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ABSTRACT

The seventeen papers presented in this publication review various programs and issues in elementary school science. At least one paper is devoted to each of these programs: The United Kingdom program Science 5/13; The African Primary Science Program; The Tel Aviv Elementary Science Project; UNESCO Program in Junior Science Teaching; The Philippine School Science Program; and The Science Curriculum Improvement Study. Other papers are concerned with teacher training and retraining, evaluation, developing new teaching materials, using the teaching of mathematics as a general model for teaching science, Brazilian science education development, and psychological foundations of science education. (PR)

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ISRAEL SCIENCE TEACHING CENTRE

THE ISRAELI JUNIOR SCIENCE COMMITTEE

THE ISRAEL NATIONAL COMMISSION FOR UNESCO

THE JUNIOR-SCIENCE CONFERENCE

FINAL REPORT

REHOVOT, ISRAEL

27–28 AUGUST 1969

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SUMMARY

A conference on Junior Science was held in the Weizmann Institute, Rehovot, under the auspices of the Israeli Junior Science Committee and the Israel National Commission for UNESCO, on August 27th-28th 1969, immediately following the Rehovot Conference on Science and Education in Developing States.

The conference began with accounts of various projects now being developed in different parts of the world.

1. The African Primary Science Programme. Produced at the Educational Development Centre, U. S. A., it embodies an environmental approach in which units for various age levels have been produced.

2. The Tanzanian Primary Science Programme. An awareness of the environment and a willingness to use it lies behind the Tanzanian programme, the aim of which is to introduce into primary schools science which will develop scientific attitudes and thereby contribute to the country's programme of education through self reliance.

3. The Elementary Science Programmes of the Philippines. Two major programmes are in operation, both influenced by, but not adaptations of, the American Association for the Advancement of Science elementary school science project, one developed by the Bureau of Public Schools (B. P. S.), one by the Science Education Centre (S. E. C.). Besides emphasizing the processes of science, both groups also stress the learning of concepts. The biological aspect of the S. E. C. programme stresses the ecological viewpoint, the physical science aspect concentrates on matter and energy. The B. P. S. programme organizes its materials around the broad topics: Living Things; Matter;Energy; Motion, Earth and Space.

4. The Brazilian Programme. Believing that science education should be centered on an active process of learning by doing well-selected experiments, the Brazilian programme (IBECC) is preparing complete units, containing low cost materials and booklets. Outlined also was the system of new textbooks, basically asking questions that can be answered by drawing conclusions from experiments using simple equipment.

5. The U.K. "Science 5/13" Programme. Following the completion of the work of the Nuffield Junior Science Project in 1966, a new project was set up to extend the lines of development initiated by the original Nuffield project. The programme embodies an environmental approach, its primary goal is to develop an inquiring mind and a scientific approach to problems by children. Various units are under development.

6. The Science Curriculum Improvement Study, Berkeley, U.S.A. This is a sequential programme, made of distinct units, where one unit leads to another. It has a conceptual approach, the course being structured round those concepts deemed to be more important for developing scientific literacy.

7. The American Association for the Advancement of Science - Science, a Process Approach. A sequential programme based on a progressive development of the basic skills and processes, both mental and practical which are considered basic to an understanding of science.

8. The Tel-Aviv Elementary Science Project. This programme has a developmental approach both to content and process, each unit having integrated within it certain clearly defined behavioural objectives. It is felt that the special issue of a new elementary science programme may be to some extent a matter of teaching method and wise reduction of the amount of factual content, rather than of oversophisticated scientific concepts. In consequence of these considerations, a syllabus for years 1-6 has been constructed and teaching units are being developed.

9. The UNESCO Programme in Junior Science Teaching. In view of the varying needs of different countries and different regions of the World, UNESCO's programme seeks to support and extend those programmes for the development of junior science which are already in existence and to stimulate and encourage the establishment of others. It further seeks to draw on the experience of those programmes which are relatively well established for the benefit of those which have only recently come into being. The programme is concerned with the dissemination of information as widely as possible about existing projects through publications, and with the stimulation of pilot experiments on the development of methods and materials for junior science teaching education in several countries. It is also sponsoring a series of Conferences and Workshops on Junior Science on an international, regional and national scale, the present meeting being the first such conference. Special services are provided to Member States of UNESCO, such as documentation services, and assistance with development of school science equipment and in the field of teacher training. The programme is a collaborative one with other international and bi-lateral aid organizations concerned with science teaching, and with the Science Teaching Committee of the International Council of Scientific Unions.

The Conference indicated complete agreement that science teaching in elementary schools should change from the authoritarian approach, too often traditional in the past, to a child-centered activity. Discussion covered the relative merits of "process" and "concept" approaches; it is not without its significance that many new projects use both. A greater dichotomy existed around the question whether courses should be structured or unstructured, but an analysis showed that in fact there were many fundamental similarities between the new programmes, all wanted the pupils to show willingness to draw conclusions based on evidence, all wanted use to be made of the environment.

Problems of transfer, problems of language, and the need for science to be socially oriented were all discussed. Two papers, one on the psychological foundations of science education, the other on the psychological considerations in the work of project teams, showed that these aspects were not being neglected in development work. Integration, both within the sciences and with other subjects in the school curriculum, had a prominent place in the deliberations. There was discussion on how to make use of resources and how to get detailed information on other projects, an area in which UNESCO is helping.

The second day of the conference began with two important papers on evaluation. One gave a detailed account of the evaluation being done as part of the "Science 5/13" Programme, together with the films used in the evaluation. This work is concerned with "on-going evaluation" as part of the development of the new programme, its chief function being to help in the production of the programme itself. The other explained in detail the interpretation and use of evaluation results as practiced by the Curriculum Centre of the Israel Ministry of Education.

Stimulating discussion followed papers on various aspects of teacher training. The need to raise the status of teachers, the importance of providing them with good teaching materials, the need for teachers to have a good science background, and the need for extensive experience of teaching during training, were all stressed. The importance of science teaching centres throughout a country was accepted as was the value of having teachers actively involved in curriculum development.

The conference bore testimony to the value of such an interchange of views. It was not without its significance that there was so much uniformity of view that school courses must be child-centered, that more elaborate arrangements must be made for extending in-service and pre-service training, and that evaluation of course materials was important.

OPENING ADDRESS

MR. A. YADLIN - Deputy Minister of Education, Israel

Ladies and gentlemen, it is both a pleasure and honour to welcome you on behalf of the Minister of Education and Culture, and to wish us all success and fruitful work in this "small" Rehovot Conference - the Junior Science Conference.

This Conference is the result of the initiative of two distinguished ladies, Mrs. Haggis from UNESCO who is our Chairman this morning, and Prof. Poliakov who is the scientific director of the Israeli Science Teaching Centre.

It is a welcome opportunity for me to thank Mrs. Haggis and the organization of UNESCO for their faithful co-operation in preparing this Conference. UNESCO, with its enormous achievements, is also a symbol of the great hope of human solidarity. UNESCO represents the glorious aspects of human nature and the eternal human values of peace, brotherhood and the rule of justice.

Let us hope that this Conference will have important results in the promotion of scientific education with all its humanistic aspirations of multitudes of young generations in all countries. Thanks are also due to the organizing committees, the Israel Junior Science Committee and the Israel National Commission for UNESCO.

I am sure that you all join me in appreciation, admiration and thanks to the Weizmann Institute, generous host to all these international gatherings.

Ladies and gentlemen, we will hear in this Conference about the important work being done in many countries in the preparation and revision of the new school curriculum in the sciences. Following the serious and detailed discussions at the recent Rehovot Conference, it would be permissible to sum up these efforts by saying that the concept of curricula preparation is no longer understood as one depending on and demanding preparation of teaching outlines, of lists of contents, or brief subject summaries. Curriculum planning today is understood to be a volumnious task which includes preparation of detailed subject outlines, of teaching guides for teachers, of many new textbooks for pupils, of new laboratory experiments, and finally even detailed tests to verify pupils' achievements.

I think that in preparing the subject curriculum for every age group and grade, various considerations should be taken into account. First, the democratically determined general aims of education; second, the problems and the needs of the State; third, development in psychology and learning theory; and fourth, the development of science itself.

From this latter development two, (maybe conflicting)opinions may be drawn: one, that new teaching methods have to be devised for the dissemination of the greater amount of information and knowledge that we want to bring to the new generation. This has in turn led to various activities in the field of audio-visual instruction, teaching machines and the introduction of instructional television. But the second conclusion is that too much stress does not have to be put upon learning of facts and figures as such, but rather the basic principles of scientific analysis should be laid down and creative and critical thinking should be developed. It is not the volume of scientific facts and items of knowledge that is important. Rather, let us develop interdependence of approach to the rapidly changing spheres of science, encourage skills to differentiate between primary and subsidiary knowledge, increase personal experience of scientific methods of research and study, and ensure the pupils' personal involvement in their studies.

My question is: are all these sound approaches having the same validity in the primary school , in the first year of primary school and even in the kindergarten levels ? I hope that this will be the main subject and topic of discussion in this Conference which is centred around the problems of science teaching in elementary schools. I feel it is worthy that this be so, for at this stage, the foundations of future levels of educational achievements are laid.

We have heard, even in this Conference, that the small child's ability to absorb knowledge is very high, and this ability must not be wasted. There is a great danger that false concepts and pseudo-scientific notions will be inculcated, such as prejudices, preconceptions and even commonly accepted fallacies.

In looking at the young child, I think I am right in saying that the young child is naturally inclined to ask questions, many of which are indeed scientific in form. The absence of suitable answers throttles and stifles motivation to further inquiry and scientific inquisitiveness, and the wrong answer is difficult to rectify.

From all these considerations, it follows that the importance of the subject under this Conference's discussions is primary. Finally, I would like to add one further remark: we fully recognise that schools may no longer only adapt themselves slowly to new situations. We are approaching an age when a modern educational system must also became an instrument for important social changes. An educational system will be worthy of its aims and will answer the challenges set before it, by not only remaining faithful to fundamental universal values, but also recognising that its function must be to adapt itself to changes, and even more important, to precede those changes by being able to foresee them and perhaps even mould and direct them.

PARTICIPANTS

Mr. S. Adiel	Ministry of Education, Israel
Dr. M. Alexanberg	University of Tel Aviv
Dr. S. O. Awokoya	Director, Dept. Science Teaching, UNESCO
Mrs. R. Ben-Shaul	Educational T.V., Israel
Dr. R. Ben-Zvi	Ministry of Education, Israel
Mr. A. Blum	Ministry of Education, Israel
Dr. D. A. Chisman	Assistant Director, CREDO, Gt. Britain
Mr. R. Cohen	Israel Science Teaching Centre, Weizmann Institute
Mr. S. Eden	Ministry of Education, Israel
Mr. J. Elstgeest	Morogoro Teacher's College, Tanzania
Prof. A. Eviatar	Israel Institute of Technology
Mr. M. Feuchtwanger	University of Tel Aviv
Mr. Z. Geller	The Israel Science Teaching Centre, Weizmann Institute
Mr. F. S. Glassman	The Israel Science Teaching Centre
Prof. J. S. Goldstein	Brandeis Unversity, U.S.A.
Mr. S. Gotlieb	Ministry of Education, Israel
Mrs. S. Haggis	Division of Science Teaching, UNESCO
Mrs. W. Harlen	University of Bristol, England
Dr. D. F. Hernandez	Director, Science Education Centre, Philippines
Dr. E. Jungwirt	The Hebrew University of Jerusalem
Dr. E. Kaplan	University of Tel Aviv
Dr. N. Lerman	Israel Institute of Technology
Dr. A. Levy	Ministry of Education, Israel
Mr. J. L. Lewis	Nuffield Physics Project, Gt. Britain
Dr. A. H. Livermore	AAAS, U.S.A.
Miss J. Lloyd	British Council, Israel
Prof. A. Minkowich	The Hebrew University of Jerusalem
Miss R. Oren	Teacher, Israel
Mr. N. Orpaz	Ministry of Education, Israel
Prof. A. Poljakoff-Mayber	The Hebrew University of Jerusalem
Prof. I. Raw	Scientific Director IBECE, Brazil
Prof. D. Samuel	The Weizmann Institute, Rehovoth
Mr. M. Silberstein	Ministry of Education, Israel
Prof. M. Smilansky	University of Tel Aviv
Dr. S. Strauss	University of Tel Aviv
Dr. P. Tamir	Israel Science Teaching Centre
Dr. H. D. Their	Assistant Director, SCIS, U.S.A.

