Long-term Prospects for Educational Technology in Southern Africa

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"EDUCATIONAL technology" is a relatively new piece of jargon that needs some definition. In England and Australia there are now societies devoted to the study of educational technology. What do their members do? In the United States there are courses in educational technology at a number of universities including several highly reputable ones. What comprises their syllabuses? There is a monthly journal titled *Educational Technology*. What do its pages have to say? What are the prospects for educational technology in Southern Africa?

The societies were originally ones whose members were interested in programmed learning. These members realized that their field of investigation and application went far beyond programmed textbooks and teaching machines. Programming as an approach to teaching and learning gained its title from computers (for which careful analysis and planning was necessary to control their operation) but also drew from both psychology and education. The teaching machines, at first thought to be necessary adjuncts to the programmed materials in order to control the learning process, helped to introduce a little more engineering thinking. The broad trend towards scientism encouraged the adoption of scientific-thinking terminology, and the term "educational technology" was coined. What does it mean? Educational technology might be defined as a systematic, logical, analytical, and technical study of education, in which a "systems approach" is employed.

Now the terms "systems approach" has to be defined! The term is bandied about very loosely, but in its strict application in education it means an approach which views education as a whole system, containing sub-systems, each of which can be analyzed. Inputs and outputs can be identified, components isolated, and the effects of changes predicted. Both physiological and engineering concepts are used in attempts to build complex models of what is, or should be, happening in education. The systems approach properly applied has the advantages of providing both a holistic and an analytic view of whatever is being examined. In education, the holistic view goes back to first principles, while the analytic view demands a scrupulous examination of the day-to-day activities in classrooms and elsewhere in the system. Properly applied, the systems philosophy makes four demands: consider a problem in its broadest context; examine the functional relationships between components of the system; investigate both interactions between components as well as their main effects on each other; and develop (and study) models to represent the actual system.

It is not easy to find a short, simple example of the application of the systems approach to education, since the educational system is so vast. If all parts of the system are to be taken into account in planning, a rather complex model has to be set up. Perhaps an example from industry will help to explain the basic patterns before a major example of educational technology in action is outlined.

In industrial training situations, such as the Witwatersrand gold mines, a systems approach to training provides the best promise of high productivity. The system to be examined includes people, equipment, resources, tasks and products. The people, equipment, and resources can be thought of as inputs to the system; the products are the output. The tasks represent the processes which link inputs to outputs. Figure 1 shows the system in schematic form.

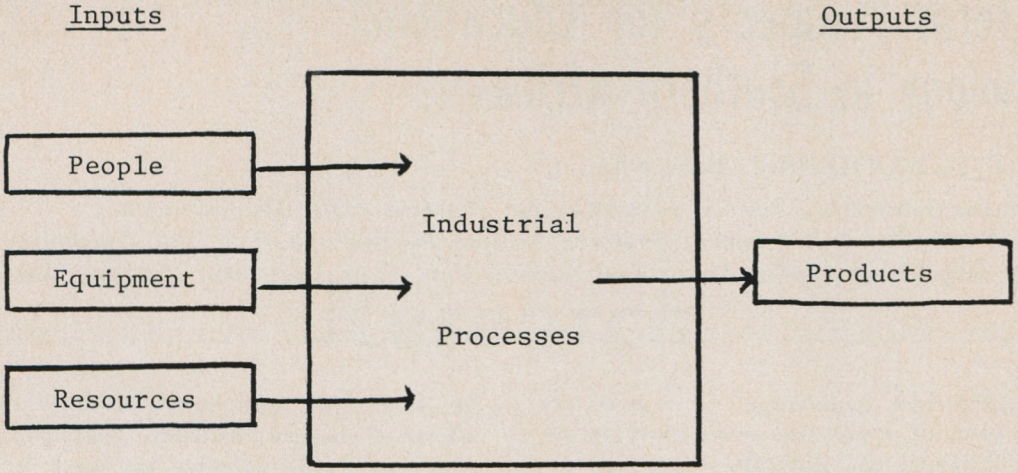

Fig. 1. A schematic view of an industrial system. Note: Resources may include such items as capital and raw materials; products may include not only manufactured goods but also trained personnel, waste, and so on.

