair success. A substantial portion of this success endures* [*p. 297*].

It is difficult to believe that learning how to learn, and learning how to profit from instruction as it is now offered, is other than an acquired skill. It is amply evident, however, that the components of this skill are not being routinely taught anywhere. Although this skill may be the most important of all that could be learned in school, what to teach and how to teach it remains a mystery.

Controlled Learning as a Research Problem

If the second alternative — improving the materials — is emphasized, the teaching of these mediational skills may be unnecessary. Aside from basic literacy, there seems to be few skills needed for learning that cannot be replaced by changes in the way in which instructional materials are designed and prepared. Much more research is required, however, before the characteristics of materials are known which will permit learning even by those not skilled in how to learn. It is quite likely that the resulting texts, films and auditory presentations would have many of the features of programmed instruction. Rather than teach a student how to isolate the main points of a presentation, for example, all but the main points could be deleted. Instead of leaving it up to the student to determine what to practice and how much practice is required, the materials could incorporate the necessary exercises and response opportunities. And, in place of instructing the student on the importance and sequencing of reviews, the materials could contain the needed reviews at predetermined critical points.

Possibly the most significant step that might be taken would be to simplify materials intended for adult instruction to a literacy level which more easily is achieved. Foote (1966), in discussing the probable impact of radio and television on nonformal education in developing countries, envisions far fewer languages

than now are in use, with isolated or primitive peoples learning from an international language instead of their own. This language, rather than being borrowed from cultures which have ample written materials and educational resources, might be wholly artificial incorporating, for instance, the very simple orthography characteristic of Finnish, the very regular grammar of Chinese, and yet employ almost any convenient vocabulary simplified to a basic word list — the 850 word English vocabulary proposed by Ogden (1944) is but one example. In many countries, the cost of as extreme a step as replacing every existing book with a parallel volume in a simpler and more universal language may well be less than the yearly cost of producing literacy particularly when several dialects are involved.

These two approaches represent extremes; realistically, a practical and acceptable solution to fostering better nonformal learning is likely to fall between them. Nevertheless, the goal of making further learning possible must be the primary aim of formal classroom instruction. Too much of the research usually done in education omits this objective altogether and, instead, considers content, media and methods of instruction or the large number of variables, such as the pupil's sex or size, which are beyond manipulation. If research is to solve the pressing problems of education it cannot go about it in a piecemeal way, expending much needed resources on relatively minor questions that would disappear completely if some of the really important problems were to be solved.

Only after a reasonable technology of instruction has been achieved will it be possible to devise educational systems well suited to each country's needs. Those nations which today have the least adequate systems are, in this sense, at a substantial advantage. Countries with fully developed educational systems may have too much of an investment to consider radical

changes, and probably would face too much inertia to allow radical changes to be made. 'Leapfrogging' not only permits advancements without repeating past errors as interim steps, but provides opportunities to avoid existing errors as well. Just as there is no need to replicate the history of education everywhere, there is no need for developing nations to copy the educational idiosyncrasies of advanced countries. Familiar patterns cannot be replaced by a vacuum, however, and research is required to develop new concepts that will be compatible with tomorrow's requirements.

Current Research Issues

Research issues which may have profound effects on future educational systems largely are those which focus attention on fundamental assumptions. A number of these stand out as problems which may have a high probability of significant returns:

1. *Instructional Content.* The influence of tradition on instructional content may be more readily recognized by the pupil than by the teacher. Memorizing hundreds of facts, dates or names cannot make literature come alive or history lastingly inspirational. Better objectives are needed within courses, but these are not likely to be produced without better ways of expressing the desirable outcomes of instruction. More specifically, research is needed to develop methods for formulating instructional objectives based on anticipated career opportunities and adult responsibility — objectives to replace those derived, usually by committees, from the content itself. Hopefully, such objectives would be those which would facilitate lifetime learning rather than those which burden students with easily forgotten details. As an example, mastery of some fundamental principles of science probably is necessary to understand hybrid crops or space travel as an adult but, in the absence of continued interest

in these fields, few adults can recite the phylum names they memorized in biology class or the formula for computing horsepower they had mastered during their physics course.

Replacing these components of instructional content with more relevant and useful information cannot be done unless techniques are created for determining which categories of content do have lasting value. It would not be surprising, for instance, that new insights into what students need to learn would give much more emphasis to driver training, sex education and money management; these are activities of far greater importance to the daily lives of most adults than algebra, chemistry or ancient history. So long as instructional resources and school years are limited, some selectivity is required in deciding what to teach. Efforts to improve the effectiveness of instruction without concomitant refinements in what is taught will have no lasting value.

2. *Presentation Media.* Audiovisual specialists probably know more about how to make presentations attractive than how to prepare them as effective teaching tools. The low cost of radio, for instance, suggests its use as an instructional device both in developing and affluent countries, but very little research has been done to determine the conditions under which radio presentations will be effective aids to learning. Techniques appropriate for entertainment programming may be completely different from those appropriate for instructional programming. The number of repetitions usually presented, for example, may be too few to insure mastery. Useful research in this area would be to devise sample lessons which were demonstrably effective in producing meaningful changes in behavior.

At the same time, considerably more effort is required to specify the characteristics of media devices which are appropriate for school use. Few educators

are aware of the tremendous power their combined purchases could exert. Instead of being forced to choose from what is available, educators could take the initiative in specifying the exact requirements of a projector, television receiver or tape recorder for school use. The end result is quite likely to be equipment which is more economical, more durable and more easily operated. Research could provide the standards for devices which would insure that investments in them were wisely spent, at least technically.

3. *Teacher Training.* Although teachers someday may be obsolete, those now employed in the classroom and those currently being trained will have considerable influence on the future of education. These teachers are likely to be the models for, and the implementers of, any constructive changes that will occur for the next several generations. For this reason, long-range plans to improve education may have to begin with teacher training. Unfortunately, however, and despite many efforts in this direction (see Gage, 1963; Ryans, 1960), we know very little about good teaching or the qualities of good teachers. We train teachers in the art of curriculum planning, for instance, but the classroom teacher has almost no voice at all in determining the content, sequence or even the textbook for a course. Teachers tend to be trained as educators; they learn about teaching techniques but rarely have the differential practice needed to develop skill in their use. Systematic research on the characteristics of good teaching probably could shorten teacher training substantially as well as improve on the quality of graduates.

Efforts also are needed to determine how experienced teachers can be kept abreast of new developments, both in content and methodology. Continuing education for teachers is a surprisingly neglected area. Yet, even the dismissal of classes for one week out of

every school year to permit teachers to attend local workshops where they could acquire new skills and information could be a very valuable step. Correspondence instruction could keep teachers informed of new knowledge, materials and techniques. Furthermore, greater emphasis must be placed on the evaluation of teachers by merit. The lack of measurement instruments to assess instructional performance in the classroom is silent evidence of how far we are from a true technology of teaching.