Mr. P. Vardin	Israel Science Teaching Centre, Weizmann Institute
Prof. J. Weiss	University of Toronto, Canada
Mr. A. Yadlin	Deputy Minister of Education, Israel
Mrs. N. Zabar	University of Tel Aviv

Co-Chairmen of Conference:	Mrs. S. Haggis Prof. A. Poljakoff-Mayber
Reporteurs:	Mr. J. L. Lewis Mr. P. Vardin

A PRAGMATIC APPROACH IN SCIENCE EDUCATION -

AGRICULTURE AS RURAL SCIENCE

A. BLUM - Curriculum Centre of the Ministry of Education, Israel

Mrs. Haggis mentioned this morning different approaches to the curriculum: the process approach, the conceptual approach the unit approach and the applied approach. I suggest that there might be another approach, called the problem centred or pragmatic approach. We developed in Israel such an approach, based on a certain philosophy of education, which takes into account the specific needs and the nature of the country.

The "Agriculture as Rural Science Project" was developed at the curriculum center of the Ministry of Education, as well as two other science projects. It is described in some details in the brochure "Let's grow plants," which we prepared for this conference, and to which I shall refer in my remarks.

Agriculture in this country, in spite of the rapid industrialization is considered still the backbone of the country. We believe in the dignity of work, we assume that a healthy nation has to be productive, and we know that in our case agriculture is one of the most scientifically minded industries. So we had the feeling that by integrating elements of science teaching with elements of agriculture, both could be more relevant and meaningful to the students.

Our old curriculum in elementary school agriculture was based on the basic trend of vocational and quasi-vocational education. In practice students grew different plants in a collective plot. They were told how to do the work, and very often got fed up quickly with the weeding, weeding and weeding again, not always understanding why they should do this strenuous work. Instead of being drawn towards the growing of plants and animals, many students felt, that if this is agriculture - then they would prefer to leave it where it was.

On the other hand we found that many of the science curricula were too laboratory centred and neglected field studies and their implications. Many science curricula tend to take up problems which can be solved in the laboratory, but which have only seldom an applied relevance, to which students are exposed. So we were looking for something in between. We started from the conception that agriculture is a technology in which Man uses the factors of his natural environment for his own purposes to the extent of his ability. Only the understanding of Nature's laws can lead to a scientific solution of Man's endeavour to change his environment in order to supply his needs.

The next consideration was that whatever subject matter content we chose, it should have two aspects, the biological aspect, and its agricultural significance - you will find examples on page 8 of the booklet. Let us take as an example the conditions required for the growing of plants. Plants grow best under optimal conditions of water, temperature, light and mineral nutrients. This is biology, but high quality produce and good yields are obtained by using fertilizers and irrigation and by avoiding density between plants. Here we have the application in agriculture. These applications should have relevance in many of the rural areas, especially where agriculture is still underdeveloped.

Or take plant propagation. Plant sections can undergo regeneration. That is the biological part of it. The biological principle of regeneration is applied when a farmer grows plants from cuttings.

The subject in the course were chosen for their importance in the life of the plant, for their relevance to problems of agriculture and because of motivation. The strategy was to begin with a problem. Let us have two or three examples. We might want to propagate a wonderful red rose growing in our garden. We can do it by taking a cutting. If we do so, will we get the same red rose which we want to grow? Well, we have to find out.

Or let us try to grow petunias(and we had very good reasons why we chose petunias from among some twenty plants which we were considering for our purpose). Will the flowers be of the same desired colour? To find an answer to that question, we have to analyze the problem and find the biological question to be asked. Then we can devise an experiment, the findings of which we try to apply to our practical problem. Usually we end up with another twenty, new problems.

Another problem which students investigated quite enthusiastically was: "Can we change the time of flowering?". We know that flowers bloom at a certain time. Why? Could we not force a summer plant to flower in winter? To answer this question, the student had to find the answer to what actually makes the difference between the seasons. They know from their personal experience that it is a question of humidity, of day length and of temperature. Then we asked: which of these factors affect a certain plant? We did not know so we had to experiment. We started field experiments for a couple of weeks in order to find out. Obviously every plant must have humidity, but what happens if we change the length of the day, or if we give the plant a cold treatment? By experimenting the students were able to find out. Our evaluation data indicates that this experimental method, although more time consuming, is preferred to the usual quicker results obtained by using laboratory type soil and seed experiments and where the students are less personally involved.

Another unexpected result, was that something like grafting would be given such a high preference by city school students. When asked why they liked grafting, the students said that it was an operation, a transplantation. They had the feeling that they were not doing just an experiment, but rather to a certain extent, something which had to do with real life and with Man's power to interfere with Nature.

Field experiments are specially suitable when we want to show the pragmatic relevance of an investigation. Let us assume that our experiment taught us that we can change the time of flowering. Why is this important? In this country, for example, this change is of commercial importance. It enables growers to stagger the supply of chrysanthemum over the whole year. At the end of the experiment we might ask students: "Could you grow chrysanthemum so that they flower on your Mother's birthday?" They could.

In the curriculum under review the criteria for choosing the plants to be grown were mainly their suitability to the themes under investigation and their adaptability to local conditions. This pragmatic approach of going from practical problems to their underlying biological principle and coming back with a solution to the problem - could be used to investigate problems in tea pruning, cocoa growing or fertilizing any local crop. In our case we took the chrysanthemum because much research has been done in this country with that flower.

This discussion has been about the seventh grade curriculum. Maybe at a later stage(we have started to prepare for the ninth grade)- we should go one step further, and stress the social responsibility. We can interfere in Nature and will have to step up production of food. This will be done in all countries, by changing environment, by irrigating and fertilizing. New varieties, will be created and all these are based on biological principles.

But there is a certain limit to and many dangers in our interference with Nature. Therefore we have now started to plan a unit on one of these problems. Just outside the window of this room are many orange trees. Their fruit constitutes the main export product of our country. Oranges are attacked by the Mediterranean fruit fly. We can spray against the fly, but by doing so, we kill also bees and many other benefical insects. What should be done? The decision is not only a scientific one. It is also a moral one. Are we allowed to spray when by doing so we are apt to damage the source of income of others, or to poison food, or to disturb the biological balance?

One of the findings at the end of the study of the problem would be, that there is not only one possible answer to these questions. Students should discover advantages and disadvantages of insect control by attractants or by introducing a natural enemy.

I would like to mention briefly two other features of our project, because of their relevance, and which might be typical for this country. We are all agreed that in school students should learn principles and skills, which will also teach them to search for more knowledge from books. That is fine, but in school one is mostly taught to read literature, and not taught to read a cook-book, nor to read a motor manual, nor how to read vocational instruction nor how to grow a certain plant. Even in this country, which is quite small and has excellent extension services, much information is given in written form and this is probably true of many countries. Our students when they come out to face life, will have to be able to read this material. We found that youngsters and sometimes also adults find it difficult to start reading professional literature. So we tried the following strategy:

We took instructions which were prepared by the Ministry of Agriculture, checked the fluency of the style, put in more illustrations and explained the concepts which we thought might be new to students in the form of a dictionary, because we could not rely on every home having a dictionary. Before we gave this to the students we discussed all the material with an expert in presenting such subject matter to children on the radio and wrote it as a story suitable for this age group. You will find part of it in this booklet.

After the student has had the first contact with the information, in a form he is more used to, we let him read the original excerpt from the professional literature. Then we told him to compare the two kinds of literature and asked: "Did Yuka(one of the boys in the story who didn't want to tell his friends how to plant roses) plant according to all the rules?"

One last point on which we are not very sure, and that is why I would like to throw it open for discussion. We had a feeling that we have to use, in any subject - even in an agricultural rural science course - some of the cultural heritage of the people with whom we are working. The idea came when we started to work with immigrants from Asian and African countries, and even more in our work with Arab students. In a patriarchal system the father and the teacher are the authority. In science education we tell the student:"You are the authority after you have done the experiment." We have the feeling that a kind of stress situation between the generations might be generated, where these two approaches clash. We hoped to alleviate this situation by saying:" Our forefathers knew a lot of things by experience, not by experiments. Experience is a fully legitimate way to gain knowledge. It takes a lot more time to get experience by trial and error, than by planning and carrying out scientific experiments; but experience still has its value. Let us take as an example the changing of the time of flowering, with which we dealt. Our forefathers in Biblical times had the problem of how to bring the first barley to the Temple on the Feast of Passover. How did they do it? They had some very clever ideas about 1700 years ago!! They grew the barley on the southern slopes only every second year in order to accumulate the rain water. They knew exactly from experience the right time for sowing and took into account photoperiodism, although they did not know <u>why</u>". We put that in the students' text.

When we started to translate the curriculum for our Arab students, we did not think it relevant to give them passages from the Talmud. Now we are looking for similar practices and sayings from their cultural heritage.

I was very impressed by the discussion at the Rehovot Conference about the clash betwen science and superstition. Let us keep the old cultural values of good standing, and let us try to combine them with good sound use of science where we can apply it to relevant problems.

'SCIENCE 5/13'

A TEACHING PROJECT SPONSORED JOINTLY BY

THE SCHOOLS COUNCIL, THE NUFFIELD FOUNDATION

AND THE SCOTTISH EDUCATION DEPARTMENT

D. G. CHISMAN - Assistant Director, CREDO

One of the many projects sponsored by the Nuffield Foundation in Britain has been a Junior Science Project for Primary Schools, completed in 1966. The materials were published in 1967 in the form of case studies in two Teachers' Guides and Source-Books of Information and Ideas (publisher: William Collins, 144 Cathedral Street, Glasgow C.4., Scotland).

In September, 1967, Science 5/13 was established as a follow-up project to extend the lines of development initiated by the original Nuffield project over the same age range for children, namely 5 to 13 years.

The present staff consists of the Project Director and five assistants; four of them are full-time; one appointed half-time acts as evaluator; another, full-time, is responsible for liaison with teachers' centres. The project is based at the University of Bristol, is administered by the School of Education, and occupies a house provided by the University, adapted and furnished for the purpose. A consultative committee has been established, widely representative of interests concerned with the project.

The terms of reference for the project included"... the identification and development, at appropriate levels, of topics or areas of science related to a framework of concepts appropriate to the ages of the pupils. The aim of the development would be to assist teachers to help children, through discovery methods, to gain experience and understanding of the environment, and to develop their powers of thinking effectively about it."The project was also to take account of the needs of children with varied abilities and environments, to study how to increase primary school teachers' knowledge of modern science, to advise colleges of education on the science content of curriculum courses and to maintain close liaison with other related projects.

The project team and their advisers could find no statement in the literature of a framework of concepts appropriate to the ages of the children and related to science: to establish a valid one would entail long fundamental research too extensive for this project to undertake, necessary as it is. An attempt was made to postulate such a framework as a first approximation, but the result proved insufficient as a reliable guide to the work of the project.

The need to state objectives still remained, so the original chart of concepts and ideas was revised and embodied in a statement of operational objectives and processes and modified, through discussion with teachers and others. It still represents what are practically first thoughts, nevertheless it is proving very useful as a working document. It is only one of many such statements that could be made and that could be valid.

Objectives that teachers could hope a particular child may fulfil will doubtless change as the child develops with age. The project selected three stages of development at which to specify objectives:.

Stage I	-	the transition from intuitive to concrete operational thinking and the early phase of this latter stage.
Stage II	-	the later stages of concrete operational thinking.
Stage III	-	the transition from concrete operational to abstract thinking.

In finding a form for expressing these objectives in schools the project team was guided by certain convictions:

1. that teachers should be responsible for thinking out and putting into practice the work of their own classes.
2. that in order to do so they should be able to find help when they needed it.
3. that, in general, children work best when trying to find answers to problems that they have themselves chosen to investigate.
4. that these problems are best drawn from the children's own environment and tackled largely by practical investigations.

