A Review of Developments in Instructional Technology

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Instructional technology may be defined in as many ways as there are definers though the expression seems most often to connote equipment, hardware, mechanical apparatus and, sometimes, programmed instruction. A more encompassing definition will be used for purposes of this paper. Instructional technology is the utilization of knowledge, research and invention in the facilitation of the human learning process. Learning will occur in school, though most learning will occur elsewhere. The basic conditions requisite to efficient human learning do not significantly differ from one environment to another. The principles governing behavior change in academic areas are much the same as in social or occupational settings.

Clearly, what is happening in education today is the use of know-how and invention and is instructional technology of a sort. The blackboards, training aids, audio-visual equipment, etc., are tools however primitive and untested, upon which heavy reliance is placed by teachers. Of more interest to us, is what might be called the new instructional technology--the technology which is not in widespread use. In the professional literature, educational, psychological, and engineering, one reads much of new techniques and tools for teaching and it is easy to erroneously assume that these are being employed in large numbers of schools. Such is not the case. The public schools are making far less use of the new products of instructional technology than private industry or the military. And in the public schools vocational education lags behind the academic programs in the utilization of technology.

What are these products of instructional technology? Which appear to be most promising? Why are they not being more widely used? Are they worth the effort of attempting to expand their use, and if so what steps might be taken to achieve this end.

Products of Instructional Technology

The products of instructional technology don't fall neatly into a systematic classification scheme. These products are sometimes things, sometimes a technique or strategy and in some instances barely more than a concept.

They vary in the degree to which their "facilitation of the human learning process" has been empirically demonstrated. They also vary in the cost of their development and implementation and in the ease with which they may be employed in an operational school environment. They also differ in where they may be used in the educational system. Some of the products impinge directly on the student in his learning experience; some relate more to changes in the roles of teachers and some to administrative procedures. Many of the products effect, and are affected by, several of the major independent variables in the educational environment, since these variables do not ordinarily operate independently. Perhaps the most important dimension on which these products vary is the thoroughness of their research and development. A description of some of the more important products of instructional technology follows.

1. Programmed Instruction. Programmed instruction has been on the educational scene for almost ten years and deserves to be treated first because almost certainly it has been an impetus for several of the other important developments in instructional technology. Behavioral objectification, individualized instruction, computer-assisted and computer-managed instruction are all specific by-products of PI. The most important contribution of PI, however, is a concept--the concept that instruction should be designed and presented in order to lead to intended outcomes; that if these outcomes are not attained the instruction, not the learner, is deficient; and that the instruction will be revised on the basis of learner feedback until it does yield predictable student learning. This concept is as useful to the classroom teacher as it is to the programmer (Morgan and Branson, 1964).

Linear programs of the early 60's tended to follow a fairly rigid format. The material to be taught was broken into small, sequenced steps with stimulus information presented to the learner with a response by the learner called for. He was then shown the right answer with which he could compare his own. These three elements--stimulus, response, and confirmation--were called a "frame." A program was constructed by writing series of frames which were intended to lead the learner, somewhat painlessly, to the attainment of the objectives. These frames were tried out on students and revised according to student error and learning. Traditional teaching and programmed instruction were compared, though many thought these to be specious comparisons. Generally, groups learning from well-constructed PI were at least as good as teacher-taught groups and often had higher average final test scores, a lower variability of student performance and less time to completion. Of course, not all programs of instruction did this well. Like learners, PI also had individual differences!

Early programmed instruction had several key features. It presented the instruction in small, logical steps. It required active participation from the learner. It provided immediate knowledge of results. It permitted the student to progress at his own rate, making relatively few errors. It was often devastatingly boring. As it happens the number of frames required to take the least apt student in a group to the objectives is considerably more than is required to take a good student to the same objectives (Morgan & DuBois, 1964). The printed page which was the medium for early programs was invariable in frame-size and number until Crowder developed the "branching" program and scrambled text. This technique allowed the students to receive varying information depending upon the answers they made.