4. *Student Attitudes.* Whether learning is teacher-directed, device-directed or self-directed, the student must exert some effort in attending to, responding to and participating in the instructional environment. Traditionally, the level of effort needed has been induced by the threat of aversive consequences for not learning. Poor grades, disgrace and lack of opportunity have been used in many schools, physical punishment in others. Success has been limited at best. The better students often cooperate but learn to dislike school. The poorer students soon become almost immune to the punishments. The development of positive attitudes as a potent alternate to aversive control has received increasing attention over the last several years (Skinner, 1968; Mager, 1968), but the introduction of techniques for making instruction self-reinforcing has not been experimented with on a large scale.

Nonformal education will require much more built-in motivation than usually is achieved by existing self-study and correspondence courses. Such courses rarely are completed despite the initial interest demonstrated by the learner in making the purchase. The deficiencies in these courses generally are not in the absence of useful information but in the lack of assistance to the learner. Mastery of new skills or knowledge can be very rewarding, but mastery will not occur unless the student in the past was taught to persevere

at a learning task and unless sufficient evidence of mastery is demonstrated to the learner at frequent intervals.

More Current Research Issues

5. *Educational Experiences.* The kinds of practice most likely to foster proficiency is evident for many kinds of learning. Handwriting and arithmetic drills are recognized as essential to producing these skills. As content grows in complexity, however, the kinds of practive needed to develop mastery becomes increasingly vague. The study of 'citizenship,' for example, rarely includes any sort of relevant practice at all; students learn about government and how it operates but they have little opportunity to experience differential reinforcement as a consequence of problem-oriented actions and decisions. Typical routines in a chemistry or physics laboratory are expected to be followed rigidly. The opportunity to experiment and discover is so lacking it is surprising that any scientists are produced by traditional educational programs; more than likely, competent researchers are the product of rewarding experiences obtained outside of school with science kits and self-initiated creativity.

Examples of a number of imaginative ideas to improve instructional experiences have begun to appear (as, Martin & Pinck, 1966). Much more research is required, however, to devise lesson plans, demonstrations and practice opportunities that represent usable substitutes for present practices. Emphasis, too, must be given to developing learning experiences which can be offered within a system of fully individualized instruction. Finally, research is required to determine how any educational experience can be made more valuable; in other words, to isolate the characteristics of assignments which yield significant increases in

mastery and retention. Most classroom activities now being used probably do little more than add variety to the school day, failing either to entertain or educate most students.

6. *Instructional Efficiency*. The profitable use of the time a student spends in school will someday become as important a goal as overall achievement. Although students are not paid for their time, the cost of furnishing space, equipment and teachers is large enough to expect that each minute of learning time should be utilized wisely. Schwarz (1969), for example, questions the appropriateness of 'enabling' objectives, those meant to prepare students for advanced instruction, in the early grades in countries where few students complete elementary school. He also points to the substantial variability among countries in the number of hours of instruction offered per day and the absence of data relating to an optimum schedule. Probably the most potent of all opportunities to improve learning efficiency would be the discovery of methods for maintaining learner involvement over reasonable periods of time. The application of techniques akin to the traditional time-method analyses conducted by industry might have profound implications for instructional management.

Adjustments in the criteria of instruction may produce still further gains in the use of student time. The definition of mastery varies considerably from course to course and classroom to classroom. Achieving perfection in second language pronunciation, in clerical skills such as typing or in reading comprehension may not be essential at all. The time usually invested in developing a skill from 'good' to 'excellent' might more profitably be spent learning a completely new skill. Too much learning also may affect potential adjustments to new knowledge; it may be too much to ask an education student repeatedly drilled in classical

teaching techniques, for example, to now accept new theories of instructional automation.

7. *Cost Reduction.* Operating a school system by conventional business standards would be a promising accomplishment. As James points out, business is accustomed to cost-effectiveness studies and cost-benefit analyses as tools to maximize productivity. Traditional school budgets, however:

> . . . *have provided little insight into what would be produced in terms of services. Interest has been increasing rapidly in recent years in program and performance budgeting as a solution to the information problem. A program budget specifies planned activities and estimates the costs of each activity, facilitating review by governing bodies. Performance budgets go further in measuring the costs in relation to benefits to be realized from each activity supported; this requires complete revision of accounts and their classification as now used in school finance. Certainly, some change is needed in school accounting, inasmuch as present practices and procedures are more useful for concealing information than for revealing it* [*James, 1969, p.* 24].

To a large degree, the more widespread use of cost-effectiveness concepts will depend upon replacing existing indices, such as cost per student hour, with more meaningful measures.

There is nothing in the background or capabilities of most school officials to suggest they are necessarily good managers, and the notion that classroom instruction can be assessed using cost-benefit accounting techniques may be abhorrent to many educators. Yet, creative budget control may turn out to be a valuable source of innovative ideas. For example, Benson (1969) suggests that a school system faced

with a sharply rising enrollment may find it more effective and considerably less expensive to train existing teachers to deal competently with somewhat larger classes than it would be to build new classrooms and hire new teachers to absorb an equivalent number of pupils. Considerably more research is needed in areas such as this one where the focus is on dimensions other than instructional methods and pupil achievement.

22

PROBLEMS AND PROSPECTS

What education may lack in trained teachers, adequate buildings and modern texts is more than made up for in unsolicited advice and outspoken criticism. Strained to capacity to prevent the total disintegration of an instructional capability which may have taken several generations to develop, existing educational systems hardly can be expected to undertake the risks of experimentation that most of its critics feel are needed. Yet, it is becoming increasingly clear that the discrepancy between what education is and the powerful force it could be already has been stretched beyond repair by simple patching. Further reprimand cannot provide the missing answers. What is needed, instead, is the support and encouragement that will make a metamorphosis possible. Education may be more willing to reconstruct itself than its distractors are willing to recognize.

The Need for Innovation

The most significant problem facing education today is the gigantic task of coping with rapidly rising enrollments throughout the world. There are simply too few teachers, too few classrooms and too little expectation of sufficient increases in either to look toward traditional approaches for relief for decades to come. As Jacobs (1969) points out:

> *The stark fact is that resources simply are not available to remedy the quantitative deficiencies by following traditional approaches and practices. New ways must be found. And unless they are found, tried, refined, and implemented, ignorance and illiteracy will continue to be the lot of an increasing proportion of the younger generation in the developing countries* [*p. 158*].

The prospects are indeed poor. The global shortage of capable classroom personnel is quickly reaching the point where even greatly expanded class sizes and severely abbreviated school sessions will afford only temporary relief. As an alternative, the promise of a technological revolution in education has become a theme of hope for world educators, particularly those who have focused their attention on the problems of the newly developing nations. Coombs (1968) says:

> *. . . the question remains whether conventional measures such as these will suffice to solve the problem. Our own guess is that something more is needed. We need a fundamentally new strategic approach which breaks the shackles of convention and dares to contemplate innovations of a sort we readily accept in other realms of life but which, for lack of courage or imagination, we have scarcely yet dreamed of in the vital realm of human learning and development* [*p. 137*].

Despite the ample evidence of need, there is far from uniform agreement that alternatives may exist or even that a technology of education is possible. Yet, the foreseeable demands on educational establishments in the developing countries are so great that any continued encouragement of these nations to attempt to duplicate instructional systems which more advanced nations already are struggling to replace would be reprehensible. Positive efforts are needed to devise and install new systems which illustrate what technology can accomplish. As Thut and Adams (1964) recommend:

> *An educational technology designed for developing nations should be created. New, bold, and different instructional techniques and materials must be introduced into the schools and used by other agencies to communicate the content of development* [p. 350].