The steps to be followed in a plan (based on educational technology) designed to improve productivity through training of personnel in a particular category of employment would probably be these:

1. An analysis of the industry as a whole.
2. An analysis of the particular category of employment for which training is to be provided.
3. An analysis of the characteristics of personnel recruited for training.
4. Development of training suited to the trainees and the skills to be taught.
5. Provision for assessment of the success of the training.
6. Provision for revision of the training.

1. *An analysis of the industry as a whole.*

A very large corporation in the United States employs one of its vice-presidents to review continuously the corporation's activities in the industry as a whole. Should he report that the industry is changing in a certain direction, his report may lead to an extension of the list of duties of a particular category of employees, to take into account the new technical developments, or it may lead to the extinction of that category because the work now no longer has to be done. Suppose that self-service petrol pumps were installed at many service stations for instance. One category of employees might become redundant, while another might be given extra tasks. The first step in the plan to improve productivity involves making certain that the category for which training is to be provided is *necessary* to the industry and that it is *correctly delimited.*

2. *An analysis of the category for which training is to be provided.*

The next step is to take a close look at the types of work done by the people who are to be trained. This "task analysis" has been performed to some extent in quite a few South African industries, but the finer the analysis the better the prospects are for good training. Educational technologists talk a good deal about behavioural objectives, which are statements of what the learner should be able to do after the training, thus corresponding to the tasks detailed in the task analysis. (The correspondence of objectives with tasks should always be high in industrial training; in education the objectives usually do no more than sample the universe of facts and skills actually learned.) The task analysis often raises new questions about what should be taught. For example, a trainee may have to learn to turn on certain valves at particular times, but there may be some debate about whether there is a special order in which they should be turned on. Technical and management people have to agree (eventually!) on what is cost-efficient. Does a shunter have to be able to explain the mechanism of Westinghouse vacuum brakes, or may he simply learn how to stop a moving truck?

3. *An analysis of the characteristics of personnel to be trained.*

The first two analyses provide preliminary indications of the outputs to be expected from the training in terms of trained manpower in various categories. The kinds of people needed will have been defined to some extent as well as the tasks they will be expected to undertake once trained. A further analysis is needed, however, in which more is discovered about the interests, aptitudes, and abilities of the people available for training. Clearly the interaction between the characteristics of learners and the characteristics of the tasks will help to determine the quality of the industrial product. Quality will largely depend on what the people are like and what they have to do. The analysis of trainee characteristics is already carried out in many informal ways in South Africa: educational qualifications, such as the Junior Certificate, may be taken into account, as well as previous employment history, physical appearance, and other subjective factors. In a few industries, aptitude tests may be given to recruits; in still fewer, a battery of psychological tests provides objective information of a kind which has a more predictive value than many other assessments.

4. *Development of suitable training.*

Nobody in industry questions the fact that the training provided must be closely related to the task to be done. Locomotive drivers are not trained to operate lathes but to drive locomotives. The training suits the task. It may not always suit the trainee, however. There is an increasing body of evidence that individual differences among trainees must be taken into account to achieve efficient training. No matter how carefully a recruiter screens the recruits for a particular job category, the members of the group being trained will still differ widely in their approach to learning. The term "learning styles" has been coined to indicate these differences of approach. Pace of learning is one dimension along which learning styles vary; the senses used seem to be another. One trainee requires much practice, another little. One learns best from the written word, another through practical demonstration. It is far from easy to identify an individual's learning style in advance, when he is being recruited for training, but sound training schemes of the future will attempt to provide a variety of routes and rates to the same goal: the learning of a job.