The only teaching machine developed during this period which is worth mentioning was the "Autotutor" manufactured by U.S. Industries. It was designed to provide branched programmed instruction.

By 1968 PI had become more flexible in its format and is found in a variety of media. Oakland Community College in Michigan commissioned the development of a series of modular paper back programs of instruction in the vocational-technical area (Corrigan, 1965). These short programs of instruction, usually an hour or less of self-instruction, are components of their auto-instructional program and are published by American Book Company of New York City. There are also programmed slide-tape presentations being developed and marketed by General Programmed Teaching, of Palo Alto, California. James F. Wilkey of the Parks Job Corps Center, Pleasanton, California, has done important exploratory work in developing instructional television using principles of PI. The ITV sequence is developed to lead to specific performance objectives with the ITV sequence being revised as described earlier. Measures of learning gain for the job corpsmen suggests this approach may hold promise for instructional television programming.

It is difficult to estimate the number of students who will receive some portion of their instruction in 1968 by means of PI. Though a fairly large percentage of students experience some exposure to PI the dollars spent for PI are not a large fraction of the total amount spent for all educational materials--probably less than 5 percent. There are several possible reasons for this, one of which is cost. Pound for pound, PI costs the school much more than textbooks.

Many programs of instruction are prepared to teach all or a large part of a course by self-instructional means. Students time-to-completion may vary from a few hours to several weeks and their finishing at different intervals is disruptive to a system geared to six, fifty minute periods. The design of shorter programs used as adjunctive or remedial at the option of the teacher will reduce the disruptive effect. The best justification for the use of PI is its validated teaching effectiveness to specific behavioral objectives. Yet, the publishers of PI rarely see fit to provide this information to the potential buyer. Demonstrated teaching effectiveness has never been a selection criterion for instructional materials so the publishers' behavior is understandable if not laudable. However, teachers and school administrators may one day demand this information from the producers of educational materials.

The variety of PI titles available from educational publishers is large but more limited in the vocational than in the academic areas. Size of identifiable consumer group is an essential factor in a publisher's decision to publish or not to publish. The vocational education materials market is small and fragmented and hasn't historically represented an incentive for the major publishers. Infusion of dollars through the Job Corps program, the Vocational Education Act of 1963 and the Manpower Development and Training Act have made this area more attractive for material developers.

Programmed instruction, as well as other instructional technology products, can add to the effectiveness and efficiency of education. This contribution can only be optimized in cost and effectiveness if certain other conditions in the educational system are permitted to change.

2. Performance Objectives. The cornerstone of instructional technology is the proposition that the goals of education and training can be operationally defined in terms of learner performance. The work of Bloom, Krathwohl, Masia and others in the development of taxonomies of educational objectives for the cognitive and affective domain has had much influence in educational thinking (Bloom, 1956; Krathwohl, 1965). A similar effort for the vocational area has been undertaken by McFann and his associates (McFann, 1968). These works, while conceptually interesting, probably have had less impact in the classroom than Robert Mager's, Preparing Instructional Objectives (Mager, 1961). Mager's inexpensive paperback book has permitted thousands of school teachers to attempt to state for themselves and their students the changes in student behavior which they hoped would result from the learning experiences they had arranged. Writing behavioral objectives is difficult and tedious, even in vocational education where the practitioners are not conditioned against thinking in terms of behavioral outcomes.

It must be recognized that the technology of performance objectification may be primitive compared to what it might be in a few years (Atkin, 1968). Likewise, it should be acknowledged by the antagonists of behavioral objectives that efforts in this area have received little federal or foundation research support. As underdeveloped as this tool is at present it still has a great utility. Even the most avid behaviorist would concede that not much is known about developing behavioral objectives in the affective domain (Deterline, 1968; Kapfer, 1968). Yet much learning time is spent in schools on the acquisition and retention of information, the development of skills, and the development of processes such as problem-solving. The fact that attitude development is also important in no way diminishes the significance of the others, and there is a growing body of experience in developing behavioral objectives for these latter areas.