Perhaps surprisingly, it may be far easier to create truly innovative systems in nations with rudimentary educational establishments than in nations with advanced economies. The more complex the system, the greater is its inflexibility and the greater is its resistance to change. Educational innovation is one area in which developing nations most easily can leapfrog established traditions and create patterns of excellence that cannot be reached by gradual evolution. But even where the need and opportunity are greatest, significant opposition to any fundamental change in educational practices can be expected.

The Cost of Educational Innovation

One problem is whether or not a developing nation can meet the cost of a radical change in its present educational system. Most new practices in education do result in added expenses, at least initially. Nonrecurring expenditures must be anticipated to permit

the acquisition of needed equipment, the training of participating teachers, and the conduct of detailed evaluations. To the traditional educator, the adoption of audiovisual materials, student workbooks or instructional television necessarily represents an added burden for already insufficient resources. From his point of view, an innovation is always a cost, never a benefit. What he fails to recognize is that all options must entail expense. The question is how funds are to be spent, and not if.

Money alone is incapable of solving fundamental educational problems. Teachers could be offered larger salaries, new schools could be erected and more equipment might be purchased but none of these steps would be likely to produce significant increments in the quality of instruction. It is quite likely that the funds allocated to the educational sector in any nation's economy reflect what that nation can afford without regard to need. Except at the extremes, the overall quality of most educational systems appears to be discouragingly similar. Some differences exist even at the community level, but these differences are difficult to attribute to specific variables. Shaycoft (1967), for example, reports that an analysis of Project TALENT data relating average achievement to school characteristics yielded inconclusive results, even to the point of detecting no relationship between relatively strong and weak course offerings and student achievement in those specific subjects.

The amount of resources available to education may not be as crucial as insuring that those resources are used in a sensible and efficient manner. In this sense, well planned innovations are far less likely to raise school budgets than the continued use of traditional approaches. Never ending requests for more teachers, more schools and more equipment — all at progressively increasing unit costs — result in a pre-

dictable increment in expenditures each year without any real hope of dramatic improvements in instructional outcomes. Standing still may be the most expensive of all the options now open to education. Developing nations which turn to more affluent economies for leadership in pioneering innovations are likely to be disappointed. Affluence can be a powerful detriment to educational change — a nation which can afford the luxury of well paid teachers, and then supply them with an abundant variety of laborsaving devices, is under little pressure to depart from accepted traditions. New models of education are more likely to appear in response to desperation.

The Direction of Educational Change

But, even if a decision is made to pursue new educational approaches, there is still the problem of which approach. The past few years has witnessed an immense growth in the instructional resources available for classroom use. New educational media and methods have appeared to supplement, support, extend, enhance and replace the traditional teacher. Deciding among them is not an easy task. To be effective, a system of instruction must begin with one or more core concepts and all other constituent parts of the system must then be selected on the basis of compatibility. The selection of the core concepts is critical.

Educational research, with its present emphasis on academic issues, has not been able to provide the guidance and direction which is now needed to shape system planning. As Schwarz (1969) comments:

> *Implicit in the problems to be solved and the decisions to be made are hundreds of specific questions that only research can answer. Yet the outcomes of the research undertaken to date have in fact had little impact on international education. The effectiveness of edu-*

> *cational practices has not been demonstrably upgraded. The capacity of educational facilities has not been increased. Savings in neither teacher requirements nor recurrent costs have been effected. Despite the promise of unlimited potential, the history of international research has been one of negligible fulfillment* [p. 344].

The Prospects for Automation

Without adequate demonstrations that it can be done successfully, there is likely to be a particularly strong reluctance to abandon the participation of live teachers, even where it is recognized that there never can be enough to cope with rising enrollments and expanding knowledge. Deviations from accepted patterns of classroom teaching, especially the notion that learning might occur in the absence of a teacher, can be profoundly disturbing. As a result, media-based instruction often is attacked for the very deficiencies — the lack of motivational influence, the failure to encourage creativity, the absence of personal warmth — that may be all too evident in the performance of many classroom teachers. Yet, the naive view persists that instruction is necessarily deficient unless it fully replicates the voice and image of the human teacher.

Even where automation is accepted in principle, as it must be if present constraints on school system capacity are to be eliminated, it then must be made operational. So long as classroom teachers are expected to idly 'stand by' while students learn from recorded lectures or programmed exercises, only token adoption is likely to occur. Yet, the cost of the devices and materials necessary to support a system of individualized and automated instruction might well be only a fraction of the cost of the teacher they could replace, even in economically impoverished regions. As this becomes recognized, automation will be applied

to overcome voids in educational opportunity and to provide some form of instruction where it otherwise would not exist.

The quantitative implications of automation, however, are not nearly as significant as the probable impact of automation on the perfection of education. Too much has been learned about learning to accept conventional patterns of education as the ideal. For example, the degree to which this automation must simulate human attributes is more than questionable. There is even considerable doubt that what the classroom teacher does is optimally effective in producing learning. Certainly, no human is capable of imposing the exacting controls over the learning environment that can be replicated again and again by a simple machine.

A fundamental issue, then, is whether teacher-based systems are the very best forms of education that can be devised. We earnestly hope not. As automation becomes more popular, it is likely that increasing attention will be directed toward the development of automated systems which assume a greater and greater share of the instructional burden. Sooner or later, efforts will begin on automating the most difficult aspects of instruction, those which are now beyond the capability of ordinary textbooks, the communications media, and even the teacher who must respond to the needs of all the students in a classroom at one time.

The Prospects for Individualization

The most significant change that is likely to occur will be a progressive increase in the individualization of instruction. Initially, self-paced practice can be expected as a complement to media-based presentations. Self-instructional assignments to be completed both in and outside of school will be used with increasing regularity at all age levels as replacements

for discussion and recitation activities. As a greater and greater share of the instructional burden is placed on these assignments, efforts to enhance their effectiveness are likely to grow. Traditional textbooks and lesson plans will be replaced with more flexible materials designed to permit each student to pursue his own goals at his own rate, and the distinction between formal and nonformal learning will begin to disappear.

This is an exciting goal for education. But, before it is reached, many problems will have to be faced. The needed technology, as opposed to the principles upon which it would be based, is far from adequately developed. Entirely new kinds of educational systems must be created, ones radically different from those now in use. The creation of these fundamentally new approaches to education will be as serious a challenge as it is an opportunity. Neither the urgency of existing deficits nor the enchantment of educational utopias will themselves produce the insights and innovations which are needed to reach vast numbers of students with the benefits of education at a tolerable cost.

The problem, as Skinner (1968) observes, is not limited to the developing nations:

> *The strength of a culture lies in its members. Its young people are its most important natural resource, its greatest wealth. The first concern of a government in the broadest sense should be the development of the genetic endowment of those it governs. Yet it must be admitted that even in what we call well-developed cultures, very few men and women come close to realizing their potential, and that elsewhere there is a shameful waste* [*p. 259*].