These convictions were shared by the team of the original Nuffield project. To put them into practice the present project team decided to produce a series of units or topics, books to which teachers could turn for advice and information when children chose to work in the area covered by one or more of them. The units are intended to give the teacher guidance as to which of several ways she might steer the children's enquiries, and what objectives for them she might keep in mind to guide the questions she asks them. It is true that a pattern of objectives and units could be restrictive if followed subserviently, but if responsibility for choosing them - and of forming others of her own - is to rest with the teacher, this risk must be taken. Hastily formed objectives or none at all might very well be worse.

The project team's statement of objectives for children learning science is one they have agreed among themselves, after a good deal of trial and some error, and that they offer to teachers in the hope that it will be of help to them in clarifying their thinking. The units that they have constructed, and which they think of as valuable for their objectives, are offered in the same spirit.

The first units, 'Metals' and 'Working with Wood', were planned and written to find out if the statement of objectives was helpful at the operational level; the team found it was very helpful. This led them to identify what they thought were the qualities that characterised a good unit, namely:

1. The content area is near to children, that is:-
    a. it engages their attention - it is likely to do so if it involves something moving or changing.
    b. it stimulates them to think for themselves and gives rise to spontaneous discussion; it causes them to ask questions and seek answers.
    c. it gives them opportunity to do something, to construct, to collect, to explore and find out.
2. It must be realisable, given the circumstances of the school. Probably this also means that it can be conducted in a variety of situations.
3. It must lend itself to development, that is, it must suggest interesting possibilities.
4. It must further the teacher's objectives for the children, and be seen likely to do so.
5. It must give the kind of help that the teacher needs; not only long-term help, as through pointing out realisable objectives, but short-term help with methods and apparatus.

Besides the general book for teachers, 'With Objectives in Mind' - which sets out the aims of the project and contains its objectives for children - the first units, hoping to appear in trial form by September, 1969, will be:-

'Working with Wood'	Stages I and II merging later on Stage III with the Unit on 'Trees'.
'Metals'	Stages I and II
'Time'	Stages I and II
'Trees"	Stages I and II

Each of these units will include a book of background information for teachers, collected from many sources, aimed at strengthening their ability to cope with enquiries that children may make in the area of the unit.

Other units in course of construction are on 'Garden Animals', 'Structures and Forces', 'Problems of Shape and Size', 'Area and Volume'(with the Nuffield Mathematics Project), 'Science from Toys' and one called "Early Experiences' which identifies the sciences in current infant practice that is related to the project's objectives for children.

When units have been written in provisional form they will be given trials (to start in September, 1969) in the pilot areas set up by the Schools Council for the original Nuffield Junior Science Project.

The team regards continuous evaluation as an integral part of its programme: it was valued in clarifying objectives, it was most helpful in re-shaping units after pre-pilot trials in local schools and it will be used in the pilot areas to assess the extent that the units are of value in helping children to achieve expected objectives. As part of its programme, the team will explore the extent to which it is possible for teachers themselves to evaluate their own work.

There are now about three hundred teachers' centres in England and Wales and another hundred or so are planned for the near future: many of them are devoted to work in primary school science and mathematics. The team hope that, throughout the project, groups of teachers in these centres will work on the trial materials that the project produces, as many such groups have done already, and will initiate developments of their own. If some of what they do can be fed back to the project, then developments that have more than local significance can be incorporated into the national project.

PROBLEMS IN PREPARATION OF TEACHERS TO USE THE NEW TEACHING MATERIALS

J. ELSTGEEST - Morogoro Teachers' College, Tanzania

When we think of "new materials" in the context of science education, we can immediately distinguish between two categories:

1. There is the continuous flow of new textbooks and of new syllabuses based on the old pattern of achieving a certain standard examined by a standard achievement test. These materials are related to the misconception that science is a body of knowledge consisting of an agglomeration of facts, which indeed is the result of science.

What is "new" in these materials is merely a few added topics, (such as moonrockets), a few new pictures (a man with a transplanted heart) and a reshuffling of the sequence of the more familiar topics. These books and syllabuses are often the product of undecided ministry officials and pensioned teachers riding along the trodden path as long as the going is good.

Concerning teacher training I see no particular problem here. As long as the essential problem of efficiency (or inefficiency) is not squarely faced, there is no problem left worth considering. Why not carry on with the usual "methodology", and expect the teachers to rote teach, and the children to rote learn? But one should forget about science education.

2. The real new programmes in science education, however, are directed to tackling the big problem of efficiency. Although they may vary in organisation, set up, philosophical and psychological background, most new programmes have this in common: to involve children in the process of science, so as to stimulate an inquiring mind, and to develop in them scientific attitudes and skills. At the sacrifice of a certain amount of factual knowledge or knowledgeable facts the children are given the opportunity to solve problems for themselves. In most cases their problem solving activities are based on materials taken from their environment.

There is a distinct shift in emphasis from "teaching about" science to educating through science; from teaching a syllabus to educating children.

And here we face the real problem.

This type of education does require a completely new outlook on education, and a change in attitude towards children, towards teaching, and towards school-science. The new science is the teaching of a skill, of a process of investigation, of the ability to make valid predictions and check them, of the ability to profit from mistakes, of a way of thinking. It is an education towards self-reliance in thinking and problem solving. This makes the problems more important than the answers. It is an education towards understanding rather than memorisation.

This takes away the security of the "one right answer", and with it the security of the well defined marks in tests. That it returns the security of self-confidence and understanding, is to many still an act of faith. There are still many "yes, but... ?" questions asked, and although some of these can be answered by "so what?", the problem is, that to others only a next generation can show the answer.

Any curriculum reform, and certainly this revolutionary educational approach, is doomed to fail, unless it is carried out by teachers in the classrooms. These teachers must have the confidence and the ability to bring about this change.

We train teachers in teachers' colleges, and the students coming to the colleges are the product of the very system of education which they must help to change. Being successful in reaching the college, they often fail to see any fault with the existing system. They have received years of education during which the bulk of their time was spent on various degrees of rote learning. The sole object of their learning activities was to pass exams which in practically all cases tested what was committed to memory. Because they "passed", they lack the motivation of dissatisfaction, and as teachers they may well continue in the same vicious circle, unless they are redirected in their approach to education.

Let me quote from a letter I recently received from Zambia:

..." I teach the upper primary students, and they have all passed form 2 (at least the intake this year). It has been astonishing to experience that these students have gained so little from nine years of teaching. (I would almost say that the teaching in science has done them more harm than good.) They have achieved some theoretical knowledge but it brings only confusion into their lives. The majority of the students will, for instance, say that Zambia has got four seasons, instead of the three ones they have experienced for 20 years. They read their English books about England, and they believe more in this than in their own experience. The first time we did some practical work with thermometers, one of the students came to me and asked for a magnet. And when I asked him for what use, he said: ' I want to pull the mercury down to the freezing point.' - He "knows" quite a lot, but it has no relation to reality, to his life least of all. He has been educated to a life in a completely foreign culture, it could be a life on another planet."

This illustration makes the point clearer than any lengthy discussion: this is what most honest science tutors experience, and it does make the issue rather urgent.

Before they leave the college, the students must go through a complete change of attitude. I would almost call it re-education, however sad that sounds. They must learn through their own experience the richness of doing science, instead of memorising the results of science. They must see from their own experience how the process of doing science is related to becoming self-reliant in problem solving and thinking.

This cannot be achieved by providing them with a number of teaching tricks, commonly called "methods". Neither can it be achieved by providing them with detailed teachers' handbooks, so called "tramline courses". It is experience they need, lots of it, which creates confidence in one's own abilities. This is a huge task, which is not done overnight. Expensive commercial equipment is a hinder rather than a help, and so are "advanced level" courses to foster further "back-ground knowledge", which, if harped on the same string, only perpetuate the confusion. Only hard work, much patience, and persistent persuasion, together with choosing the most appropriate materials, will have any lasting effect.

The new approach to science education relies very much on simple, understandable, every-day materials taken from the immediate environment. But the successful employment of these materials depends very much on the resourcefulness of the teacher.

Almost anything taken from the environment can become a gate opening into a whole new field of serious study. But where to find the key to this gate?

The key can only be found in a person's own enthusiasm, sense of wonder, confidence, and inquiring mind; all qualities systematically killed in a rote system of learning. The key turns easier, and the gate opens wider according to the abilities and skills acquired to investigate, to observe, to ask, and to experiment. It is for this that experience is essential; much experience to be given within a limited time.

A fresh look at things is required, a look that sees possibilities and potentialities. A bamboo bush represents much more than a long forgotten Latin name. Within the bamboo there are balances, cages, containers, battery holders, telescopes, pumps, bows, and abacus rings. There is a fast growing giant grass; there is a hollow structure of high strength; there is a typical way of propagation; there is a home for animals; there is a bush full of maths and science. And an ant-lion hiding in its drab pit is more than an unimportant insect larva mentioned in the small-print-not-to-be-learned section of the biology book. If it comes out of this book, then there is a living organism with its own interesting code of behaviour built in, and which will reveal many of its secrets, if one understands the art of asking it in the right way.

It is obvious that the students find it difficult to appreciate the new approach to science on the first day that they are confronted with it. Initially there is very much resistance to be overcome. It is painful to begin to realise how little you really know, and to admit it. It is difficult to swallow that the old, safe, successful answer doesn't stand up to the test. It is hard to begin to learn what you thought you had learned so well before. It requires courage to admit that a seemingly easy problem beats you, and therefore you say: "This is too easy, it is kid stuff." and leave it at that. It needs confidence to tackle a problem to which there is no answer in the book. It is much easier to sneer: "What is the use of all this?", than to face the (imagined) possibility of making a fool of yourself.

This is a psychological problem more than anything else, which may not be so acute with students who are taken into the colleges after less years of school.

Whatever the case, after the initial resistance has been overcome, the students should have the opportunity to obtain enough experience working on their own to feel confident in their acquired skills and abilities of scientific investigation. The security of the omniscient teacher may not be there, but there will be the security of knowing your way about, and recognising the resources.

It needs little discussion at this point to acknowledge the great danger of prescribed textbooks and written examinations in the teachers' colleges, as well as in the schools. This may completely sabotage all efforts done in educating the teachers.

The fear of "lowering the standards" (whatever this means) is strong among education administrators, and this too affects the students and the teachers. It seems that facts and information are pushed into the background, and with it the "reliable" ways of testing "achievement" and "attainment". In a sense this is true . Facts and information, however, remain important, but only when they are relevant. For children facts become relevant only when they fill a real need, which comes from the children themselves. Some people find it difficult to accept that facts which seem relevant to adults (teachers, or syllabus makers) often are totally irrelevant to children; and facts that are relevant to children may often seem irrelevant to adults.

What is new in the new approach to science is, that the children are confronted with their environment, and given materials from the environment. They are allowed to manipulate these materials so as to practice solving problems: problems that they can handle, and to which they find solutions that they can understand and appreciate. This makes facts relevant, and to the needs of an increasingly inquiring mind can be given meaningful information.

It is difficult to make young, inexperienced adults aware of the special nature of children and the way they learn. Yet the students have to learn to identify problem solving situations which are suitable for children of different ages and abilities. A good psychology course may be helpful, but only if it gets out of the armchair. Practice with children will assist, but where to find sufficient time? Out of necessity we must limit ourselves to periods of teaching practice, and occasional observations or micro-teaching situations. But how adequate are these?

However, if the determination is created, the interest aroused, and the confidence established, the experience with children will be supplemented once the teachers are in the schools.

Serving teachers have the great advantage of experience with children. If they are motivated by dissatisfaction, if they feel free (or supported) to experiment, they are often remarkably quick in appreciating the new materials, and working with them effectively.

On the other hand, we find in most cases that serving teachers have great difficulty in adapting themselves to the new approach. The change is so great, the break with the normal routine so complete, the philosophy so new, and so much is required from the teacher's own resourcefulness, that one cannot expect any rapid change to take place in the schools.

This is a growth process which must take its own good time, with periods of acceleration and with periods of consolidation.

The mistake is often made by giving teachers an in-service course, and then to expect them to implement a new programme. They won't. In-service courses are of necessity short. Often they take place during holidays, and the teachers' full participation and interest is not assured. They are often overloaded to justify the expenses. And because of lack of manpower and funds they are relatively rare. In-service courses, in other words, are generally inadequate. In fact, without proper follow-up they do more harm than good.