5. *Provision for assessment.*

The concept of feedback is quite widely understood today, and has its applications to training systems. An ideal training system is constantly improving itself, not on the basis of a new training manager's opinions or the latest gimmick in audiovisual aids, but on the basis of data gathered concerning the performance of those trained. Figure 2 illustrates how feedback operates to modify the training system.

Usually there is some testing of the recruit at the end of the training period; some trainees may be held back for further training at this point. The results of this testing provide some feedback about the effectiveness of the training, but most of the feedback should come from the trainees' actual job performance. If a new telephone operator cannot handle long distance traffic, the training department should hear about that. The ideal system demands that the training be altered until a very high proportion of new operators can undertake successfully a very

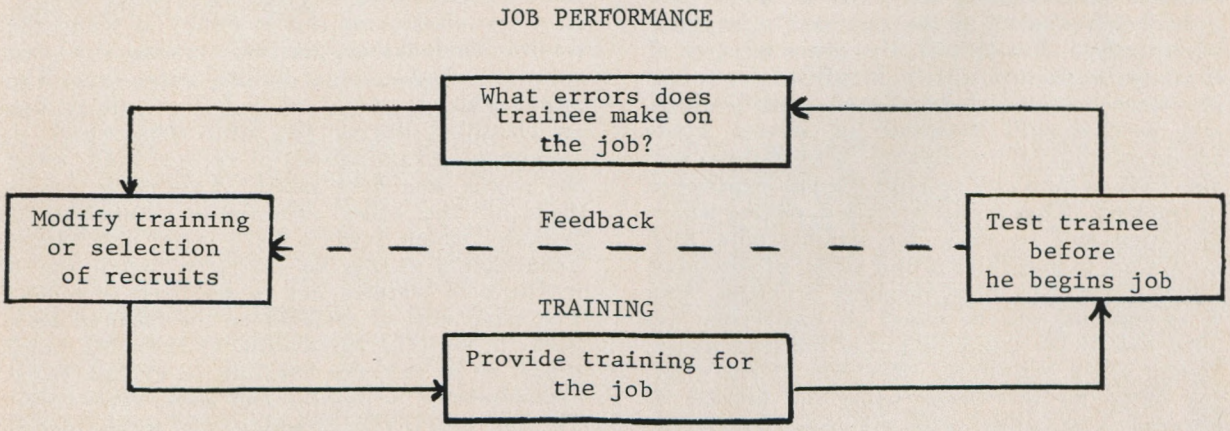

Fig. 2. The operation of feedback to modify a training system.

high proportion of the tasks for which they were trained. Of course, the training department may complain justly that management is recruiting the wrong kind of people: that is why Steps 1 and 2 are vital in the systems approach. If operators are so poorly paid that only weak recruits are obtained, a low level of efficiency must be expected. The cost-effectiveness of such policies then has to be examined. But the policies may only be questioned when *assessment* reveals the low performance on the job.

6. *Provision for revision of training.*

Perhaps it is obvious that training schemes should be revised, yet it is a fact that many fail to keep up with changes in the jobs for which they train. One of the reasons for this lag is that no deliberate provision is made for revision. The incentives provided to trainers to spend extra time revising their courses on the basis of feedback from supervisors and management (and from the tests given during training) seem to be too slight. The same procedures are taught year after year long after they are no longer used on the job. Revision of the training is essential to complete the system, and that revision should be continuous to allow for changes in the real world of job descriptions, and of trainee characteristics too. The basic education of recruits for a particular job category may rise considerably over 10 or 20 years.