The prospects for educational change are worldwide as well. This is an age of technology, a time when actual accomplishments have turned imagination into prediction. It is difficult to believe that the same

energy, resourcefulness and dedication that has yielded so much improvement in most other endeavors cannot do equally as much for as important a human concern as education. And perhaps more.

23

SELECTED READINGS

The field of instructional technology is a rapidly growing one, and no single survey of its methods and accomplishments can hope to include all the information that has been produced. For this reason, the following collection of source materials has been compiled for those who are interested in learning more about what can be done to change education. Most of the topics touched on in this book are represented by one or more selected readings. For convenience, the titles have been divided into three categories:

- Educational Policy and Planning
- Instructional Methods and Techniques
- Current Periodicals and Publications

Only a few of the hundreds of available references which might have been appropriate for this list could be included. As a result, preference has been given to

more recent works and those which represent the efforts and views of a number of different authors. Each reading is described briefly to indicate its scope, emphasis and intended audience so that those of particular interest can be identified. In addition, sufficient information has been provided to permit ordering any of these publications through a bookstore, library or mail order dealer. Prices do not include discounts, when applicable, or shipping expense.

Educational Policy and Planning

Cerych, L. *Problems of aid to education in developing countries.* New York: Frederick A. Praeger, 1965 (Pp. xiii + 213; $7.50).

This study examines and assesses various forms of external aid to education in the developing countries. The need for assistance in the primary, secondary, rural and other educational programs of emerging nations is considered in the light of the findings of three major conferences on regional educational development: the Karachi Plan, the Addis Ababa Plan and the Santiago Plan. Special attention is given to the kinds of assistance that could be provided, such as direct financial support, a supply of classroom teachers, invitations to study abroad, the contribution of instructional aids and materials, and the help of experts and advisors. Criteria are discussed for deciding how much and what kinds of aid should be offered.

Committee for Economic Development. *The schools and the challenge of innovation.* New York: Committee for Economic Development, 1969 (Pp. ix + 341; pap. $4.00).

This book is a collection of thirteen stimulating and well written essays prepared by leading educational thinkers. The four major topics considered are the improved use of the financial resources available to schools, the need to advance education through more effective evaluation and research, the probable impact of technology and innovation on teachers and teacher training, and the design and cost of innovative systems based on programmed, audiovisual, televised and computer assisted instruction. The overall emphasis of the volume is on the changes which are now occurring in education and how these are likely to influence future educational planning.

Coombs, P. H. *The world educational crisis: A systems analysis.* New York: Oxford University Press, 1968 (Pp. x + 241; $6.00, pap. $2.50).

The demands for more rapid progress within developing countries, according to the author, has resulted in an almost unmanageable stress on their educational systems. The encompassing analysis he presents suggests that the continuation of traditional practices and approaches in educational planning and management will fail to halt the growing crisis in world education, and that new and innovative concepts are required. The systems approach is applied to this broad problem both to determine existing deficiencies and to identify potential resources. Particular emphasis is given to viewing education as a lifelong investment in human resources. A useful annotated bibliography is included as an appendix.

Curle, A. *Educational strategy for developing societies.* London: Tavistock Publications, Ltd., 1963 (Pp. xi + 180; $5.00).

The principal contention of this book is that educational development and economic growth cannot be separated. Special attention is given to the political, social and cultural conditions which affect progress in both the education and the economy of developing nations. No effort is made to describe the practice of education. Instead, the author's emphasis is on the appropriate role of education in national development and the need to consider education as an important component of any long-range developmental plan. The book asserts that education should meet the needs of the economy and explains, in terms of economic causes, why developing countries have problems in trying to create better educational opportunities.

Elam, S., & McLure, W. P. (Eds.) *Educational requirements for the 1970's: An interdisciplinary approach.* New York: Frederick A. Praeger, 1967 (Pp. vii + 266; $6.50).

This book contains seven papers originally presented at a symposium held under the auspices of Phi Delta Kappa. The purpose of the symposium was to explore the political, technological, social, and economic forces which are likely to influence educational requirements for the next ten years. A cultural anthropologist, a social psychologist, and four economists contributed chapters which consider the relationship between social structure, economic deprivation, employment policies, manpower needs, national productivity, technological change and educational planning in the United States. Transcripts of the discussions following the presentations provide insights into the implications of each author's position.

King, E. J. *Comparative studies and educational decision.* New York: The Bobbs-Merrill Company, Inc., 1968 (Pp. x + 182; $6.00).

This book provides an historical introduction and philosophical framework useful to the understanding of how educational change can be produced through policy decisions. The position expressed by this book is that decisions affecting educational systems and the results of these decisions on social and economic development can be viewed as an empirical process with demonstrable cause and effect relationships. A kind of systems approach to educational improvement is recommended in which the outcomes of tentative changes are determined as they occur and this feedback then is used to shape the course of further decisions.

Lerner, D., & Schramm, W. (Eds.) *Communication and change in the developing countries.* Honolulu: East-West Center Press, 1967 (Pp. xiv + 333; $9.50).

The first half of this book, the result of a conference of more than a dozen U. S. and Asian experts at the East-West Center in 1964, consists of eight essays on the growth of mass media as an educational and economic influence and on the role of communications in national development. The second half of the book details nine case studies from India, the Peoples Republic of China and the Philippines which illustrate the relationship between communication and various economic and political changes which were observed. A final chapter summarizes the need for a strategy of communications specifically concerned with its effects on economic development.

Organization for Economic Co-Operation and Development. *Methods and statistical needs for educational planning.* Paris: OECD, 1967 (Pp. 363; pap. $8.50).

The collection of detailed statistical information on the structure and function of an educational system is an important component of effective educational planning. This volume is an effort to conceptualize statistical needs in terms of standard practices which would facilitate intercountry comparisons. The first half of this book describes the methods and purposes of data collection and analysis, with emphasis on sociological, manpower and fiscal planning requirements. The second half of the book provides a number of examples illustrating collection methods and the uses of statistical data, principally in economically advanced nations.

Scanlon, D. G., & Shields, J. J. (Eds.) *Problems and prospects in international education.* New York: Teachers College Press, Columbia University, 1968 (Pp. xxii + 399; $12.50).

This extensive collection of papers on international education stresses the role of technical assistance in educational development. Articles by a number of experts describe the scope and activities of various U. S. and other educational assistance programs throughout the world, consider the importance of educational aid to the overall economic development of emerging nations and identify problems associated with cultural differences between technologically advanced and developing societies. Other articles consider cultural exchange and information dissemination programs, the experiences of exchange students, and the present role of the United States in international education.

Schramm, W. *Mass media and national development.* Stanford, Calif.: Stanford University Press, 1964 (Pp. xiv + 333; $7.50).

Economic growth in the developing countries depends heavily on an effective communication system. This well documented book considers the distribution and growth of mass communication media throughout the world, the role of communication media as agents of social change and national development, and the problems associated with planning, equipping and operating coordinated information services. Most of the potentially useful media are discussed, including newspapers, books, radio, television and the cinema. Emphasis is given to what could be done by developing countries to bring needed changes in their communication systems about and a number of practical steps are recommended.