Mager's experiment at Varians Inc., with new industrial trainees suggests furnishing the learner with explicit statements of what will be expected of him will, by itself, yield more effective training at lower costs than some formalized training programs. The Varians trainees were given the objectives along with information about materials or resource people who could help them in relation to specific objectives. From that point the trainees' activities were self-directed. They were not uniform in their entry level behavior and some needed to spend more time on certain objectives than did others. The results showed that the self-directed trainees reached the objectives better and in less time than their formally trained counterparts--and were happier in doing it. If one could generalize from this experience to the public school it might be concluded that we ought to give the students the objectives of the program, remain available to give help when asked by a student and otherwise keep out of the students way.

Since behavior change is the effectiveness criterion against which instructional technology should be assessed more attention needs to be given to the development of this criterion (Altman, 1967). If we had objectives for all the subject areas, including vocational-technical, an analysis of the objectives would doubtless reveal a large number of needless and unintended overlaps across areas. It is likely that it would also reveal a number of important educational goals, thought to be served by the schools, which had fallen through the cracks found between disciplines. Bruce Tuckman of Rutgers University's Department of Vocational Education is attempting to develop a model for the analysis, evaluation and classification of behavioral objectives (Tuckman, 1968). His model, if successful, should permit the reorganization of objectives into coherent and learnable sequences independent of the disciplines from which the objectives were derived. Frank Lanham of Michigan University is heading a project which is attempting to catalog the behavioral objectives for the field of business education and office occupations. These projects are both part of a planned effort by the Bureau of Research of the U.S. Office of Education to develop performance objectives which can be useful to the classroom teacher, the school planner, the educational evaluator and the curriculum designer.

Some local efforts have experienced success in efforts to objectify their goals. One which is noteworthy because of its attempt to integrate occupational and academic objectives where appropriate, is taking place in the Quincy, Massachusetts Public Schools under the direction of Superintendent Robert Pruitt (Pruitt is now with USOE). Other attempts to merge vocational and academic for the mutual strengthening of both were made by the Office of Economic Opportunity's Job Corps Program and by the Richmond, California school system. This latter effort is presently being evaluated by the Stanford Research Institute. The Quincy program is not far enough along to have evaluative data and the Job Corps effort, while probably the most extensive of the group, is not likely to be evaluated.

3. Computer Applications. The use of the high speed computer in education has been the most dramatic and publicized application of technology to instruction and, indeed, for many is the sum and substance of instructional technology. The computer seems to loom larger than life, defiled by some and feared by many. These grey, blue or green boxes need to be placed in perspective by educators and be examined in terms of what they can do today and what that costs and what they are likely to be able to do in the next five to ten years and what that can be expected to cost. (A note of caution: One's personal prejudices can operate effectively in the face of empirical data; they are particularly potent in the absence of data.)

Perhaps the most extensive coordinate use of computers in attacking instructional problems in a school setting has been the effort in the Philadelphia Public School system directed by Sylvia Charp (Charp & Wye, 1968). Dr. Charp has used the computer with students in (a) simulation and games, (b) problem solving, (c) vocational training, and (d) computer-assisted instruction. She has used both Philco and IBM hardware. Computer-assisted instruction has been investigated by a group of researchers, the most significant of whom include Pat Suppes of Stanford, Harold Mitzel of Penn State, Don Bitzer of the University of Illinois and Duncan Hansen of Florida State University. It might be argued that Hansen's work is more legitimately computer-managed instruction in that the learner is routed off-line for some 90 percent of his instruction. The distinguishing characteristic of CAI is that the machine and the learner interact, with the machine performing an instructional role. This instruction may take the form of drill and practice as in the case of Suppes' work or the computer may perform as a tutor with characteristics of the branching program of instruction described earlier. While it is too early to draw anything but tentative conclusions about CAI, on the basis of results to date, one might make the following generalizations. CAI reduces time to completion of a learning task. While of interest to the psychologist as a dependent variable, reduced learning time is not a compelling sales point with schools, which in discharging their custodial function must still use up 100% of the students' fixed school time. Don Bitzer has gathered retention data on students taught by CAI which suggests the forgetting curves of Ebbinghaus do not apply. His students showed little performance loss through time. Generally, the students learning by CAI have not been shown to be superior to students traditionally taught. The largest barrier to CAI's widespread use is its prohibitive costs which would be a factor even if its teaching power were unequivically demonstrated. A study by Booz, Allen and Hamilton found that with commercially available equipment the cost of drill and practice by CAI would be nearly $2.00 per hour per student. Drill and practice is probably the least expensive form of CAI. Tony Oettinger of Harvard University has taken a pessimistic stance in regard to CAI and speculates that it will be years, and maybe never, before schools can afford CAI.