In an analysis of the copper refining industry (perhaps at Messina) in 1970 it may be found that it is not economic to automate the electrolytic tank house loading process. Step 1 has been undertaken. For Step 2, task analyses are to be carried out for each of the two categories of employment in the tank house, namely, supervisors (white) and others (non-white). The turnover in these two categories is known and provides an estimate of the numbers to be trained annually. For Step 3, the characteristics of those to be trained will be identified from employment histories, educational qualifications, and psychological measures of several kinds administered by the company. The training will also have to take into account the past experience of trainees. That is part of Step 4, during which provision will be made for trainees who need more time to absorb facts and skills, or who need visual displays to offset language problems. Step 5, assessment, will be based on supervisors' reports and by the actual output of the tank house, among other indicators. Revision of the training (Step 6) will occur when the process of refining is amended or as the characteristics of trainees change over the years.

In a general, fairly loose way, the systems approach is probably being followed by many Southern African industries. But educational technology has as its goal the more exact analysis of what is to be learned, who shall learn it, and how they shall learn it. Such analysis is known to lead to vast improvements in the performance of people and of the systems they work in, both in industries and in schools.

Applied in schools, educational technology has the same patterns for us to follow as in industry. In both situations, behavior is to be changed, in a system. The first step in the education system must involve reassessment of the curriculum and of the syllabuses provided for each subject in the curriculum. Historically, the curriculum is extremely resistant to outside pressures, in many countries. The curriculum is set up by those who have been successful products of something similar, and who wish to protest their success (the Establishment!). Thus Latin is valued as part of the curriculum by those for whom it has been associated with success. Is it strange that others scorn it, or else pay it distant veneration as some kind of status symbol? Reassessment of curriculum is essential, however, because of rapid changes in the demands being made of educated people. Those who have been through the system now have to live for 50 years or more in a world which becomes less and less related to what they learned.

Once the curriculum is established and the syllabuses within it, the exact nature of the learning tasks for individuals in the system has to be approached. This is the second step, and is more in need of attention even than the first. The third step involves analyis of the characteristics of learners. Such analysis always reveals immense individual differences, even when it is cursorily performed. Hence one would expect that the fourth step would be to provide for those differences in everyday classroom teaching. In a few classrooms this is done; in many the traditional lockstep persists, turning out vast numbers of educational failures every year. The pupils who are identified as failures are in fact so identified during the fifth step, which is assessment. Examinations of various kinds select the pupils who have failed. Less often, use is made of the other information examinations provide: which systems have failed and where. Examination results do not offer much useful feedback to learners nor to teachers, it seems! The sixth step, of revision on the basis of feedback, to suit the curriculum to changing pupil needs, or to suit the teaching to evident pupil characteristics is painful and slow, everywhere. Yet that step is vital if educational technology is to make its contribution.

In Utopia, there might be an educational system which based its curriculum and syllabuses upon empirical studies of the long- and short-term needs of the country and of the people in it. All the people would have to be considered, by an impartial agency. (Utopia remember!) Analysis of the learning tasks making up each syllabus would reveal sets of behavioural objectives. A variety of learning approaches would be developed to suit individual learners' styles. Possible variables might be reading level, cognitive attack (e.g. audio, visual), pace, sequence, and so on. The lockstep would disappear entirely, since learners would learn what they perceived as necessary and desirable, bearing in mind foreseeable goals. Groups would be formed only for learning activities known to be reinforced most by groups. (In Utopia . . .) The learner's performance would be assessed from time to time (say, once in each subject each week or month), depending on individual rates and needs for feedback. The whole system would be continuously modified by decisions based on the feedback provided by thousands of pupils' performance on each objective each year.

The United States of America is a country far from Utopia educationally speaking. Step 1 in the system proposed earlier is well-nigh impossible to carry out in the U.S. Thousands of school districts exist, each retaining a high degree of autonomy when it comes to syllabuses. Some states have brought about general agreement in the elementary schools, but in senior high school (last four years of secondary schooling) autonomy is king except where statewide examinations exist, as in New York State. There is no general consensus about what should be taught in any single subject area, whether it is History or Science. Certainly the syllabuses are not based on empirical studies of long- and short-term needs of the country.