Shane, H. G. (Ed.) *The United States and international education.* The Sixty-eighth Yearbook of the National Society for the Study of Education. (Part I.) Chicago: The University of Chicago Press *for* NSSE, 1969 (Pp. xiii + 379; $5.50).

The topic of this volume is the role of the United States in the support and encouragement of international education activities. The fifteen chapters prepared by separate authors are grouped into four sections. The first of these in concerned with emerging trends in international education. The next section describes a number of governmental and private programs of educational assistance for developing countries. The third section considers the scope and goals of U. S. participation in international education. The final section attempts to derive recommendations from international education which are applicable to the curriculum and programs of U. S. schools and to the planning of future research.

Vaizey, J. *Education in the modern world.* New York: McGraw-Hill Book Company, 1967 (Pp. 254; $4.95; pap. $2.45).

Written by a prominent world educator, this book deals with the economic, social and educational changes now taking place within a number of countries in various regions in the world. The orientation of this book is both sociological and economic. Particular emphasis is given to contrasts in the systems and content of instruction between the developing nations of Africa, Asia, Latin America, and the advantaged nations of Europe and North America. New instructional methods and devices receive attention as possible means for circumventing traditional practices. The history of educational policies are examined to suggest how significant changes in education might be encouraged.

Instructional Methods and Techniques

Brown, J. W., & Norberg, K. *Administering educational media.* New York: McGraw-Hill Book Company, 1965 (Pp. xii + 364; $8.50).

Although intended primarily for audiovisual media specialists and administrators, this book should be of considerable value to anyone interested in the broad field of instructional technology. Topics include the selection, purchase, storage and distribution of both materials and equipment, the development of facilities for media production, inservice training for teachers in audiovisual techniques, and the design of classroom space for using aids effectively. Both textbooks and television are considered in addition to programmed instruction and more typical audiovisual materials. Numerous case studies and suggestions for further reading add interest and depth to the discussions.

Bushnell, D. D., & Allen, D. W. (Eds.) *The computer in American education.* New York: John Wiley and Sons, Inc., 1967 (Pp. xxx + 300; $6.95).

The nineteen papers included in this book, many prepared originally for a conference held at Stanford in 1965, touch on a wide range of possible applications of computers in education. Four chapters describe progress on computer assisted instruction, two report on automatic processing of educational data and four consider the use of computers for educational management. The remaining chapters discuss the teaching of computer sciences, the role of automation in education, the development of data banks and the place of computers in higher education. The final chapter presents a number of recommendations for enhancing the utility of computers in educational applications.

Carpenter, F., & Haddan, E. E. *Systematic application of psychology to education.* New York: The Macmillan Company, 1964 (Pp. xviii + 270; pap. $2.95).

The learning theory foundation of instructional technology is the central emphasis of this book. The first few chapters describe the behavioristic orientation of modern theories of learning and identify the explicit principles of learning which have been derived from them. The next several chapters analyze educational phenomena in behavioral terms. The remaining chapters examine popular instructional techniques such as lectures, group discussions, films, field trips, and programmed instruction from a behavioral and reinforcement point of view. A final chapter outlines classroom experiments which illustrate behavioral techniques.

Chu, G. C., & Schramm, W. *Learning from television: What the research says.* Washington, D. C.: National Association of Educational Broadcasters, 1968 (Pp. v + 116; pap. $3.50).

Considerable research has been carried out on television as an instructional tool. This survey of several hundred reported studies carefully summarizes the findings that have been obtained with respect to learning from television compared with conventional instruction, the conditions required for television to be effective, the characteristics of a televised lesson which influence learning, and the characteristics of students and classroom situations that affect results. Other useful sections report on attitudes toward instructional television, the use of television for education in developing countries, and the contrasts between instructional television and other new media.

Coulson, J. E. (Ed.) *Programmed learning and computer-based instruction.* New York: John Wiley and Sons, Inc., 1962 (Pp. xv + 291; $8.95).

This book is the product of a symposium held in 1961 on the application of digital computers to automated instruction. The first part of the book contains twelve presentations summarizing the methods and variables characteristic of instructional programming. The second part of the book consists of six papers on the concepts underlying computer-based instructional systems, descriptions of available equipment, and some observations on the effectiveness of this approach based on preliminary research. The third section contains three papers describing developmental trends in hardware and software for computer-assisted instruction. Although now technologically outdated, this book contains much useful, helpful and practical information.

DeCecco, J. P. (Ed.) *Educational technology: Readings in programmed instruction.* New York: Holt, Rinehart and Winston, 1964 (Pp. xiv + 479; pap. $6.95).

The book is a collection of forty-three original and previously published articles which present research findings and discussions by noted educators and psychologists concerning the psychology of learning, instructional technology, and programmed learning. A number of different points of view are represented, including some which are critical of programmed instruction and its value and appropriateness to education. The book, which is intended to supplement more homogeneous texts on programming methodology, is a convenient source of information on the views and concerns of many of the more prominent participants in the early work on programmed instruction and educational technology.

de Grazia, A., & Sohn, D. A. (Eds.) *Programs, teachers, and machines.* New York: Bantam Books, 1962 (Pp. vi + 309; pap. $.95).

This book contains thirty-four articles by knowledgeable psychologists, educators, theorists, programmers, and research specialists in the field of programmed instruction. The original and reprinted papers included in the book describe programmed instruction and its historical roots, consider the learning theory positions applied by major approaches, describe techniques used in program development, sample research and opinions on various subject matter applications, and explore the future of programmed instruction in education. Both enthusiasm and caution are well represented as are a full range of applications to various school subjects and different instructional levels.

Deterline, W. A. *An introduction to programmed instruction.* Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1962 (Pp. x + 131; $3.95).

This concise book presents an introductory and generally useful overview of the field of programmed instruction. A description of basic techniques and their applications is followed by a review of the background and history of programming methods and teaching machines. The principles of learning which guide program preparation are presented and discussed. Variations in program styles are described and various experimental results on the use and acceptance of programs are summarized. The last chapter discusses the role of programmed materials in the overall process of instruction. The appendix contains three sample programs on introductory statistics which help clarify differences in programming approaches.

Dizard, W. P. *Television: A world view.* Syracuse, N. Y.: Syracuse University Press, 1966 (Pp. ix + 349; $7.95).

This book describes the use of television for communication, entertainment and education throughout the world. Emphasis is given to program content, production styles and the reception given to television by the viewing audience. The history and present and future trends of both commercial and government television is discussed. The chapters on educational television relate the experiences of both industrialized and developing nations. Attention is given, too, to the political influence of television in national affairs, to the role of television as a propaganda medium, to the probable future of communication satellites, and to the problems of establishing networks for global television communications.

Gage, N. L. (Ed.) *Handbook of research on teaching.* Chicago: Rand McNally & Company, 1963 (Pp. xiii + 1218; $15.00).

Fully encyclopedic in scope, this volume has achieved considerable popularity as a comprehensive and authoritative source of information on almost all aspects of teaching research. The first three chapters consider the history of teaching and the methods used to study teacher performance. The next six chapters describe the research techniques that are used to observe, investigate and analyze teaching behaviors. The following five chapters summarize present knowledge in the principal areas of current teaching research. The remaining nine chapters review past research on teaching methods suitable for various age levels and content specialties.