We must accept that nowhere is there hope for a quick implementation of a new education programme. But, given the support and direction from the top administration, and relying on the goodwill and sense of responsibility of the majority of the teachers, we may expect effective expansion, if we start from a hard core of experienced, good, well trained and enthusiastic teachers, including college tutors.

Many of the problems have remained unmentioned in this paper. But most of the details unmentioned are related to the broad outlines I have tried to give. Many problems will remain unsolved for some time to come, but... that is exactly what the new science education programmes aim at: to face unsolved problems with confidence.

THE TEL AVIV ELEMENTARY SCIENCE PROJECT

GENERAL CONSIDERATIONS

M. FEUCHTWANGER - Tel Aviv University

A booklet describing the general aims and the present position of the Tel Aviv Elementary Science Project has been circulated among the participants of our conference.

I would like to concentrate only upon some major decisions which underly our work. But first of all let me say how extremely happy we are to have the opportunity of your criticism and that we will appreciate most gratefully all critical comments and advice which will be made in the conference discussions or in private talks.

Now, I would like to discuss three points: problems of adaptation, problems of synthesis and problems of the general philosophy of the project.

Ten or fifteen years ago, conceiving a new elementary science program, we had to face only old facts and new ideas, old facts being conventional teaching and old fashioned syllabuses and new ideas being improvement and modernization. In the last ten years a third front has been opened: i.e. the elementary science teaching projects based on the recent progress of science teaching. They have been apparently justified by the teaching experience of a decade or so. Even from statistical considerations it can be derived now, that the probability of making basically new discoveries in curriculum development approaches zero. Instead, current research is now in the direction of efficiently applying the progress made by educational science and practice in the last decade. However, this is correct only as to the very initial stage of our work. For there is no completely unequivocal educational progress we can rely upon, but rather an embarrassing variety of new programs. Therefore we cannot decide without some inquiry, which program is the most applicable to our situation or which elements of various projects may meet our needs the best way. As previous evaluation in other circumstances is of little significance for the new situation, further research is needed for trials on a scale similar to that of the original projects. This situation has been discussed generally by Prof. Holton in a paper submitted to the Rehovot conference, and I would like to clarify the point by analysing two examples, one of a more remote area and another from within our special realm.

Considering a great variety of various adaptations of a given program - I analyzed for instance various adaptations of PSSC - we can discern a broad spectrum of approaches to transfer of projects from country to country: translation or total adoption almost without modifications, fairly moderate changes owing to differences in student population and general educational structure, far reaching alterations or adaptations coping with drastically different new situations and finally new creative work in the spirit of a given original program reflecting rather a common philosophy than a similarity in subject matter. The decision as to which is the desirable approach is dependent on how much the conditions of two countries differ from each other. Elementary science programs depend on a great number of factors as fauna and flora, cultural background, school organisation and others. Therefore their adaptation tends toward significant alterations and transformations, to selectivity and to synthesis. Instead of modifying one plan, there is now a growing tendency to synthesize selected "organizing principles" of two or more projects. Let us speak frankly: at first view this seems to be any easy way of escaping decisions or risks. But as a matter of fact it is a common trend in all pedagogical development. For instance, European continental educators discovered some fifty years ago the importance of students experimentation and autonomous mental activity and they constructed special instructional schemes for the implementation of this new theory. But their real success started at the time when their discoveries were forgotten. For their guiding principles were embedded without apparent expression in integration-oriented instructional programs. The discussions of the last 15 years and-even those of the last days - reflect this effect quite neatly. So, a new educational principle tends often to predominate over an educational pattern and then fades away apparently, but as a matter of fact it merges into the whole pattern of educational reality and that is the beginning of its success and effectiveness. So, synthesis will sometimes be the hidden lever of success.

Let us turn to our second example now. We learned this morning from Dr. Hernandez - and she has stressed this point in her abstract too - that the Philippine program is an attempt to combine the process approach with the major concepts approach. Reading these materials one may easily recognise that the content is structured by the major-concepts approach like SCIS, while the lessons are apparently shaped by behavioral objectives according to the process approach. This is the position of the Tel Aviv Elementary Science Project too. Let me avoid misunderstandings. I do not refer now to the format of our lessons, which is very similar to that of, SCIENCE A PROCESS APPROACH (SAPA). This is a more technical point. We use this format as a consequence of our pilot experiments in schools, as we have learned that most teachers need and sometimes even press for highly detailed and clearly structured lesson plans like the SAPA format. But this format, while displaying a behavioral tendency, does not involve a specific sequence and hierarchy of processes. Dr. Livermore says in his paper submitted to the Rehovot conference(pg. 2): "The similarities of the new programs are more significant than the differences". But I am quite sure that he will not underestimate the differences. Nor do I think that we can justify our decisions only by a general philosophy of synthesis along the lines of the argumentation I just explained. What matters is not whether we are allowed to select and to synthesize, but whether we must do it, and how we can do it successfully now.

In the last analysis two principles are struggling for prevalence in all projects: the concept approach on the one hand and the behavioral goals on the other, the latter appearing mostly as the process approach. To make a decision on this point or to find the right balance of these two tendencies is the very heart of our problem. Most of the projects I know tend to a synthesis of these principles, but in order to be clear and honest we have to deal first of all with the main features of the SAPA project which are:

1. The main goal of elementary science teaching is the development of the basic mental processes of scientific thinking.
2. There is no curriculum of major science concepts in the SAPA-program. Instead, the backbone of the curriculum is a sequence of mental processes.
3. The SAPA plan is supposed to significantly accelerate pupil's further understanding of science.

One of the basic assumptions of SAPA is almost generally accepted. It seems to be agreed that stating behavioral goals clearly, is highly desirable. By their guidance writers will select suitable subject matter and structure the lessons toward pupil-acquisition of abilities and skills. Teachers will gain clearer insights into the essential aims of their instructional effort. Moreover, the analysis of the scientific thinking process and the detection of its elements as established by SAPA is an important and interesting contribution to the theory of scientific method. Its value and importance exceed the bounds of educational considerations. Clearly, it is an attractive and convincing theory, and I personally must confess that, if I were an elementary science teacher, I would feel tremendously challenged to try out the pure process approach even in the strict format.

Now, despite all these arguments, why do almost all elementary science projects tend to a compromise, combining a more or less diluted process approach together with a concept approach? In order to save time I am omitting theoretical considerations and I shall concentrate upon our situation here only.

A powerful stimulus to learning is growing self-confidence. This feeling is nourished by the pupil's experience of gradually mastering a subject and gaining insight into a system of interrelated concepts, of interactions and laws, which he believes he is able to understand. Teachers, especially teachers of average students, will not easily give up the chance of using this natural learning stimulus, which the pure process approach does not offer to the student, because the scientific content is not placed in a conceptual framework.

A similar argument holds from the teacher's side. Most of our elementary teachers lack self-confidence when teaching science, because we have not provided them with an adequate knowledge of science. The SAPA teacher has to switch over to a new subject area at the beginning of every lesson and his inferiority complex increases, as he cannot see any way of studying one specific subject matter area which could provide him with a consistent context of background knowledge for his lessons. These are sufficient reasons to suggest that a synthesis of behavioral and conceptual goals seems to be desirable for Israel.

So, while clearly being influenced by the SAPA project, we have adopted to a great extent the "major concepts" approach of SCIS.

After pondering the above-mentioned considerations I do not think that we have achieved the desirable balance of the behavioral goals and conceptual aims in the version of our materials we have presented to this conference. These materials reflect our ideas of some months ago. We are still struggling with the need of a more accurate and realistic approach to behavioral goals. We shall therefore reformulate our behavioral goals in order to meet the following requirements:

1. They must be formulated in such a way that the instructional procedures are really shaped by them and that any change in the goals will change the procedures.

2. They must reflect a thorough analysis of the several processes which occur in the lesson, rather than oversimplifying headlines as "observing" or "inferring".

3. They must be accessible to evaluation, i.e. we must be able to find out whether the goals have been reached or not.

Hopefully the trials of the essential features of foreign programs under new conditions will serve a purpose of educational science too. In this respect, may I be allowed to refer to the short statements of my abstract without further comments.

To Summarize:

1. Our position is one of adaptation, but research and evaluation work in the developmental stages are required on a scale similar to that of the original projects.

2. Synthesis of various elements originating from various sources is a natural process of educational development. It is specially desirable in "second generation" educational programs.

3. The wide spread modern tendency of combining concept-oriented elementary science teaching with behavior-oriented approaches is suitable for Israel's position also.

As I said before, your critical comments are most welcome and I think that the main purpose of my presentation should be to provoke these comments.

PROBLEMS OF TRAINING SCIENCE TEACHERS

F. S. GLASSMAN - The Israel Science Teaching Centre

Let me preface my talk with the following remarks:

We hear frequent expressions of concern over the quality of people entering the teaching profession on the elementary and secondary levels. We hear, also, frequent expressions of concern over the lack of holding power of the teaching profession. And there is much wringing of hands over the matter. But it is finally necessary, I think, to stop these fruitless expressions of concern.

The economic injustices to, and the diminution of status of, teachers must be actively and continuously attacked on all levels by all individuals involved in the educational enterprise.

SO LONG as economic rewards and high status are directly proportional to increased distance from the classroom;

SO LONG as administrative considerations precede educational considerations;

SO LONG as the professional structure is non-democratic in that the teacher is low man on the totem pole in his own house, the last to be heard, the last to be considered;

SO LONG as reactionary and authoritarian institutions of teacher training and of certification rule without effective challenge;

JUST SO LONG will the best young people not be attracted to the profession;

JUST SO LONG will the best young people leave the profession after only a few years;

JUST SO LONG will the problem of overfeminization in the schools persist;

JUST SO LONG will the erosion of status and its consequent economic disabilities continue;

JUST SO LONG will the quality of teachers be an outspoken public concern;

AND JUST SO LONG will teacher organizations draw their strength from elementary dissatisfactions and take - increasingly - actions not primarily related to professional improvement but to wages and hours and conditions of work in adversary relationships to the educational enterprise as a whole.

So - I repeat - the economic injustices to, and the diminution of status of, teachers must be attacked actively and continuously by all of us.

And when we are thus engaged, then, it seems to me, are we entitled to discuss the topic before us.

The topic breaks down into several component parts.

First, teachers in general, and science teachers in particular.

In the U.S. - elementary school teachers are required, generally, to have a baccalaureate degree awarded after 4 years of study of a general program which includes some educational courses and usually a bare minimum of science and mathematics courses. By the way - in student lingo- these science and math courses are frequently referred to as "mickey mouse" courses - an uncomplimentary allusion to their content and to the level of intellectual stimulation they afford.

In Israel - elementary school teachers study for 2 years in a Teachers' seminary after graduation from high school. Their science and math courses are an advance over the high school level, but, in many instances - are barely of university calibre.

As a result of certain reformations taking place in the educational structure in Israel - that is, the gradual development of a discreet middle school, grades 7,8,9 - a third year of instruction has been tacked on to the seminary sequence (during which these people destined to teach science in grades 7,8,9 take some additional work in science and in pedagogy.

This is a necessary procedure during the transitional period of development of the middle school (or, as it is otherwise known in the U.S. - the Junior High School). To solve the initial problem of staffing, certification authorities can move only in two directions. Either they can certify secondary school teachers "down" to the middle school levels, or they can certify elementary school teachers "up" to the middle school levels, or both.

What happens next, however, determines the course of development of the middle school. In the U. S., the certifying authorities opted for certification of secondary school teachers, so that now there is no distinction in certification, nor effectively, in preparation of secondary and middle school teachers. This has meant, of course, that the organization of the middle school is practically identical with that of the secondary school - that is, the teachers are subject-oriented, they are certified as subject area specialists, and the school day is divided into subject periods with different teachers for each subject.

I will not go into the pros and cons of this development, beyond pointing out that there are many second thoughts now. The BSCS has begun developing a program for the middle school and has pointed out the necessity for specialized training of people for it. Perhaps the U. S. will now develop a third specialized program of teacher preparation. I don't see how a developing country, concerned with the problems of training and staffing the existing schools, can afford to do more than what was mentioned before - lengthening the seminary program and certifying secondary school teachers. However, it is worth keeping in mind for future planning, particularly as we begin to speak of integrated and interdisciplinary course content.