At the present time, no general trend towards nationally-approved syllabuses is apparent. The diversity is challenging and stimulating, like much in the U.S., and demands flexibility. To fit a major experiment in educational technology into such an environment is by no means easy, but an attempt is being made in Project PLAN, which is a joint venture of the American Institutes for Research in the Behavioral Sciences, the Westinghouse Learning Corporation, and more than a dozen school districts spread from Massachusetts in the east to California in the west. Project PLAN is based on the systems approach to education, and deserves a full description.

Step 1 in Project PLAN has comprised chiefly the analysis of the curricula and syllabuses in the five states in which PLAN operated 1967-69 and in the other states where PLAN will also operate 1969 onwards. Since the syllabuses are under revision in some subjects in some states, PLAN has had to be aware of possible changes, and has also attempted to be forward-looking by considering other syllabus reviews (such as BSSC, CBA, SMSG) in science, mathematics, English and social studies, the four subjects included in the present model of PLAN. The complexity of this task is illustrated by the fact that there were in 1968 no fewer than 40 syllabus reviews proceeding in social studies, taking into account the 12 grade levels at which PLAN is to operate.

The establishment of syllabuses for Project PLAN was accomplished by teams of researchers, teachers and consultants. The teachers were drawn from the school districts in which PLAN operated, and the consultants were nationally-recognized experts, usually professors.

Step 2 in Project PLAN involved the preparation of complete sets of instructional objectives for each of the four subject areas (and their subsidiaries, like algebra, in the high school) at each grade level. These sets are already prepared for Grades 1-3, 5-7, and 9-11. The sets for the remaining three grades will be ready next year. Each instructional objective describes the bahaviour that is to be developed or strengthened in the pupil. Often the conditions under which the behaviour is to be performed are mentioned, and the criterion of successful performance may be given too. Wherever possible the objectives are written in language the student can understand.

The objectives written in a grade level for, say, social studies, are grouped together into modules. The simplest definition of a module is that the work in it will take an average pupil about two weeks to complete, making about 20 modules a good year's work in any one subject.

Step 3 in Project PLAN, the analysis of pupil characteristics, is based on extensive psychological testing. Such testing is of course far more common in the United States than in Southern Africa, and a wide range of tests can be employed to provide a detailed profile of each pupil's abilities, aptitudes, and interests. Such a profile has to be interpreted by what is known in American schools as a guidance counsellor, and a course of studies must be recommended based on the interpretation. But that is part of Step 4. In Step 3, as much as possible is found out about

the pupils. Ideally, there would be much more detailed analysis, in the hopes that this would lead to better matching in Step 4.

Step 4 in Project PLAN involves the matching of learning tasks to student characteristics. The vast range of these characteristics was well known to those who initiated PLAN, since they had worked previously on Project TALENT. TALENT tested 440,000 senior high school pupils (each for 2 days) in 1960, using measures of aptitude, ability, and achievement. The data demonstrated the wide variability of human performance within only four grades. Once measured by tests, as in Project PLAN, the pupils' characteristics were to be matched to what was to be learned — not in a particular grade level necessarily, but wherever most suitable. In other words, the judgement of the counsellor, together with teachers' advice, determined the module at which the pupil began work.

The flexibility of the PLAN model is very great. Some of the children in a mathematics class, ostensibly and nominally in ninth grade, completed the normal course in half the school year and went on to the next year's work. Others in the class did not manage to finish the basic course that year and continued with it when they returned to school after the summer holiday. Thus individual rate can be provided for.

Individual route is also provided. Although each group of objectives constitutes a module, for each module there are several teaching-learning units (TLUs). Each one is a set of learning instructions prepared to meet a different set of learner characteristics. Ideally, there would be enough to take into account amount of practice to be offered, different logics (inductive or deductive), and reading level. As yet, PLAN has developed only a few TLUs for each module, but enough exist to offer several different ways of learning to read in first grade, for instance, so that the teacher is not restricted to using *only* the phonic method, or i.t.a., or a psycholinguistic approach. Each pupil gets his own programme of studies, chosen by the counsellor and teachers, perhaps with his help!