Gerard, R. W. (Ed.) *Computers and education.* New York: McGraw-Hill Book Company, 1967 (Pp. xxi + 307; $7.95).

This book contains the proceedings of a conference held at the University of California at Irvine to consider the future of computers in education. The first two papers consider the methodology and technology of computer assisted instruction. The next two papers discuss computers in library and instructional resource systems. The following two papers describe the role of computers in school administration and educational planning. The last paper is concerned with the desirability of regional and national networks to reduce costs and promote information exchange. Although not an inclusive look at computers in education, the papers and accompanying comments of discussants examine issues of current importance.

Glaser, R. (Ed.) *Teaching machines and programmed learning, II: Data and directions.* Washington, D. C.: National Education Association, 1965 (Pp. xvi + 831; $11.50).

This comprehensive volume has become a basic reference on programmed instruction. The seventeen well-documented chapters, each prepared by a programming expert, cover almost every aspect of programming technology. The first section consists of eight papers on determining objectives, selecting techniques, assessing outcomes, and the use of devices. The second section contains five chapters on the applications of programmed instruction to major content areas. The third group includes papers on the use of programs in schools, industry and the military. A final chapter considers the overall contributions of programming instruction to educational technology.

Goodlad, J. I., O'Toole, J. F., & Tyler, L. I. *Computers and information systems in education.* New York: Harcourt, Brace & World, Inc., 1966 (Pp. viii + 152; $5.95).

This volume presents an overview and survey of electronic data processing applications in education. The first part of the book discusses the growth and uses of computer technology. The next part is a nontechnical discussion of electronic data processing systems. The third part describes the application of computers in education for administrative, instructional, information retrieval and research purposes. The last part summarizes the recommendations of several data processing specialists with respect to problems and issues likely to affect the future of computers in education. A useful appendix describes the cost, features and utilization of data processing installations in twenty-seven school districts.

Guggenheim, F., & Guggenheim, C. L. (Eds.) *New frontiers in education.* New York: Grune & Stratton, Inc., 1966 (Pp. ix + 310; $10.75).

Innovation in education, as the eighteen authors who have contributed chapters to this book demonstrate, is far from limited to new media and devices. The first nine chapters are devoted to the changes that are occurring in the goals of elementary and secondary school instruction. The next five chapters describe several new and useful concepts in school organization and pupil grouping. Three of the remaining chapters are devoted to progress being made in the fields of programmed instruction, educational television and language laboratories. The final chapter considers social problems and other issues arising from school integration.

Haga, E. (Ed.) *Automated educational systems.* Elmhurst, Ill.: The Business Press, 1967 (Pp. 343; $15.00).

This book contains eighteen papers on the use of computer systems in education for administrative and instructional purposes. Numerous case studies and examples illustrate the sequence of computer functions for each type of problem. The first three chapters provide an overview of the application of computers to educational systems. The next several chapters consider educational data processing centers and services offered nationally, statewide, regionally, and locally. The remaining chapters describe specific applications and techniques, sampling a useful variety of administrative and instructional uses of data processing equipment by schools and school systems.

Hilgard, E. R. (Ed.) *Theories of learning and instruction.* The Sixty-third Yearbook of the National Society for the Study of Education. (Part I.) Chicago: The University of Chicago Press for NSSE, 1964 (Pp. xi + 430; $5.50).

This collection of seventeen papers contributed by renowned educational psychologists provides a broad range of fundamental background information on theories of learning and their implications for instructional practices. Various chapters consider the history and concepts of major connectionist and configurationist theories, the educational significance of research in other fields of psychology, the relationship between learning and teaching, the influence of learner characteristics on the ease of learning, the application of learning laboratory principles to enhance instruction, the role of new media in automating effective teaching, and the prospects for a science-based technology of instruction.

Hillson, M. (Ed.) *Change and innovation in elementary school organization.* New York: Holt, Rinehart and Winston, 1965 (Pp. xvii + 387; pap. $5.95).

This book contains forty-two papers by different authors on the changes and innovations now occurring in the organization of the elementary school. The book is divided into six parts which cover ability grouping in the elementary school, various grouping plans and their consequences, the advantages and disadvantages of departmentally organized elementary schools, the use of team and collaborative teaching as an organizational concept, the development of compromise grouping plans, and effects of nongrading on pupil performance. Numerous studies are cited on the background and outcomes of various efforts to reorganize elementary schools so as to better reflect individual differences among students.

Knirk, F. G., & Childs, J. W. (Eds.) *Instructional technology: A book of readings.* New York: Holt, Rinehart and Winston, 1968 (Pp. xvi + 300; pap. $5.95).

The thirty-one brief papers reprinted in this volume sample opinions and positions of a number of educational authorities on a wide range of educational innovations. Included are contributions on the growth and impact of technology in education, the design and evaluation of instructional systems, the use and characteristics of teaching media, the storage and retrieval of information, the design of school facilities, the economics of education, and the application of learning theory to problems in education. The nontechnical content of the papers make the book useful as an elementary overview of educational technology and the changes which are taking place in schools and classrooms.

Lange, P. C. (Ed.) *Programed instruction.* The Sixty-sixth Yearbook of the National Society for the Study of Education. (Part II.) Chicago: The University of Chicago Press for NSSE, 1967 (Pp. xii + 340; $5.00).

This volume presents a broad overview of programmed instruction and discusses its relationship to traditional educational practices. The ten chapters describe the background and history of programming techniques, the methods used to develop and assess programs, and the use of programmed materials in a conventional classroom. Detailed attention is given to topics of particular interest to administrators who are considering the adoption of programmed materials to complement present instructional resources. Intended primarily for educators, this book avoids technical controversies and stresses the teacher's continuing role in the management of instruction.

Loughary, J. W. (Ed.) *Man-machine systems in education.* New York: Harper & Row, 1966 (Pp. xii + 242; pap. $4.95).

Seven authors contributed the fifteen chapters in this book to provide an integrated treatment of the utilization of computers in education. The first several chapters briefly introduce underlying concepts. The three following sections, which represent the main emphasis of this book, describe the application of computers and computer technology for instructional, administrative and guidance purposes. A number of detailed examples are given to illustrate practices now in use or under development. The final section considers the preparation of educators for anticipated new roles and identifies some concerns about the future of computers in educational affairs.

Meyer-Markle, S. *Good frames and bad: A grammar of frame writing.* New York: John Wiley & Sons, Inc., 1964 (Pp. xiv + 278; $5.50).

This is a self-instructional program, in book form, which has been designed to teach program writing skills. Various sections of the program provide instruction on the learning principles upon which leading styles of programming are based, the analysis of program frames to determine their instructional functions, the correct use of programming terminology, the identification and revision of errors in frames and sequences, and the production of original programs. The overall presentation is a useful example of the way in which programs teach, and the sample frames which are used for illustrative purposes demonstrate that a program can be entertaining as well as instructive.

Murphy, J., & Gross, R. *Learning by television.* New York: Fund for the Advancement of Education, 1966 (Pp. 95; pap. free).