This brings us to the next component - science teachers. How are science teachers trained? First of all, there are no science teachers, as such, in the elementary schools. Some areas in the U. S. have begun experimenting with specialists - in science, math, language - but I am not familiar with the significant reports of results in this.

For the average elementary school teachers in the U. S. - his science training consists mainly of "mickey mouse" courses. The secondary school teacher also takes these "mickey mouse" courses, and - if the University requires it - additional science courses taught by University specialists.

In Israel - in the seminaries - the level of science courses has been indicated. Even if another year is added, this means only a small increase in the level of sophistication in subject matter. In the universities of Israel, the future teacher takes the same courses that the future biologist must take - difficult, pre-professional work.

In either case, the experience is generally irrelevant to the didactic problems of the science teacher in the classroom. Why is this so? Because the methods of teaching science at these levels - seminary, college, and university - have not been effected, with rare exceptions, by the revolutions in curriculum and methodology that have been going on at the lower levels. Therefore, the science teacher of today has not personally experienced - certainly has not been continuously exposed to new methodologies, new concepts of the learning process on the operational level and most certainly not to new understandings of the range of interdisciplinary relationships "which pertain to understanding (the world and) man and his interactions with the physical, natural and social environments."[1] This is an unarguable desideratum of the whole educational enterprise, but most expecially for the elementary and middle years - those crucial years when the vast majority of the world's population receives its only organized education, and after which it leaves the school to enter into the business of constructive citizenship in the community,

This brings us to the final component - the problem of training. This divides into two parts - first, the problems of training the future teachers (i.e., the student-teachers,) and second, the problems of training(or re-training the certified and practicing teacher.

As is clear - from my preceding remarks - the future teacher should be exposed at higher levels (as, increasingly, he will be exposed at the elementary and secondary levels, as curricular and methodological reforms take hold) to good teaching methodology, to teaching of subjects in a way consistent with modern understandings of learning process, of conceptual development, of processes of science.

It is an axiom of the universities that the best teacher of biology, for example, is the man engaged in biological research, that the man at the very frontiers of research in his field is best able to teach general knowledge about that field. Really? Is that really so? I think that a student who is committed to a particular field of study certainly can learn a lot from a field specialist, that someone who is going to do graduate work in biology can learn a lot from a practicing biologist. But I am not at all sure that the student committed to teaching on the lower levels can learn as much that is helpful. It seems to me that a biology teacher whose commitment is teaching biology is a better teacher of biology than someone whose commitment is biology and who is also interested in training biologists.

So, I think it is time we looked hard at that university axiom. I think that it is at least equally true that future biology teachers can learn as much biology and can also (and this is most important) learn how to teach biology if they take their instruction from biology teachers rather than trainers of biologists.

So, for the first part - the training of future teachers - I think we must find people and develop curricula in science that will teach not

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1. BSCS Newsletter no. 34, "The Middle School," p. 4

only subject matter, but - by exposure and example, how to teach that subject matter as well. For this, I suggest we find successful secondary school teachers, for example. These are people who can teach the subject. They should be people who are interested in education as well as in the subject they teach. One caution, though - keep them in the secondary school classroom; don't cut them off from the source of their inspiration and technique. Reduce their load, rearrange their hours - these are administrative matters - but let them keep one foot in the high school classroom. Of course, they should be accorded permanent university or seminary status as well. The Schools of Education and the colleges and universities will have to develop a flexibility in this.

And vice-versa - put the future teachers into the classrooms early and often, and keep them there a long time - not just a day here and there, or a week or two or three. Half of the student-teacher's entire program should be in the classroom. In his last year, he should - like a medical intern - be prepared to assume full responsibility for one or two hours under the supervision of an experienced teacher - a master teacher, if you will - and there should be a gradual increase in responsibility during his first year or two of teaching.

Now, for part two- the retraining of certified teachers - this is also a problem on two levels.

First, the upgrading of his subject knowledge. Teachers should be officially encouraged to maintain adequate levels of knowlege by liberal allowances for the purchase of books and periodicals in education as well as in the subject areas they teach. This is done in many schools in Israel. In others, the allowance is so small that the purchase of a single book wipes out the annual allowance. So far as I know, it is not done at all in the U.S.

Then, courses should be offered during the school year and in the long vacation period. These, again, should be taught by people sensitive to the special professional needs of school teachers. Discussions of how and when and where to integrate new knowledge should be a part of the course, as well as development of meaningful laboratory exercises that can actually be undertaken in a classroom.

Second, the upgrading or retraining of his pedagogical techniques and knowledge. The U.S. approach is, I imagine, well-known. In Israel, we have attempted to do both upgrading of knowledge and upgrading of techniques in the same courses - although by different groups of people - and then, so far, for secondary school teachers.

For example, during the school year, about once a month, a seminar or workshop is offered to teachers. It is usually organized around a single, narrowly defined topic - DNA, for example. In the morning there is a lecture by a prominent research personality. In the afternoon, a laboratory exercise is performed by the assembly. This may be a sophisticated experiment favored by the lecturer to illustrate a point in his lecture, or it may be an experiment for students, related to the topic.

In the summer, a variety of courses is offered, most of them of university calibre and organization, given by university personalities. They are supposed to be designed with teachers in mind, but they generally are designed by the instructor to conform to his experience and to reflect his point of view and his techniques of work - which are not necessarily relevant to the universe of the school teacher. This summer there were only two courses specifically designed for teachers, one for teachers who were to begin to teach according to a new curriculum - the locally adapted BSCS Yellow version biology, and another for teachers who were to begin to teach according to the BSCS Special Materials curriculum, Patterns and Processes.

One of the serious problems of the teaching profession is isolation. Specially, the teacher must analyze and evaluate and organize the material he is to teach, say a chapter in a textbook. He does not have an opportunity for discussion with his colleagues on the matter. He does his work in isolation. He then prepares lesson plans around the material he is to teach. Again, there is no opportunity for discussion of his work with his colleagues and he must do this, too, in isolation. An occasional visit by an administrator or an inspector, which may or may not be followed by a critical review of the lesson taught, is of no real practical value to the teacher for such obvious reasons that there is no need to mention them here. Rarely, and then only in bits and snatches, do teachers have the opportunity to discuss, in any meaningful way, with other teachers what they do in the classroom.

With this in mind, we at the Israel Science Teaching Centre, this year conducted a special two-week summer course for veteran teachers who were about to begin teaching the first year of our three-year sequence in Biology. There were a number of lecturers on subject matter, an important lecture on techniques of evaluation and testing, there were laboratory exercises each day, but I want to tell you, in some detail, about the significant didactic retraining that was central to the course. At the first meeting of the class, two chapters of the text were assigned for each day. The class was asked to analyze the chapters for significant material and to divide the chapters into daily lessons. Three members each day were assigned to prepai analyses for submission to the class for discussion and criticism.. These three members were asked, too, to prepare a detailed lesson plan for one lesson only from the chapter to be presented before the class. They were asked to consult with each other only as to the subject of the lesson so as not to duplicate work. Two periods in the morning were devoted to presentation and discussion of the analyses of chapters and two periods in the afternoon were spent on presentation of the lessons, followed by discussion and critique by the class.

Well, the initial response can be imagined. Here were people who had been working for years, doing - for years - what we were asking them to do now. But - they had been working in splendid isolation. Suddenly they were being asked to expose their professional selves, their activities and techniques to ----- peers! Good Lord! Professional colleagues! Impossible! Psychologically they were devastated. With much hard work and gentle persuasion, with prodding and pulling, we got them through the first few days, Then it was clear sailing - more or less - and it ended with expressions of - well, not appreciation so much as recognition that an important, valuable and eminently relevant professional experience had been undergone. We are convinced that this kind of experience as a way of introducing new ideas and techniques in curriculum and methodology deserves further trial and examination. We are already considering a number of modifications, additions and deletions, and invite enquiries by anyone who sees some merit in the method.

By way of conclusion, let me say that with all the proposed and adopted improvements in content, curriculum and methodology, insufficient time or thought has been spent on the problems of training or retraining teachers for the new programs. No matter how successful a pilot project is reported to be, no matter how positive the research indicates a program to be for the student - if the training or retraining of the average teacher cannot be accomplished in a reasonably short time for a reasonable majority of the teachers involved or available, that program will not succeed and that generation of children may well be lost.

The central problem of the teaching profession - of the whole educational enterprise in all its varied manifestations and with all its splendid institutions - is this: when will the voice of the teacher be heard in the land?

THE AFRICAN PRIMARY SCIENCE PROGRAM

PROF. J. S. GOLDSTEIN - Director, Astrophysics Institute and Physics Department, Brandeis University, U. S. A.

The African Primary Science Program (APSP) developed at a meeting held in Kano, Nigeria, in February 1965. The conference was called to consider whether it was possible for EDC to provide assistance to African countries in the development of suitable curriculum materials in science. African, American and British scientists, educators, and ministry representatives met for a week, and at the end of that time recommended strongly the establishment of a program in Primary Science. One significant aspect in the scheme outlined was the mechanism built into the program for local development and adaptation of materials. In order to facilitate this aspect of the activity, Science Educators were to be posted by EDC to local curriculum development projects. Primary science centres have been established and are operating, with EDC support, in the following countries: Ghana, Kenya, Malawi, Nigeria, Sierra Leone, Tanzania and Uganda.

Ten EDC-supported Science Educators are currently on location at the centres -- five in Kenya, and one in each of the other five countries. In addition to these Science Centres, EDC is supporting another science centre effort in Lagos, Nigeria, which is staffed by local personnel.

When Science Educators are seconded to science centres in Africa, a counterpart Science Educator is appointed and paid from local funds. In every case where Program staff are now working, counterparts are in fact available and working. In general, Program support to science centres varies considerably, to reflect local conditions and other resources available. While staff are not stationed in all the countries participating in the Program, a sufficient network has been established to allow trial of the materials in the following countries in one dimension or another: Ethiopia, Ghana, Kenya, Lesotho, Liberia, Malawi, Nigeria, Sierra Leone, Tanzania and Uganda.

The principal development of materials under the Program has taken place during summer workshops held in 1965 in Entebbe, Uganda; 1965 in Dar es Salaam, Tanzania; and 1967 in Akosombo, Ghana. The early development of the materials was, until this summer, done in the Eastern Region of Nigeria and in Kenya, Tanzania, Malawi, and Lesotho. With the exception of Kenya, where plans are quite well advanced, the trial use of the science units with tutors, teachers and children is only now beginning to reach a stage where significant interpretations of the Program can be made. Nevertheless, indications from early try-outs have been highly encouraging.

There are presently more than 50 units in various stages of development; of these, approximately 12 are ready for production and distribution on a wide scale. In addition, there are several science readers in preparation as supplementary materials for use both in and out of the formal school situation. Two teacher training films, entitled: Using Gases and Airs to Teach Science and Using Liquids to Teach Science have been produced. These films were taken in Tanzania in 1966 using African children and teachers. Narration has been added, using African commentators. Efforts are currently underway to interest commercial publishing concerns in producing these materials to fulfill needs beyond the immediate Program requirements.

In September 1967, the African Education Program and the British organization ,Centre for Curriculum Renewal and Education Development Overseas (CREDO), co-sponsored a meeting in Oxford, England. The meeting was attended by representatives from 13 African countries, AEP, CREDO, UNESCO, and the Commonwealth Secretariat. The purpose of the meeting was to consider the present needs and priorities in curriculum development facing the represented African countries and how the sponsoring organizations might jointly, or separately, assist in meeting those needs. It was agreed, however, not to inhibit discussions by limiting them to the existing resources of the AEP and CREDO.

The Conference heard reports on the extent of the curriculum development work already being undertaken in many of the countries represented. It was clear that the major impetus towards further activities would -- as it should -- come from Africa, and that there was a remarkable measure of agreement with regard to the major needs and priorities.

The importance of curriculum development work at the primary school level underscored the proceeding of almost the entire conference. One reason for this emphasis is that for the present and for some time to come, in most of the African countries represented, a relatively small number of people will receive post-primary education.