It would be difficult at this stage, when only a comparatively small amount of experimental work has been completed, to determine what is the best pay-off in terms of number of TLUs to be provided to meet individual pupil needs. Since the variety of combinations of characteristics is almost infinite, a practical restraint has to be imposed. Perhaps 10 TLUs per module will offer almost all pupils something close to what they need to learn well. PLAN stands for "A Program Learning in Accordance with Needs."

Step 5 in Project PLAN is based on testing. At the end of each module there is a test of one kind or another. Some are "teacher certify" tests for objectives which cannot easily be tested by paper-and-a-pencil tests. The regular testing of each module is fundamental to the system. Not only may a pupil not go on to the next module until he has passed the test for the one he is working on; the results of the tests for every module and every TLU within that module are vital feedback for revising the whole system.

Step 6 in Project PLAN comprises revision. Some 4000 pupils were using the PLAN system in the 1968-69 school year; about twice that number will be using it in the 1969-70 year. The feedback from these children, plus the 2000 using the system in 1967-68, provides a mass of data. How can it possibly be used for revision? The answer lies in the computer which monitors all PLAN pupils' progress.

The computer in PLAN is administrative in function, not instructional. Unlike Computer-Assisted Instruction projects in the U.S.A. and elsewhere, the PLAN computer does not teach pupils. The teachers do that, using the highly individualized system of TLUs to provide each pupil with his only learning route and rate. Pupils are never on-line with the computer in PLAN, but in each district there is at least one computer terminal which transmits messages over telephone lines to the computer, which is in Iowa City (in the Mid-West). The messages are taken from cards which have been marked by the teachers or pupils or both. Some of the cards carry test answers; the tests are automatically scored by the computer and the pupil's marks are printed out on the terminal overnight for the teacher and pupil to look at next day. The test results are also entered on the pupil's record within the computer. Other cards carry details of how far a pupil is towards completing a TLU. The computer provides each teacher with a printed status report, weekly, for every child in the class. The complete record for any child can be obtained from the computer by his teacher on request. If children lag far behind average progress, or get far ahead, the computer keeps the teacher posted. Thus the computer supports the system, but does not dominate it.

After two years of experimental operation in the schools, PLAN is being assessed by testing the performance of PLAN pupils and of others selected as controls. The testing was completed in June, 1969, and data analysis is proceeding at the time of writing. The test battery included measures of reading comprehension, arith-

metic reasoning, abstract reasoning, sentence construction, visualization in three dimensions, and mechanical reasoning, as well as others.

There is no doubt that PLAN represents a finely-conceived example of educational technology applied to the problems of American education today. As it becomes operational, the project is drawing considerable attention. Many would say that the analyses of subject-matter and of pupil characteristics are impossible, but they have no empirical evidence to support that claim. Through massive testing programmes like Project TALENT, data banks of pupil characteristics have been built up. Studies are being made of the existing behavioral repertoires of children of various population groups. Re assessment of curricula is continuous in many subject areas: mathematics and science may have attracted most attention, but English, history, economics, geography and foreign languages also have review group meetings regularly. Tests of abilities and scholastic achievement are under review too. Studies are being made of the relationships between achievement and personality variables. The U.S. Office of Education may sponsor 25 experimental schools, costing $1 million a year each, to provide a large-scale laboratory in which the systems approach can be implemented. The evidence from these and other studies will undoubtedly influence the direction of American education during the remainder of the twentieth century. Whatever criticisms may be levelled at the U.S. educational system from overseas, it is one which is flexible enough to permit experimentation and change.

In Britain, the new Open University may also provide soon a large-scale laboratory for implementing the systems approach of educational technology. The Open University is to accept its first students in September, 1970. Its nearest counterpart in Southern Africa is the University of South Africa, but the similarities are few. It will provide first and higher degree courses for adult students, and by local tutorial groups. *No* formal academic qualifications will be required for registration as a student.