This brief volume concisely examines the growth of instructional television and its impact on American education over its first significant decade. A substantial number of individual projects and systems are described in detail to illustrate how various applications were planned and operated. In discussing the results of these efforts, the authors concluded that while the basic effectiveness of instructional television as an educational tool has been demonstrated, its future remains to be determined. Expanded utilization, they suggest, will depend on more imaginative boldness and talent among the people using instructional television to improve its quality, variety and usefulness.

Pfeiffer, J. *New look at education: Systems analsis in our schools and colleges.* New York: The Odyssey Press, 1968 (Pp. xxi + 162; pap. $1.50).

This book presents a nontechnical introduction to the methods of operations research and the application of these techniques in education. A number of examples from education and other fields are described to illustrate the use of mathematical models and computer technology as tools in problem analysis. There is a heavy emphasis in the book on procedures for budget management and administrative decision making within school systems. Chapters describe the background of systems analysis, computer simulation models for studying educational change, the use of systems analysis in education and other areas, and potential developments which will affect the value of systems analysis in the future.

Rossi, P. H., & Biddle, B. J. (Eds.) *The new media and education.* Chicago: Aldine Publishing Company, 1966 (Pp. ix + 417; $8.95).

This book is a collection of eleven essays on newer educational media and their impact on society. The first part considers the acceptance and future of instructional media. The second part describes a number of educational media and their applications. The third part discusses the likely economic and social impact of new media. The fourth group of essays considers the potential value of instructional media in higher and adult education. The last part concerns the probable effects of media on long-range patterns of American education. The viewpoint of this book is largely sociological, and stresses the effects of instructional media on classroom organization, the educative process and society as a whole.

Saettler, P. *A history of instructional technology.* New York: McGraw-Hill Book Company, 1968 (Pp. xv + 399; $8.95).

This book presents a broad and informative overview of the history of instructional technology. Following an introductory chapter, successive sections of the book consider the foundations of instructional technology from 450 B.C. to the present, the evaluation and development of media-based instructional systems, and trends in media research and dissemination efforts. A final chapter identifies several problems and prospects for instructional technology. This book focuses on the historical development of educational technology, on the issues that have been of persistent concern and on the contributions which have had significant effects on modern instructional concepts and practices.

Schramm, W. (Ed.) *The impact of educational television.* Urbana, Ill.: University of Illinois Press, 1960 (Pp. viii + 247; $5.00).

This book contains a collection of fourteen papers reporting the results of research projects on educational television in the United States selected from among those that had been sponsored by the National Educational Television and Radio Center. Findings from both surveys and experimental studies are included. Sections of the book are concerned with the content, audience and programming of community television, the use of instructional television in the classroom, the special characteristics of television directed toward children, and a survey of research literature pertinent to the design of telecasts for instructional purposes. The papers serve both as sources of information and as models of television research.

Schramm, W., Coombs, P. H., Kahnert, F., & Lyle, J. *The new media: Memo to educational planners.* Paris: UNESCO, 1967 (Pp. 175; pap. $3.95).

Several authors have combined their efforts to prepare this aid to educational planners. It contains information relevant to decisions on whether and how to use new media, particularly radio and television, in terms of the instructional and administrative problems which may exist and the resources that would be required. The book attempts to answer these questions: what problems are media being used to solve, how effective have various media proven to be, how are the new media used most effectively, what are typical costs, and how should the system be planned? Although based on the twenty-three studies in UNESCO's *New Educational Media in Action*, additional discussion and analysis is included.

Skinner, B. F. *The technology of teaching.* New York: Appleton-Century-Crofts, 1968 (Pp. ix + 271; pap. $2.95).

Several of the author's previous papers have been combined and complemented with newly prepared chapters to provide an organized presentation of his views on teaching and learning. The author's principal contention is that neither the degree nor the kind of control typically imposed on classroom learning is at all conducive to the rapid or thorough mastery of needed skills. The proposed alternative is a technology of instruction based on learning research. Although only one point of view is presented, it is the one that has been responsible for many of the concepts and innovations which have characterized modern instructional technology.

UNESCO. *New educational media in action: Case studies for planners.* (3 vols.) Paris: UNESCO, 1967 (Vol. 1: Pp. 203; $4.50. Vol. 2: Pp. 226; $4.50. Vol. 3: Pp. 198; $4.50).

These three volumes contain twenty-three detailed case studies which describe how new educational media are being used throughout the world. The use of educational television is described in American Samoa, the Niger, Nigeria, the United States, and elsewhere. Educational radio is the topic of reports on Australia, Thailand, Honduras, India, Japan, and other areas. Media-based, in-service training programs are described in Algeria and Lebanon. Although the case studies are limited, with two exceptions, to systems based on radio or television, the careful description and analysis of each project as well as the specific cost information that is given should be of help to educational planners in developing countries.

Washburne, C. W., & Marland, S. P. *Winnetka: The history and significance of an educational experiment.* Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1963 (Pp. xiv + 402; $7.95).

Two superintendents of the Winnetka school system wrote this informative account spanning forty-four years of the Winnetka plan. The first part was written by Carleton W. Washburne who created the plan and was superintendent from 1919 to 1943. The second part was written by Sidney P. Marland, Jr., superintendent of schools in Winnetka from 1956 to 1963. The book describes the development and operation of the Winnetka Plan in its early years and how the innovations introduced forty years ago have continued to evolve. It presents an interesting case study of the adoption of new ideas in curriculum design, teaching methods, architecture, educational research, administration, and individualized instruction.

Weisgerber, R. A. (Ed.) *Instructional process and media innovation.* Chicago: Rand McNally & Company, 1968 (Pp. xi + 569; $6.75).

The twenty-six chapters in this book consider a wide range of educational media and innovative methodology. Although there is some unevenness in the thoroughness, applicability and quality of the various contributions, most of the authors succeed in provocatively describing their own positions and approaches. The most original papers included in the book are grouped under headings representing techniques for changing the learner, media applications at varying educational levels, systems designed to meet instructional needs, the technology of media and devices, and incorporating innovations in the instructional process. The theme of most chapters is on the utilization of media rather than on theory or production.

Wittich, A. W., & Schuller, C. F. *Audiovisual materials.* (4th ed.) New York: Harper & Row, 1962 (Pp. xvi + 554; $10.95).

The very wide variety of media available to enhance classroom instruction is well represented in this book which covers the preparation, selection and teacher's use of most of the audiovisual materials and aids to be found in schools. Heavily illustrated chapters discuss the chalkboard, photographs, graphics, displays, field trips, maps, language laboratories, audio devices, still projectors, motion film, television and programmed instruction. Intended as an introductory text, the book includes suggested activities for the teacher trainee, extensive bibliographies and checklists which could be used to assess the effectiveness of various media in the classroom.

Current Periodicals and Publications

American Educational Research Journal (published by the American Educational Research Association, 1201 16th Street, N. W., Washington, D. C. 20036; four issues per year of approximately 160 pages each; subscription rate U. S. $6.00/yr., foreign extra; free to AERA members).