Assuming that the teaching effectiveness of CAI is eventually shown there are some considerations that would surely alter the probability of its use in schools. First, $2.00 per student hour of instruction is hopelessly non-competitive with most in-school instruction--but not all. Some vocational education and special and remedial education probably cost more and CAI could be efficiently employed in these areas. Second, technological developments could substantially reduce the cost of CAI. Don Bitzer and Dan Alpert have developed protypes of a plasma screen student terminal which could be served in large number (as many as 4000) by a central processing unit. Their projections of costs for a full system with five-year amortization of development costs would provide instruction at $0.25 per instructional hour. A third development which could effect the timing of CAI use is the rising personnel costs in the schools. Teacher militancy with its associated increases in teacher pay may accelerate the pace of adoption of instructional technology in general. A fourth development is the use of computer systems by schools to perform functions other than instruction where the bulk of costs are borne by these other functions (such as administrative data processing). It may be that the machine down time could be used for CAI at high per hour costs but be negligible in terms of the total system costs.

A more recent trend in instructional application of the computer is computer-managed instruction. There are several efforts presently ongoing, no one of which is far enough along to permit evaluation of this approach. Though the principals might not all agree that they are working on a CMI model the following projects may be so classified: Harry Silberman's work with the Southwest Regional Laboratory and the Los Angeles Public Schools; Robert Glazer of the University of Pittsburgh working with the Oakleaf School in Pennsylvania; Donald Torr of Sterling Research Institute, Don Tosti of Westinghouse Learning Corporation and Alexander Schure of New York Institute of Technology all of whom are working with the U. S. Naval Academy. All of these projects are sponsored by the U. S. Office of Education. Another large project involving CMI is headed by John Flanagan under the sponsorship of the American Institute for Research and Westinghouse Learning Corporation (Flanagan, 1967). These studies differ in a variety of ways such as reliance on off-the-shelf materials as opposed to developing new instructional resources. They also address different academic levels and areas. Their similarities are greater than their differences, however. All are designing learning interventions based on carefully specified behavioral objectives and all are using the computer to mediate between the student, his individual performance on the objectives and the inventory of instructional resources related to the objectives.

In a sense, these projects are programming the instruction in modular pieces, using a variety of media with redundancy across the pieces. The computer, based upon earlier validation data, can select for a student a mosaic of learning experiences whose particular make-up is uniquely tailored to that student. The instructional power of this approach is yet to be demonstrated but will need to be very dramatic to justify the developmental costs which are estimated at around $30,000. per instructional hour (as contrasted with around $2,000. per hour for PI). Since the principle function of the computer in CMI is to prescribe and schedule, it could serve thousands of students daily and the operational costs of CMI should be less than traditional instruction.

Work by Leslie J. Briggs of Florida State University and David Markle of the American Institutes of Research suggests that the potential instructional power of this approach is great (Briggs, 1967). In the empirical development of an instructional system for a first aid course built for American

Telephone and Telegraph Company, Markle was able to reduce the time to completion by 25%, increase the average final test score from 145 for the traditionally taught group to 270 for the experimental group (Markle, 1967). The standard deviation was reduced from 42 to 9 and the worst performer of the experimental group scored 44 more points than the best performer of the traditionally taught group. This study employed a mix of tailored media which underwent three revisions based on learner data. While this study is not conclusive, it does suggest that more effective instruction can be developed even without the computer.