This major innovation in the British educational system requires careful planning to assure integration of four teaching media. The steps to be followed in adopting a systems approach will be remarkably similar to those in Project PLAN, the other side of the Atlantic.

First, there has to be some study of the universe of knowledge to decide which portions should be included in the courses offered by the Open University. Four "Foundation" courses have been selected already, titled mathematics, understanding science, literature and culture, and understanding society. These courses are to be designed to familiarize mature students with modern concepts in each field, and to make intellectual demands upon them of the same order as the demands made by any normal first-year university course. Students will be required to pass two of the four foundation courses before proceeding to further study.

The second step will involve detailed analysis of what is to be taught within each of the "lines" of study initiated by the foundation courses. Mathematics will include such courses as statistics, computer science, pure mathematics, and so on. Six courses, including two foundation courses, will make up an ordinary degree, and eight the honours degree. The detailed analysis of the syllabuses for all the courses to be taught will have to take into account not only the academic desirability of one component or another but also the practical use to which the knowledge will be put in the working world, since the students of the Open University will be living and earning in that world, and will have quite different expectations of their courses than students going straight into university from school.

The third step in the systems approach will be slightly different from that proposed in Project PLAN. The students who register for the courses of the university will come from varied backgrounds and the university staff will be anxious to make sure that students who begin will be able to continue. This may mean dissuading some people from embarking upon the courses. Every student that registers will be asked to discuss his courses with counsellors and tutors provided in many localities. The counsellors and tutors will use a variety of techniques, including possibly standardized testing, to identify the characteristics of the applicants they interview. This way the courses should be suited to the students, and the students to the courses.

The fourth step will demand careful analysis of the subject matter to be taught, as carried out by the second step, together with examination of the best means of communication to be employed for each segment of each course. It seems very unlikely that there will be some sections of any one course better suited to television and others to correspondence courses, for example.

In the fifth step, provision for assessment will be made. Students will acquire a certificate for each course only if they have been successful both in the continuous and the final assessments

of their work. This regulation implies a system of periodic testing as well as the traditional final examination. These assessments will only provide evidence of how well the students have absorbed and applied the knowledge taught in the courses; they will tell nothing about the usefulness of the education given by the Open University. Until graduates of the university are seeking employment, there will be no basis for validating what the university is seeking to do.

Revision of the courses will no doubt occur continuously. This revision may be based partly upon student demand, partly upon student achievement in the assessments, and eventually on the acceptance of a degree by employers.

It is much too early to predict how detailed the analyses will be in the Open University, but the initial appointments of staff include many whose wide experience of innovation in education give promise of a determined attack through the systems approach.

What of the educational systems in Southern Africa? Do the long-term prospects for that system include the introduction of Project PLAN or of an open university? What influence will educational technology have upon school and universities in Southern Africa? Is a systems approach to be adopted now? Is detailed analysis going on to determine present and to predict future needs? Or is the system too rigid to allow radical changes where that is required?

For those in Southern Africa who have attempted to introduce educational technology there should be many salutes, but, to an outsider, the dominant racial group in Southern Africa appears to be quite well-satisfied with its educational system, which has helped to bring that group to dominance. The need for change is not very apparent. The Establishment is well-established! The subordinate racial groups see little hope for change in their situation, hence they too have few expectations for change in their educational systems. Southern Africa is relatively isolated from the rest of the world; perhaps this area will fail to note some of the imperative needs for change until it has fallen far behind some other nations. The authoritarianism which pervades the scene of Southern Africa does not easily permit change.

Generalizations are always dangerous but if they are based on observations they may be appropriate and relevant. If readers of this journal observe the Southern African educational scene, what generalizations do they arrive at concerning the long-term prospects of educational technology in the area?