The implications of curriculum development for teacher training -- both pre-service and in-service -- were considered at length. The successful introduction of change into the classroom depends upon teachers who have received appropriate general and professional education; teachers who are prepared and willing to adopt new and frequently very demanding methods of teaching.

Specific recommendations placed emphasis upon language and social studies. The Conference recognized the pivotal importance of devising curricula and materials in mathematics and science appropriate to the maturity of the children, the ways in which they learn, and to their environment. Recognizing, however, the extent of existing activity in these fields, it was not felt necessary to devote to them so large a proportion of the Conference's time as would have been appropriate at a similar meeting only a few years ago.

The Conference recognized that major changes in primary education have important implications for secondary education, but it would not, in the time available, study the consequences in details. It was therefore recommended that a conference on the curriculum of the secondary school in Africa should be convened within twenty-four months.

There was great concern expressed about the persistence of an extensive "drop-out" of youngsters from schooling at all stages. The participants were convinced that a partial corrective to this problem could be found in the development of curricula more closely related to the needs of the pupils in his environment, and designed to develop enquiring minds and constructive attitudes to life and work. This would bring the activities of the schools into greater harmony with the needs of society.

This kind of program is not a one-way street of technical aid in education to developing countries. There is a continuing and substantial benefit to EDC in the form of new materials, approaches, strategies, and insights which are relevant to education throughout the world.

Many of the ideas being developed under the African Primary Science Program have relevance to classrooms wherever they are. But in particular, the style, approach and need to use the most basic materials provide insights which are not limited to the African continent.

Since the media of instruction in the African classroom sometimes results in communication difficulties, there has been an effort to develop materials that minimize the need for teacher to student interpretation of a unit. This problem is particularly acute in the lower primary grades. Thus we have attempted to provide materials which take the stress off verbal and written communications as a means of introducing the child to some of the concepts involved in the APSP. This, in turn, has led to a different approach to working with the children, and it is here that there seems to be application to the education of the children in U.S. urban schools. In both circumstances, precious little effort has been made to understand the children within their frame of reference. We have tended to be more concerned with their deprivations then their motivations -- their sense of reality and their ability to cope with things and ideas. The African Education Program aims at achieving sensitivity to the total environment of the child and to capitalize on it in school.

Over the next two years the preparation of additional Math and Primary Science materials, the phasing of the Mathematics Program from innovation to implementation, and the extension of the APSP to other centres, are reasonably well-defined priorities. Additional activities may be undertaken in primary school social studies and in teacher training, based on the discussions at the recent meeting in Oxford. In any event, our activities will continue to be responsive to African direction and aimed at assisting in the expansion of indigenous capabilities to cope with curriculum development.

AFRICAN PRIMARY SCIENCE PROGRAM MATERIALS

In trial use

1. A Manual of Balances
2. Ask the Ant Lion
3. Bicycle - Background Information for the Teacher
4. Black Boxes
5. Buds & Twigs
6. Chicks in the Classroom
7. Chima Makes a Clock (Children's Science Reader)
8. Colour & Pigment
9. Activities for Lower Primary - Introduction
10. " " " " - Arts & Crafts
11. " " " " - Construction
12. " " " " - Cooking
13. " " " " - Dry Sand
14. " " " " - Games
15. " " " " - Water
16. " " " " - Wet Sand
17. " " " " - Woodwork
18. Description Games for the Classroom
19. Dwellers in the Soil
20. Earthworms
21. Electromagnets
22. Estimating Numbers
23. Fly Cycle
24. Germinating of Seeds
25. Growing Plants
26. Growing Seeds
27. How Plants Make Food
28. Human Body
29. Kofi Makes a Balance (Children's Science Reader)
30. Learning About Insects
31. Making Small Things Look Bigger

32. Making Things Look Bigger - Pupil's Book
33. Making Things Look Bigger - Teachers' Handbook
34. Making Things Move with Magnets
35. Measurement of Length, Area, Time & Weight
36. Microbes
37. Mobiles
38. Moon Watchers (Children's Science Reader)
39. More Microscopes - Pupil's Book
40. Mosquitoes
41. Nature Trail
42. Number by Any Other Name
43. Palm Tree Unit
44. Penny Chemistry
45. Plasticine in the Classroom
46. Powders
47. Racing Roaches
48. Reading Out to the World
49. Scientific Look at Soil
50. Sinking & Floating
51. Sitting On Top of the World
52. Soils, Seeds, Plants
53. Sour or Soapy
54. Spinning Calabashes
55. Stars Over Africa (Reader)
56. Strobe Viewing
57. Substances, Mixtures and Powders
58. Time and Its Measurement
59. Variations

THE UNESCO PROGRAMME IN JUNIOR SCIENCE TEACHING

S. HAGGIS - Division of Science Teaching, UNESCO

Rationale

1. There is a growing concern throughout the world that science should be introduced into the school curriculum at as early a stage as possible, that it should become part of the very ABC of education. In many countries, the vast majority of children never get beyond the primary school if they have any formal education at all. If they are not introduced to science in the primary school they may remain scientifically illiterate for the rest of their lives. The UNESCO programme in junior science has been developed in response to this concern. It aims to assist the Member States of UNESCO to stimulate and strengthen the scientific attitudes and skills of children and to promote science teaching - both appropriate to local needs and consonant with modern views of science education-in primary schools and the lower forms of secondary schools. It covers the first eight or nine grades of schooling, with particular emphasis on the primary school level, so that science can be introduced at the earliest grade possible and thereby reach the largest group of children while they are still at school. It is also concerned with an integrated approach - that is with presenting science as a unified whole, rather than in a fragmented way.

2. Those of us gathered in this room can bear witness to the fact that an ever-increasing number of experiments to assist children in learning science at the primary and lower secondary stages of education are being carried out at the present time in many countries of the world. In designing its programme, UNESCO has drawn on the experience and knowledge of those who have pioneered these experiments. At a Planning Meeting for UNESCO's Programme held last March, when UNESCO was fortunate enough to secure the se· ices of leaders of a number of these projects, including several people present in this room, it became apparent that the existing projects have many features in common. For example, they all emphasize children "doing" science and developing intellectual and manipulative skills rather than just acquiring encyclopaedic information of the natural world. They are all, to some extent, based on psychological studies of how children learn. They all build on the child's pre-school and out-of-school experience of exploration, manipulation and learning with his senses. Indeed, they recognize this experience, springing from the child's natural desire to find out more about his environment, as the living roots from which scientific experience and knowledge can grow. This is in marked contrast to much primary school teaching in the past, which sought to replace the child's natural environment with an alien school world which had few points of contact with his daily life, and which tended to stifle rather than to develop his natural curiosity.

3. There are differences, however, between the various courses which relate principally to their philosophical, psychological and organizational bases and to the environment for which they have been produced. For example, some programmes such as "Science 5/13" and "The African Primary Science Programme" place particular emphasis on the child's environment, and may be said to employ an environmental approach . Others, such as the IBECC programme, while not neglecting the environment, lay considerable stress on the applications of science and may be said to be characterised by an applied science approach. The Science Curriculum Improvement Study is structured round some of the "big ideas" of science, and may be said to embody a "conceptual" approach. The Philippines programme is based on the progressive development of those skills and processes, both mental and practical, which are considered basic to an understanding of science and employs a process approach. The Israel programme embodies several of these characteristics, being to some extent both conceptually and environmentally oriented.

4. In view of these valid differences of approach, and of the differing needs of different countries and regions of the world, UNESCO has not attempted to set up a Programme embodying a "UNESCO approach". Rather, it seeks to support and extend these programmes for the development of junior science which are already in existence, and to stimulate and encourage the establishment of others. It further seeks to draw on the experience of those programmes which are relatively well-established for the benefit of those which have only recently come into being. It is also concerned to disseminate information as widely as possible about existing projects, the situations to which they cater, their aims and objectives, their approaches, the materials they have produced and how far they have been successful in achieving their goals. In order to have the greatest "multiplier effect" and the widest impact, the programme is being focussed on key personnel in science teaching improvement such as science curriculum planners, tutors in training colleges and science supervisors. It concentrates particularly on methods and materials for the preparation of teachers (both pre- and in-service) and due attention is given to the use of the mass media.

The UNESCO Programme

5. The Programme consists essentially of four parts:-

The first part is the collection and dissemination of information about science teaching by means of series of publications and through documentation services. Publications to be produced in 197? include:

(a) New Trends in Integrated Science Teaching. As 1970 is

International Education Year, this volume will be part of UNESCO's special programme intended to stimulate innovation in education and an integrated approach. It will contain information on integrated science teaching, mainly at the junior level, from all over the world, and the needs of developing countries will be particularly borne in mind.

(b) A revised edition of the UNESCO Source-book for Science Teaching will be produced, incorporating much modern material and removing material which is outdated or impracticable.

(c) A Bibliography of junior science programmes and projects.

It is intended that UNESCO's future programme of publications should include a supplementary volume to the revised UNESCO Source-book, a guide-book to what is known about effective science teaching with particular bearing on the processes of learning, and a book of case histories of innovation in science teaching.

6. The second part of the programme is the stimulation of pilot experiments on the development of methods and materials for junior science teaching and for teacher education in several countries. UNESCO will work with already existing groups concerned with science teaching improvement. For example, here in Israel work has begun with the Tel Aviv University Project and will be linked with the UNDP-UNESCO Science Teaching Centre. In the Philippines, work has started in collaboration with the Science Education Centre at the University of the Philippines and the Ministry of Education. In Ghana, it has started in collaboration with the Ministry of Education's Curriculum Development Unit and with the Ghana Association of Science Teachers. Other countries where work will be started during 1969-70 are Ceylon, Malaysia and Thailand in Asia, Nigeria and Zambia in Africa. In UNESCO's future programme, assistance will be extended to a wider range of countries. UNESCO's assistance to recognised working groups will be made available in three principal ways:-

(a) Teaching materials will be supplied, which can be used as resources in local development projects.

(b) The services of short-term consultants will be provided who are themselves involved in major science curriculum projects.

(c) Contracts will be entered into with the various working groups, which can make available the results of their work to Unesco for wider dissemination.

As UNESCO's funds for this project are very limited, it is intended to encourage countries participating in this programme to seek additional assistance through the United Nations Technical Assistance and Development Programmes, and through UNICEF.

7. The third part of this programme consists of Conferences and Workshops on an international, regional and national scale to exchange information, to examine particular aspects of junior science and to study particular programmes. This present meeting is the first such Conference. Next year, two others are planned, one in Africa, and one in Asia, which will be held in the Philippines.

8. The fourth part of the programme is to provide special services to Member States of UNESCO, At UNESCO headquarters, a briefing room is maintained in which modern science teaching materials are displayed. UNESCO science teaching experts and others visiting UNESCO are briefed on these modern approaches on their way to field assignments. A second service is in the field of local production of science teaching apparatus. Due to factors such as modern developments in school science apparatus design, far-reaching curriculum change, a huge expansion in the number of pupils learning science and the problem of foreign exchange, the manufacture of some, if not all apparatus locally has become a pressing and urgent problem in many countries, and will be given more emphasis in UNESCO's future programme. Again, in the field of teacher training, assistance is being given to national institutions concerned with teacher education to develop training programmes in the use of new methods and materials, and procedures for assisting teachers subsequently in their classrooms.

9. In conclusion, I should like to emphasize again the collaborative nature of the programme I have outlined.

(a) It is collaborative in working with people such as yourselves and the programmes you represent for advice, expertise and materials.

(b) It is collaborative in working with international and bilateral aid organisations with similar concerns in science teaching so that more assistance can be made available than UNESCO alone can provide.

(c) It is collaborative in working with non-governmental organisations such as the International Council of Scientific Unions' (ICSU's) Science Teaching Committee, which acts as a permanent adviser to the programme.