The Naval Academy studies by Stirling Institute, Westinghouse, and New York Institute of Technology were designed to yield answers to some questions not dealt with in Markle's study (HRB-Singer, Inc., 1968). How powerful can such a system be in terms of how much is learned in what period of time? Can we find principles governing media selection as opposed to blind trial-and-error? How much reckoning must be taken of what Jerome Bruner calls "learning style"? What roles can the computer effectively play in such a system? What is the minimum computer power required and what is the maximum that can be efficiently used? What are the most effective uses of human resources as contributors to the operating system? What different instructional approaches will need to be taken as course content varies from high-structure to low structure? What are the real development and operational costs of computer-managed, multi-media courses? What kinds of organizations can be expected to develop this type of curriculum? In a sense these studies should be guideposts for future curriculum development efforts, and from their importance should not be underestimated.

One of the more promising immediate uses of the small computer in vocational-technical education is in simulating defects in a trouble-shooting exercise. A technique devised by H.R.C. Dale requires the student to make systematic tests using a schematic diagram in order to find the cause of improper equipment performance (Bryan, 1968). The difficulty of the simulated defect search can be increased as the learner gains sophistication. The computer permits many more diagnostic exercises in a given time than would be possible using real equipment. NASA and the AEC have made wide use of this technique and it is coming into use in electronic and TV training programs.

The U.S. Office of Education has sponsored in the past half-dozen years projects on computer applications in education costing several million dollars. Applications research include those previously described plus computer-based guidance systems, and flexible scheduling. Federal agencies such as the National Science Foundation, and the Department of Defense have also been sponsoring education related studies involving the computer. USOE, in an attempt to assess the state of development, formed an Ad Hoc study group to determine what had been accomplished and what were the most pressing priorities for future computer applications support. This study group collected information on the progress of the various on-going research projects, solicited the views of a number of computer technology experts both from within and outside the government.

The major conclusions drawn from this analysis were:

a. Of the several kinds of computer applications being researched, some should become operationally feasible before others.

b. With the existing hardware many of the more exotic applications (CAI, CMI and computer based guidance systems) would not become feasible for widespread school use unless significant reductions could be made in per student cost.

c. There are a number of non-exotic but useful functions which could be furnished to schools with the available technology.

d. Computer systems for schools should be developed to provide services currently available and be able to accommodate the expected newer functions at a future time with minimum disruption and systems modification.

e. The services provided by such a computer system probably should not increase the per student per year costs by more than 2%. In order to provide a range of services within this cost level it is reasonable to assume that a large central computer service with terminals extended to participating schools and school districts would be required.

As a consequence of this survey and analysis the Office of Education decided that one of its highest priorities would be to study the feasibility and desirability of supporting the establishment of such a computer center. In the planning phases this program has been called "A Computer Utility for Educational Systems" (CUES). In response to competitive bids, two contracts were awarded, one to International Business Machines and the other to General Learning Corporation to study this problem and to make recommendations for an approach. Questions that these two contractors were asked to address included: what are the services that are needed by schools today which can be offered with least delay, what numbers of students and numbers of schools in what geographic range would be required to meet the desired per student cost, what kind of equipment would be required at the computer center and what kinds of terminals would be appropriate in what numbers for providing these services, what computer programming would be required and what kinds of systems analysis would need to be done at the school and district level, what would be required in the way of non-computer software for supporting the services, what requirements would there be for staff-orientation and training?