This is a scholarly journal of theoretical studies and reports of original research in education plus reviews of recent books of special interest to educational researchers. The submitted articles tend to emphasize the problems of statistical technique and research design, test construction and educational measurement, studies of human learning, factors affecting classroom teacher performance, and techniques for investigating complex skills and attitudes. A number of experimental studies of programmed instruction and computer assisted instruction appear regularly.

Audiovisual Instruction (published by the Department of Audiovisual Instruction of the National Education Association, 1201 16th Street, N. W., Washington, D. C. 20036; 10 issues per year of approximately 120 pages each; subscription rate U. S. & Canada $6.00/yr., foreign $7.00/yr.; $3.00/yr. to DAVI members).

Each issue of this magazine contains a number of well illustrated articles on a variety of topics of interest to audiovisual, automated instruction and media specialists. Typically, each issue is devoted principally to articles in the same general area such as dial access laboratories, the local production of audiovisual materials, or media applications in vocational training. Each issue also contains reviews of new books and materials, news of interest to DAVI members, and a list of reviews appearing in other publications. A wide variety of products and services is represented in the informative advertising.

AV Communication Review (published by the Department of Audiovisual Instruction of the National Education Association, 1201 16th Street, N. W., Washington, D. C. 20036; four issues per year of approximately 120 pages each; subscription rate U. S. & Canada $8.00/yr., foreign $9.00/yr.; $5.00/yr. to DAVI members).

This is a scholarly journal intended principally for educators, researchers and members of education faculties who have a professional interest in theoretical, experimental and review articles on the use of media in education. Each issue contains submitted papers on a variety of topics selected for inclusion by a competent board of editors. Usually, preference is given to research papers of general interest to those in the communications media field. There also are several cogent

reviews of recent books in each issue plus a series of abstracts of selected technical reports describing the results of research projects.

Educational Media (published by Educational Media, Inc., 1015 Florence St., Ft. Worth, Texas 76102; 12 issues per year of approximately 30 pages each; subscription rate U. S. $10.00/yr., foreign $20.00/yr.; free to educational administrators).

This new periodical in magazine format contains informative, well illustrated and timely articles on the preparation and use of new instructional media for both education and industrial training. Emphasis is given to descriptions of elaborate, device-based systems, particularly dial access laboratories, computer assisted instruction, and multimedia teaching facilities. The advertising keeps readers up-to-date on sources of educational films and audiotapes, terminals for computerized instruction, carrels for individualized instruction, and other automated instruction products.

Educational Technology (published by Educational Technology Publications, Inc., 456 Sylvan Ave., Englewood Cliffs, New Jersey 07632; twelve issues per year of approximately 60 pages each; subscription rate U. S. $18.00/yr., foreign $21.00/yr.; personal subscriptions $3.00 less).

This magazine features submitted articles on a range of topics of general interest to instructional technologists. Occasional issues feature several articles all relating to a particular area such as the systems approach in education or the factors affecting administrative decisions to pursue or adopt innovations. Descriptions of new equipment and materials regularly are included in each issue as well as a valuable sum-

mary of new items concerning government activities, major new products and other developments of concern to media developers, users and researchers.

> *Journal of Educational Psychology* (published by the American Psychological Association, 1200 17th Street, N. W., Washington, D. C. 20036; six issues per year of approximately 80 pages each; subscription rate U. S. $10.00/yr., foreign $10.50/yr.; discount to APA members).

This journal contains theoretical papers and reports of original research on learning, teaching, growth and development, measurement and other topics of interest to educational researchers. Generally, technical content is emphasized and the research reports contain detailed descriptions of the experimental procedures used, the statistical treatments applied in the analysis of the data and an academically oriented discussion of the findings. Because of the scope of the journal, only a few of the articles in each issue are directly concerned with media although most have implications for a technology of instruction.

> *NSPI Journal* (published by the National Society for Programed Instruction, 715 Stadium Dr., San Antonio, Texas 78212; 10 issues per year of approximately 24 pages each; subscription rate U. S. $20.00/yr., foreign $1.50 additional; $5.00/yr. to NSPI members).

This magazine features informal articles on the theory, development and use of instructional programs, and on program preparation, implementation and assessment procedures. A feature of almost every issue is an invited contribution by some noted personality in the field of programmed instruction. Also, each issue generally contains one or more reviews of published pro-

grams or new books on programmed instruction, a timely editorial, letters from members, reports on conferences and meetings, news on the Society, its chapters and its members and a report on the annual NSPI convention.

Review of Educational Research (published by the American Educational Research Association, 1126 16th Street, N. W., Washington, D. C. 20036; five issues per year of approximately 90 pages each; subscription rate U. S. $10.00/yr., foreign extra; free for AERA members).

This is a technical journal which contains invited, comprehensive reviews of recent research in education. Each issue is devoted to a particular area of research and the articles in that issue summarize the findings of studies relating to that topic. Many topics are presented cyclically, with a new review appearing each two or three years. Some titles of recent issues include guidance and counseling, the education of exceptional children, mental and physical health, vocational education, educational and psychological testing, growth and learning, and school organization and finance.

The Audio-Visual Equipment Directory (published by the National Audio-Visual Association, Inc., 3150 Spring St., Fairfax, Virginia 22030; one edition each year; price U. S. $6.00, foreign postage extra).

This is a trade catalogue of audiovisual equipment which gives a description, the technical specifications, a picture, a list of options and accessories, and the published price of almost all of the audiovisual devices currently marketed in the United States. Included are sections on 16mm and 8mm motion picture equipment, filmstrip and slide projectors, tape recording and play-

back devices, language laboratory systems, teaching machines, classroom television and radio equipment, and a variety of miscellaneous items. Several hundreds of manufacturers are represented.

Research in Education (published by the Division of Information Technology and Dissemination, Bureau of Research, U. S. Office of Education; twelve issues per year; subscription rate U. S. $21.00/yr., foreign $26.25/yr.; order from Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402).

This is a listing of the titles and abstracts of otherwise unpublished documents and research reports available from the 19 ERIC (Educational Resources Information Centers) Clearinghouses which have been organized by the U. S. Office of Education to collect and disseminate this information. The emphasis and location of the ERIC Clearinghouses are: Adult Education (Syracuse University), Counseling and Personnel Services (University of Michigan), Disadvantaged (Columbia University), Early Childhood Education (University of Illinois), Educational Administration (University of Oregon), Educational Facilities (University of Wisconsin), Educational Media and Technology (Stanford University), Exceptional Children (Council for Exceptional Children), Higher Education (George Washington University), Junior Colleges (University of California at Los Angeles), Library and Information Sciences (University of Michigan), Linguistics (Center for Applied Linguistics), Reading (Indiana University), Rural Education and Small Schools (New Mexico State University), Science Education (Ohio State University), Teacher Education (American Association of Colleges for Teacher Education), Teaching of English (National Council of Teachers of English), Teaching of Foreign

Languages (Modern Language Association), and Vocational and Technical Education (Ohio State University). Requested documents are supplied at a charge of $.05 per page for photocopies or $.25 per microfische (of about 60 pages) plus a service charge of $.50 on each order. There is an additional charge of 25% on foreign orders for delivery outside the United States. Most Clearinghouses also publish information bulletins and have prepared research summaries; these can be ordered directly from the appropriate center.

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