EVALUATION - GENERAL PRINCIPLES AND AN ACCOUNT OF ONE EXPERIMENT

W. HARLEN - University of Bristol, England

"Evaluation" is a term which is given to processes which vary very much from each other, describing, for example, anything from a philosophical analysis of the aims of education to the use of classroom tests. There is a whole galaxy of activities covered by it, each of which has its appropriate methods and principles. Many attempts have been made to group these forms of evaluation, but there seems to be no unique classification. For myself I find it useful to distinguish between four types of evaluation, which seem to have different purposes and functions in the main, though they overlap considerably. These four are as follows:

1. Firstly, there is evaluating the suitability of the objectives of an educational programme. This is nothing to do with whether the objectives are being achieved or even whether they are achievable, rather it concerns whether they are worth trying to achieve and how they compare with other possible and perhaps competing sets of objectives. This tries to answer questions such as "are the aims of the programme appropriate, worthwhile, relevant and, above all, complementary to the other aspects of personal development?" One important function of this kind of evaluation is to probe the effect of innovation in one area of the curriculum in the context of the total education of the individual.

2. The second type is "on-going evaluation" carried out as part of the programme of curriculum development. This has as its chief function helping the production of the educational programme once its objectives have been accepted; though of course both the objectives and the material are under trial during this kind of evaluation.

3. The third type of evaluation I would like to separate is evaluating individual readiness and progress. Included here are all forms of evaluation which can be used by teachers themselves, perhaps as part of the programme being developed, to diagnose their children's ability to benefit from certain experiences, to gauge their progress, to locate their difficulties, and so on.

4. Fourthly there is terminal evaluation, the evaluation of a final draft of a programme or approach which has been tried out and modified during its production. The important function of this is to find out whether the final programme does, as a whole, achieve what it set out to do, whether it does this any better than other possible programmes or approaches, and how extended is any effect which it may have.

I do not want to over-stress these artificial divisions between types of evaluation, much less to suggest that they are alternatives, or even that one type is more important than another. They may all be relevant to a programme at one or another phase of its development, and it is essential that any type which is relevant is used at the appropriate time.

All four types I have described involve the same basic activities: of clarifying objectives, of developing and using various ways for getting evidence of changes in children, of interpreting the evidence which is found, and of making use of the information gained. However, the way you go about the gathering of evidence does depend on why you are gathering it, what kind of evaluation you are carrying out, As I shall be concentrating on the second of these types of evaluation, "on-going evaluation", I just want to make it clear that the principles which I shall try to outline are to some extent particular to this type of evaluation and not necessarily appropriate to the other kinds of activity which go under the name of evaluation.

What then are the principles of on-going evaluation ? I think these follow from an examination of what in fact this process is. On-going evaluation is an integral part of curriculum development. It begins not after the writers have produced their material, but before this happens. It begins at the stage of establishing the objectives of the programme. This is not always easy for the evaluator - this searching out what the rest of the team want to find out - partly because it depends very much on the close relationship between the evaluator and the team which, sadly, is not always found (at least not as well it is in Science 5/13!). My position as a team member of Science 5/13, right from the start - and I think this is important - has meant that I know (I think) as well as the rest of the team what we are trying to do, both in broad outline and in detail in the various parts of each Unit. Now when this is not the case and the evaluator is treated as one who is from outside, or is brought in as a team member sometime after the beginning of the project, then there are great difficulties in communicating details, aims and the general ethos of the material to the evaluator. I have been in this position, not in doing on-going evaluation but in carrying out a terminal evaluation during the last year of a project. At this stage the team members are usually very much concerned with meeting publication dates, with teacher's courses, and so on. If before this point they have not taught in terms of identifying the kind of behaviour changes they hope will result in the children working with their material, then it is very difficult, if not impossible, for them then to begin doing so.

Another relevant feature of on-going evaluation, when it is regarded as part of the curriculum development programme, is that it has to be as flexible as the programme itself and to allow for development, modification of ideas, changes of emphasis. This has consequences for the kind of evaluation instruments which can be used, for obviously these must not be determined in such a hard and fast manner that they cannot be changed or modified.

By its nature on-going evaluation is a continuous process, taking place throughout a project's life and throughout the trials of the materials; it must not interfere with the conduct of the trials. This is another feature which places restriction of the type of instruments which can be used and the amount of information which can be gathered. Information has to be gathered economically: the luxury of tests which take a long time to prepare or to administer, however thorough they may be, cannot be afforded. There must be careful selection of instruments, in the light of this, since it is desirable to gather as much information as is needed to enable the results of trials to yield positive guidance for rewriting, not merely to show which parts of the material were working and which were not.

This, then, is how I see on-going evaluation and some of the problems it involves. Drawn-out of this are these principles which have guided me in trying to come to terms with the problems:-

The first is that one must be prepared to spend a great deal of time and make tireless efforts to find out exactly and in detail what it is that the project is aiming to do through the materials it is producing. Not until facing this in practice was it borne on me just how much time and effort is necessary, and now that it has been borne on me I am more than ever convinced that it is entirely essential - everything which is done later is questionable if this initial thinking is hurried. In Science 5/13 we spent the first year of the project searching out what our aims should be, then examining them, analysing them and formulating them as behavioural objectives. It involved looking at other projects' work and results, the findings of research, the theories about children's scientific ideas and concept formation, but above all it involved looking at children working, at their environment, at the classroom situation, to see what help was needed and in what form it could be best provided. This was a joint task, undertaken by the whole team and as I was the one who put things down on paper I did reach a thorough understanding of what we are about. Although most of this activity was carried out in the first year of the project, it did not end there, for it must be continued throughout the project's life, and continued in the realization that it is an endless task, for such a thing as a complete and ultimate set of objectives does not exist.

The second principle is that one must keep constantly in mind that the evaluation concerns not the material as an independent entity but the behaviour of children, the material being merely the agent of change in this behaviour. And behaviour is a very complex thing; one should not expect to gauge or detect changes in it by simple techniques. I see apprising behaviour as a problem which is multi-dimensional, and, just as a point in multi-dimensional space cannot be located if only one co-ordinate is known, so one needs many different kinds of information about behaviour to make any useful description of it. So one must look at the problem from all angles, use different kinds of tests, probably both subjective and objective kinds will be necessary, examine reports of independent observers, subjective assessments, gather evidence about the attitudes of the teacher, children, and others involved.

The third principle is that one must find, or develop, techniques of evaluation which are appropriate to the behaviours we are trying to investigate and which interfere as little as possible with these behaviours and the activities which are going on. Also one must try to find techniques which are enjoyable, not arduous or laborious for either children or teachers. I noticed with particular interest that in a progress report by Professor Feuchtwanger dated March 31st, 1969, he wrote "the positive responses of teachers and pupils gave rise to a problem of evaluation. Their enthusiasm made it necessary to develop an instrument, which will adequately evaluate the effectiveness of each of the units at each grade level without undue influence of the enthusiasm factor." I do think that it is most important to try not to interfere, not to reduce enthusiasm, to make the evaluation unobtrusive, and, where it has to be obtrusive, at least enjoyable. This is important at all levels, but especially when dealing with young children. It is one of my very strong guidance principles.

The fourth guideline is to think very carefully about the probable results of using any evaluation instrument before it is chosen, consider how usable the outcome is likely to be or, whether one can handle the amount of information it would yield. One should collect only information of the kind and in the quantity that one can use. Collect, of course, all one can use, not too little, but, equally important, not too much. It may seem trivial to put emphasis on not over-collecting information because, after all, one could always ignore any extra. But we are dealing with human beings whose time and energy have to be respected - each item of information represents the efforts of someone on our behalf and we should not treat the results of these efforts lightly. Our experience in the United Kingdom of collecting feed-back from teachers has shown that they are very generous with their time and will willingly collect information, write reports, send examples of children's work, complete forms, and so on, but naturally they mind very much if none of it is used. Unfortunately this has happened and some teachers are less willing to help a second time. Obviously this has to be avoided, and one must always be thoughtful of the burden which an evaluation programme may place on others. It falls to the evaluator to consider very carefully what questions need to be asked, to ask only 'real' questions, and only those whose answers one honestly wants and can use. Although I intended not to quote from books I must repeat Dr. Bruner's words "measurement follows understanding" which neatly sum up all I am trying to say here, for this principle applies to all evaluation techniques not just to teachers' reports and questionnaires.

How are these principles seen in practice in the case of Science 5/13 ? I have already given some account of how the whole team worked to establish a set of objectives which, although first thoughts, were the best we had to start from. In each unit there is a statement of the objectives which might be achieved by children undertaking the kind of activities suggested in it. In addition there are other objectives which we hope children will achieve as a result of working in the way we advocate. These concern approach to problem solving, ways of communicating developing attitudes and interests; they are common to all units. So the first step in evaluation has been completed. Before coming to the selection of evaluation techniques I need to say something about the organisation of the trials so that the evaluation is given some context. We have four units ready for pilot trials starting in September and since we are obliged to carry out our trials in twelve pilot areas throughout the country(these were chosen for the Nuffield Junior Science Project) we have arranged that each unit is evaluated in three areas. Each area is providing six classes in which the material will be tried and six control classes. So eighteen classes, chosen to cover the junior age range and various kinds of school, and eighteen control classes are involved in the trial of each unit.

When it came to making decisions about what we wanted to find out from the trials I had to take into account that our objectives are ones that we hope children will achieve, but our material is written for teachers. Direct testing of changes of behaviour in the children has to be undertaken in order to explore any effect the material may have, and we also need to know the reactions of the teachers and find out whether we have been able to communicate our ideas successfully to them. The link between ourselves and the teachers is obviously crucial and it is therefore essential to gather information about the opinions and attitudes of the teachers as well as accounts of the experiences of their pupils. In addition we feel that the physical and social conditions under which the trial work is done may play an important part in determining attitudes, and even the outcome of work, for both teachers and pupils. So relevant details must be known and collected, preferably, by an independent observer from outside the school.

The evaluation is thus a four-sided attack - information being gathered from the children, the teachers, from an independent observer and from members of the team who visit the classes during the trials.

Now we come to the question of techniques and the choice of evaluation instruments. My guiding principles here, you remember, are that the instruments must be appropriate to what one wants to find out, must interfere as little as possible with the work and be as painless as can be, preferably enjoyable.

For testing children who are able to read I use a technique which involves the use of moving film sequences. It is a method which has been developed over several years, its origins being some individual testing I did in order to explore children's scientific concepts. The individual test, in which a child is shown a problem involving some apparatus or materials which are present in front of him and shows by his actions whether he has developed the ideas needed to solve it, has much to recommend it, particularly for the purpose of exploring the child's reasoning. However, for use on a large scale it has overwhelming practical disadvantages, so it was first converted so as to be suitable for group administration. In this form a group of children had one set of objects in front of them and were questioned about it after a demonstration or some manipulation of the equipment. The physical presence of the actual objects involved in the question was felt to be of utmost importance if the children were really to understand the problem. If instead they were to see only a drawing or picture of the apparatus this would give only a two-dimensional idea of what the children were required to think about in three-dimensions and it would be uncertain whether the children were in fact visualising the problem as intended. In this situation an incorrect response could result from inability to visualise the problem as much as from the lack of necessary concepts needed to solve it. However, even this has its obvious disadvantages for use on a large scale, so rather than change to a pencil-and paper form I decided to make moving films of the demonstrations. Although a two-dimensional medium the movement of the objects and apparatus provides the necessary cues for their real form to be appreciated. The most practical form of film was the 8mm loop film for use in a projector suitable for daylight viewing and with an integral screen with rear projection, for convenience. Incidentally, this kind of projector has the advantage of resemblance to a television set so that the children are already familiar with it as a source of information.

Experience with this form of test, which extends to testing at least 300 classes has demonstrated that the children invariably enjoy it. They regard it as a treat rather than an examination and rarely do they ask about their results or show signs of anxiety common to test situations. When I have retested the same class they have seemed delighted to see me and at the end asked for more. Recently a small group of teachers has been administering this kind of test themselves to their own children. The experience of these teachers has agreed with my own experience of administering the tests - both the teachers and their classes enjoyed it. This has also shown that it is quite feasible for teachers to administer the tests and so reduce the 'interference' of an outside administrator. We plan, therefore, that the teachers involved in our pilot trials will test their classes using the test materials provided by the project. The administration is sufficiently standardized for this to be possible; the teachers are supplied with all that is needed.