While there were significant differences in the findings of the two investigators there were some remarkable similarities as well. In order to develop rapprochment between the two studies and refine the analysis a third contract was let to Computation Planning, Incorporated, under the direction of Mr. Herb Bright. These studies concluded that four services could be provided to a network of schools that would not require extensive research or development. These are administrative data processing, a basic course in computer technology, integrated problem solving and vocational training. Studies assumed that at a later time, computer managed instruction, computer guidance and career information systems and library services could be added. One or more of these services to be offered from the onset of the program are in operation in several schools in the nation at the present time. Only a few large school districts have all four of the services functionally operational.

The administrative data processing would include such functions within the school as student scheduling, classroom use, payroll and various other normal record-keeping functions.

The basic course in computer concepts would be offered for all students, probably at the ninth grade level, and would cover basic fundamentals of computer technology. It would be primarily designed to provide basic information about computers to the students but would also equip them with some rudimentary programming skills. This course would be regarded as part of the students' general education program.

The third use of the computer would be as problem solving device in appropriate courses within the existing curriculum. Problem solving exercises involving the use of the computer would be integrated into the physics, chemistry, mathematics, business education and other courses. The integrated use of the computer within these courses would be a standard part of the sequence of learning experiences for each student.

Vocational training application of the computers would be to prepare students as key punch operators and it should be possible for the students to actually punch the programs written by other students. Since all of the schools will have a remote card reader and printer and have a requirement for some form of production control, selected students can gain experience at an elementary level in that aspect of computer facility operation. Certain students in the vocational area should be equipped as beginning programmers.

The computer time required will not be equal for all three instructional applications. It is expected that students will have six to seven programs per year on the average, to be processed by the central processing unit. Problem solving and vocational training students will have a larger number of programs with smaller numbers of students involved. The course in computer concepts will have large numbers of students enrolled but limited use of computer time.

An early additional application anticipated, computer managed instruction has already been described.

The analysis compared time-sharing systems to multi-programming batch systems with a cost differential favoring batch processing of about two to one. A decision was made to design the system for multi-programming batch processing. Cost estimates for CUES on an operational basis range from twenty-two dollars to fifteen dollars per student per year, depending on the number of students to be served by the system and whether the system is leased or purchased. With 200,000 students in fifty to one-hundred schools within a seventy-five mile range, the cost of purchasing the central system and terminals with leased lines would be about fifteen dollars per student. This would be with five year amortization of purchase cost and would assume an average line length of thirty miles. These figures do not take into consideration any cost displacement or savings for administrative uses of the computer and the fifteen dollars per student should be accordingly reduced to arrive at the instructional expenditure for each student. The non-recurring expenditures for development and demonstration are not included in the operational costs and are expected to be approximately five million dollars.

It is anticipated that the hardware required for the CUES System will consist of commercially available equipment, including a highpowered computer and related hardware at the central site and medium speed card readers and printers in the remote schools. Since the work load requirements cannot be estimated precisely at this time, it is not feasible to determine the exact central facility equipment requirements. The computer will be a high speed device with approximately one-half million characters or one-eighth million words of main (directly-addressable high speed) memory. Both high and low speeds secondary storage will be provided for input/output, library routines, and so forth. Four magnetic tape drives are to be provided in addition to one card read/punch and one high speed printer. The remote input/output station for the proposed system will include card readers capable of reading intermixed marked sensed and punched information at the rate of 200-250 forty column cards per minute. Printers will be used which will combine medium speed (over one-hundred characters per second) and relatively low unit cost. Part of the administrative work load for which only limited input/output is required will be sent to and from the central facility via courier. The instructional functions of CUES will have first priority with most administrative jobs being processed after the end of the school day.

The next step is for a contracter and school district (or a group of districts) to be selected for the actual development of a CUES center. The advantages to educational planners and decision-makers should be several. Computers are expensive and unwise expenditures by schools can and have resulted in enormous waste of money. CUES should demonstrate what reasonable and desirable uses can be made of the computer in an operational school setting and what these services cost. School representatives will have a place to see for themselves the program in operation and will be able to talk to the actual school users of the system. Of significant value will be the detailed specifications of the required hardware systems, both central and remote, and the existing software--all of which can be borrowed or copied by other schools.

It can be anticipated that after CUES is developed and refined it can become a profitable enterprise. If this turns out to be correct, then it may be reasonable to assume that private enterprise, on its own initiative and with its own capital, working in cooperation with other school districts, will replicate the CUES model. It has been estimated that thirty strategically located centers, like that envisioned for CUES, would bring instructional computer services to almost 90% of the nation's school population.

4. <u>Computer Based Guidance Systems</u>. Another use of the computer is being made in the vocational guidance and career area. The kinds of information about career opportunities and training requirements for various careers that are available in most schools are not adequate for students. The student doesn't know enough about the jobs nor about himself to make wise career decisions and the result is that thousands of youngsters drift into jobs for which they are ill equipped in terms of training and aptitude. Many will shift several

times in their occupational life--often to jobs which are no more suitable for them, virtually precluding a rewarding career pattern. David Tiedeman of Harvard University has been studying the career decision process of students for the past several years and has developed a career information system which permits machine storage of information about a large number or careers and for which there is actual employment opportunity in the region. His system permits the student to examine these career specifications and relate his own qualifications to specific jobs. Using the computer the student can simulate a series of decisions that are like those one would actually make in systematically analyzing a career progression. Tiedeman's project hasn't been underway long enough yet to determine whether a student's career pattern will be effected by these organized experiences and it will be several years before the real effects can be assessed. However, the approach appears to be logical and eminently sensible and on the basis of its face validity it will probably be utilized by other schools when its development is complete. John Flanagan is developing a similar program as a coordinate part of Project PLAN, which is likely to be operational before Tiedeman's program. Frank Minor of the IBM Corporation is also developing a career information and guidance system using the computer.

5. Individualized Instruction. Perhaps the most promising development in instructional technology at the present time is individualized instruction. It is promising because there is evidence that such approaches can be locally developed and operated without exotic equipment and without great additional operational expense. There are several programs of individualized instruction that are in operation and continuing development today. The two that have been underway the longest and are the best known are the Nova high school program in Broward County, Florida and the Oakleaf elementary school program in Pennsylvania. Both are being evaluated as development continues and in neither case is the evaluation data conclusive, nor yet exciting. Gary Foster of Florida State University has been in residence at Nova for the past four years collecting comparative data on the students in the program, and while his data analysis is not complete, the experimental students do not appear to be excelling the matched control students. The evaluation data on the Oakleaf project is being collected by Bob Glazer and his colleagues at the University of Pittsburgh and is equally tentative.

Two more recent projects are underway in the Duluth, Minnesota public schools and the Bloomfield Hills, Michigan public schools. Thorwald Esbensen of Florida State University (formerly Assistant Superintendent of Duluth) was the Project director of the Duluth program and Robert Boston, Assistant Superintendent directed the Bloomfield Hills effort. Both of these are too recent for any meaningful evaluation to have taken place. While there are differences between the four projects they are sufficiently similar for a description of one to suffice. In Bloomfield Hills, the entire curriculum for three schools has been individualized. The three schools, an elementary, a junior high and a high school, provide a kindergarten through 12th grade test environment. Teams of local faculty members in these three schools, working with central district office specialists and outside consultants, developed specific behavioral objectives for the entire curricular offering. There are terminal performance objectives, the sum of which make up a defined course of study, and interim performance objectives, a sequential group of which lead to a terminal objective. After developing the objectives the teachers analyzed the instructional materials available in the system and encoded portions of these materials against the objectives. For certain objectives, they judged no material to be suitable and developed their own instructional resources. Their next step was to develop instruments or techniques for determining whether or not a performance objective had been attained by a student at the specified level of proficiency. Finally, the products of these efforts was organized into a "student learning packet," which for a given block of instruction told the student what was expected of him in objective terms, what resources (including teachers) he might fruitfully employ in achieving these objectives, and, finally, how he was going to be evaluated on the objectives. The student could then proceed at his own rate, calling for assessment on any given objective whenever he felt he was ready. Indeed, many of the students were able to demonstrate proficiency on some of the terminal objectives at the beginning of the learning sequence, thus avoiding spending time on things they already knew.

A visit to any of these four programs, and talking to students and teachers, is a convincing experience even in the absence of evaluation data. While the youngsters are moving through the curriculum at variable rates, they are, as a group, tending to go faster than the traditional pace and some of the students are moving rapidly. A major problem which will have to be faced shortly in these individualized programs is what to do with the students who finish the present offering of the school before they reach graduation age.

What Needs to be Done?

Much of the impact for instructional improvement by using instructional technology is lost because of the apparent inflexibility of the educational system and because the products of technology are usually employed in a piecemeal fashion, if at all. There are many critical variables in the educational system which affect student learning and these variables do not operate in isolation from one another. These include the instructional objectives, the role of teachers and administrators, the physical environment, the motivation and background of students, the administrative practices, the instructional processes and more. Research has been done on all these variables usually treating one independently of the others. Yet, maximizing the effect on student learning of any one of these is constrained if the educational researcher is not free to appropriately change the other variables. If all the major components in an educational program are to be optimally articulated, one might conclude that the smallest experimental unit for significant educational change is a whole school.

An application of systems approach to the re-design of the total educational program for a school is exemplified by a cooperative program presently underway called "educational Systems for the Seventies." The U.S. Office of Education's Bureau of Research has joined with seventeen local high school districts located in fourteen states in designing and developing a new educational program at the high school level. These schools will serve as a flexible staging area where the interactive effects of the important components of the educational process can be tested and revised in terms of both contribution to student learning and cost benefits. The seventeen schools, currently participating in the planning of this program, will serve as test sites for its major components, and will later serve as demonstration schools for the operation of the total program.

The overall plan will identify all the activities that must be completed before the total new curriculum can be operational. These activities can be generally classified as either research, development, or demonstration. Because of the magnitude and complexity of the task, many diverse institutions and organizations will be involved in the effort. These will include universities, profit making and non-profit making organizations, and professional associations. The local schools will have primary responsibility for the definition and acceptance of the program as well as the try-out demonstration activities.

The specific tasks to be done range from the preparation of inservice training programs for staff to the analysis of design requirements for facilities. The plan anticipates that courses as we now know them, may be changed and that Carnegie Units as a measure of student progress may become inappropriate. Therefore, new accreditation and student certification practices may be necessary. The activity having the most pressing priority relates to the setting of the educational goals and operationally defining the performance objectives. The performance objectives define the output specifications for the system and must precede the design of the system. The ES '70 schools have already agreed upon their broad aims. Each graduate of this yet to be built program will receive a comprehensive education. He will have the requisite academic attainment for college entry and also for salable job skills. He will be equipped to cope with the socio-economic environment as an adult. These are ambitious goals and will require a powerful educational system if they are to be realized for all students. For these goals to become purposeful in a design of a new system they must be operatively defined in terms of behavioral outcomes.

An important reason for specifying the outcomes of educational systems is that it is necessary for longitudinal validation of the effectiveness of public education in preparing young people to cope with the social and economic environment when they leave school. Unless we know with what behavioral attainments a youngster enters the adult world, there is little basis for relating his later success, or lack of it, back to his school experience. Another reason for needing behavioral objectives relates to cost effectiveness of educational programs. The American taxpayer will inevitably grow weary of continuing to vote increased taxation for educational funds with no tangible evidence of the effect these funds have on the education of his children. With the performance objectives it should be possible to associate behavioral change with program cost. Student learning should certainly be the most if not the only basis upon which cost effective analyses are made in education.

Once these objectives are set, and agreed upon, all the other variables in the educational program need to be arranged in such a way as to optimize student attainment of the objectives. It should be possible to experimentally manipulate the other variables disregarding, where possible, the traditional constraints found in the educational system. This can be done by careful and systematic planning.

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