Administration is simple: the children are provided with answer booklets in which they mark their responses to the questions which are in multiple-choice form. There is only one item on each page and the children are told to turn over as soon as they have completed an item; this enables the administrator to gauge their rate of responses and also minimises sharing of answers which would no doubt take place if several answers were open to view on each page. The first sequence is shown on the screen whilst the administrator reads out the commentary and the problem is posed. At any point the film can be held by using the frame-stop mechanism so that particular views can be seen at length. At the end of each sequence the screen shows a reproduction of the page of the booklet on which the question is to be answered, The administrator reads out the words on it, thus helping slow readers to locate the alternative they choose to mark. The test is not speeded, all the children are given chance to respond to each item before passing onto the next. The total testing time depends on how quickly the children respond and, by breaking the administration into several sessions, the varying periods of concentration of different groups of children can be accommodated.

In our pilot trial each class will take two tests of this kind. One is composed of items relating to the objectives of the unit with which their teacher is working, and the other of items relating to the objectives including those concerning attitudes and interests, common to all units. Both these tests will be given to experimental and control classes alike before the trial work begins and again when the teachers judge that the work has been completed by the experimental class. The teachers will mark the tests, using the scheme and mark sheets provided, so they will have immediate knowledge of the results of their children. The mark sheets will be returned to us for large-scale analysis. We have reasons to believe that teachers do not mind this extra work and in fact prefer to be fully in the testing and marking, rather than excluded from it and made to wait to hear about the outcome, if in fact they are told at all.

Although poor readers can be helped to do this kind of test it is not satisfactory for them and the test is certainly not intended for non-readers. For them and for infants individual testing is essential and is best carried out by the teacher. When our unit for infant teachers 'Early Experiences' is being evaluated the teachers will be provided with suggestions for this testing.

Information is being gathered from teachers mainly by questionnaire but also by direct contact with team members whenever possible. There are three forms which will be distributed at appropriate points in the trial period. On one the teachers will be able to give a free account of the relevant activities of their children. On another, which is largely pre-coded, they are asked for their opinion as to the desirability and practicability of the objectives of the unit, of the teachers' guide and of the background information, of the effect of the work upon other areas of the curriculum, of the value and format of the material they have been given and of the general list of objectives. A third form asks for their preferences as to various methods, approaches, activities both within and outside the classroom ; this is in fact an indication of the teachers' attitude, of a covert kind.

In each pilot area we have a person who has been designated by the Local Education Authority to assist us in the conduct of the trial. These persons have already helped in the selection of trial classes and will continue to give assistance during the trials by distributing materials, calling meetings of participating teachers, arranging for circulation of test films, and so on. These are also the independent observers from whom we shall obtain information about the physical and social environment of the children.

So far, of course, we have no results, we are working up to putting our plans into practice. During this past year, however, the second year of the project, all the evaluation techniques and most of the plans have been given pre-pilot trials, and we have reason to believe that they are capable of producing useful results. However, even at this stage, before the trials begin it is, I believe, quite fair to claim that on-going evaluation has already had beneficial impact on the project. The writing of the test items is an exercise which compels one to dig down to the heart of a matter, and item writing has been going on at the same time as the writing of the material. This has meant that I have been asking awkward questions, not always welcome, trying to identify the behaviour changes we are aiming at, whilst the writers have been findings ways of encouraging the changes. The result has been a greater awareness on both sides of each other's problems, notwithstanding our inability to solve them, and a sharpening of our understanding of what we are collectively trying to achieve.

THE PHILIPPINE SCHOOL SCIENCE PROGRAM FOR GRADES 1-8

DR. D. F. HERNANDEZ - Director, Science Education Centre, Philippines

In the Philippine school system elementary education extends from grades 1-6; secondary education begins at the grade 7 level and extends for four years to grade 10. Science and mathematics are taught from grade one through the secondary grades. The specialized science courses are not offered till the last 2 or 3 years of the secondary school level. Most schools teach in the seventh and eighth grade levels, a course in general science the content of which is like an extension of the elementary school science of the first 6 grades. Hence, this paper will cover the science programs of the Philippines in grades 1-8.

There are two major elementary school science curricula used in Philippine public schools. One has been developed by the Bureau of Public Schools in cooperation with the Peace Corps; the second is a curriculum development project of the Science Education Center, University of the Philippines.

Both programs have been influenced by the AAAS[1] elementary school science project known as Science: A Process Approach. However, both programs consider the teaching of science concepts as significant as the teaching of science processes. Both programs utilize a spiral approach in the development of concepts; broad science topics have been selected around which the program is organized. The same topics in increasing complexity are carried upward through the grade levels.

The Bureau of Public Schools - Peace Corps (BPS - PCV) elementary school science program is organized in terms of concepts about the following broad topics: (a) Living Things, (b) Matter, Energy and Motion, and (c) Earth and Space. Materials for the first two grades had been developed much earlier - these are now being taught in grades 3-6. All of these materials are in the form of teacher's guides - no student texts have been developed. However, these teacher's guides are very detailed and include particular lessons for use with the pupils. The program for each grade level begins with what is called a process unit. Such a unit includes lessons designed to develop

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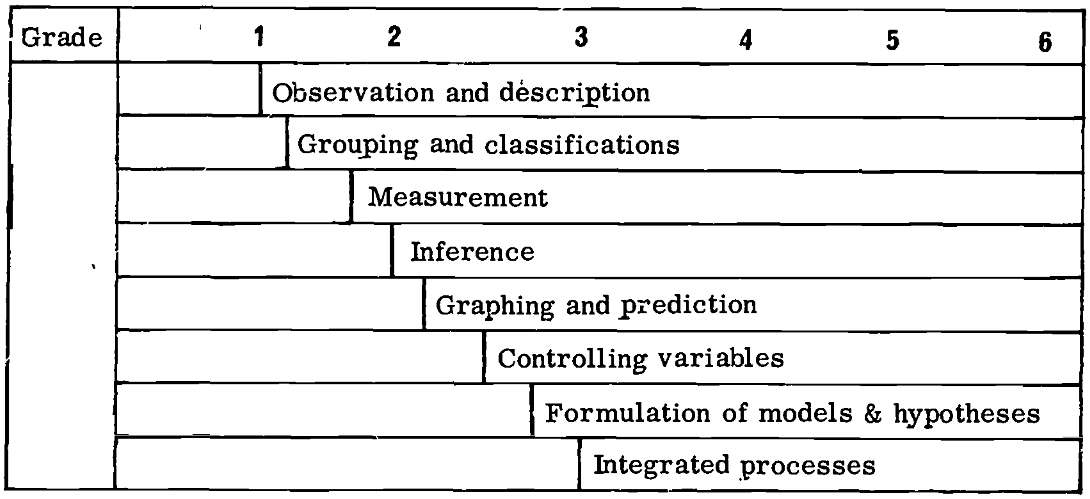
1 American Associations for the Advancement of Science.

particular skills or processes emphasized in a particular grade level. The process unit is followed by units organized around content areas (the 3 broad topics mentioned above); however in the development of the content the stress is on activities that also stress those processes of science appropriate for each grade level. We could take one broad topic as an example - Living Things - to show how this is developed from grades 3 through 6. In grade 3 the pupils study characteristics of living things, and they observe life processes:reaction to stimuli, movement, growth and reproduction. The activities developed around these concepts involve the children in observation, description and classification. In grade 4 they study the rice plant in some detail - its germination and growth, its parts and their functions. They also study animal growth, and the development of some common animals. Finally they study themselves - their sense organs, nervous system and skeletal system. The activities of this grade level emphasize measurement. In grade 5 the activities are organized around adaptations of plants and animals to their environment, and on how man uses his food. The process emphasized at this grade level is likewise measurement. On the sixth grade level the processes emphasized are prediction and controlling of variables. The major concept is on the interdependence of living things. The various processes developed in earlier grade levels are carried through to each succeeding grade level. Thus there is a continuous reinforcement of the processes previously learned. This program is presented in outline form in Appendix A.

The program being prepared by the Science Education Center is similarly aimed at the development in the child of (a) an understanding of the basic biological and physical concepts about the world in which he lives and (b) the skills (processes of science) he will need to solve problems of a changing environment.

In these materials basic concepts in the physical and biological sciences were distributed to the different grade levels according to their complexity. Some stress is given to the ecological viewpoint in the biological science part of the program. The major concepts in the physical science part relate to matter and energy. An important consideration in the selection and placement of physical science concepts was in terms of how they contribute towards the understanding of certain biological concepts. Stress is also made on the interaction of living and non-living things.

A topical outline of the content coverage of the elementary school science materials of the Science Education Center is included in Appendix B. This outline, however, does not show a significant aspect of the materials - this is the progressive development of science processes along with the development of concepts, with the simplest processes introduced earlier and the more complex ones later. The chart below shows the grade levels at which particular processes are introduced:



The science program of the Science Education Center for grades 7 and 8 levels tends to be more content-oriented. The BPS-PCV materials for these grade levels are still strongly activity-centered but the science processes which these activities tend to develop are less obvious than in the lower grades. In general it may be said that at this level both BPS-PCV materials and SEC materials tend to incorporate some activities that could develop integrated science processes such as the formulation of hypotheses, defining operationally, experimental procedure, interpretation of data, inference, predictions, formulation of conclusion, deducing a principle, law or relationship and application of principles and concepts.

In terms of content, the BPS-PCV materials for grade 7 begins with a unit which attempts to acquaint students with the methods of science. This is followed by a unit on earth science entitled "The Earth Influencing Life", which in turn is followed by 2 units on biology entitled "Living Things in Their Environment" and "Man Functioning in His Environment". The materials for grade 8 begin with a unit that introduces the student to the "discovery approach" and the physical properties of matter. This introductory unit is followed by 4 other units, all on the physical sciences. These are: Matter, Its Composition and Changes; Force, Motion and Work; Energy; Energy on the Move.

It is noted that the BPS-PCV materials have a similar pattern of presentation from grades 3-8 in that they all begin with a unit on the processes or methods of science. The approach however is not descriptive - the students become acquainted with the various processes by means of a series of activities.

The SEC materials for grades 7 and 8 stress earth science in the 7th grade and biology and the universe in the 8th grade. Unlike the BPS-PCV project which has produced only the teacher's guide, the SEC materials include both a student text and a teacher's guide. These materials tend to include much descriptive materials although attempts are being made to orient them more towards activities and the processes of science.

The desire to make available materials that would relate more closely with the new elementary school science materials in terms of stress on individual student participation led to a joint curriculum project with the Bureau of Public Schools - the ISCS Adaptation Project. Furthermore, since the teaching at this level tends to be verbal, descriptive and oriented towards teacher demonstrations rather than student involvement, the need for materials that strongly stress pupil activity seemed desirable. On the other hand, it was realized that problems related to supplies and equipment which such programs demand, may be too difficult for most schools to solve, hence the decision of the Science Education Center administration to proceed with two sets of materials for the grade 7 and 8 levels - one conventional (the SEC materials) and the other self-pacing (the ISCS).

Early in 1969 it was therefore decided to try out the Intermediate Science Curriculum Study (ISCS) materials with a view to adapting them to local conditions if they were found feasible. To begin the project, an experienced staff member of the ISCS was invited to conduct an orientation program for a group of high school teachers some of whom would try out the materials during the current year and others who might constitute a corps from which to draw possible members of a writing team. The materials are currently being tried out in 2 classes each of grades 7 and 8 of a large public high school . The progress of these classes is being watched closely and the teachers submit feedback. At the end of the current school year, a decision will be made as to whether or not the materials could be feasibly adapted. If so, it is then planned to hold a writing conference during the summer session (May and June 1970), and refinement of the materials and finalizing them can thus be done during the school year 1970-71.

It is pertinent to point out here that we do not have any studies about how our children learn science concepts, nor how they deal with natural phenomena and interpret them. Nor are there any studies on how our students perform on sequential learning tasks. Hence, sequencing of our materials has been mainly arbitrary or based on the experiences gained from abroad. The new programs have emphasized the lack of psychological and pedagogical information regarding the way Filipino children learn. It is our hope that these new programs will stimulate investigations which would shed light on how our children learn and on how they cope with learning problems and other psychological and pedagogical information which are needed to improve learning.

To summarize, the new school science programs in the Philippines for grades 1-8 tend to emphasize both content and the processes of science.

PROBLEMS IN THE RETRAINING OF TEACHERS

IN THE USE OF NEW MATERIALS IN THE PHILIPPINES

DR. D. F. HERNANDEZ - Director, Science Education Centre, Philippines

This paper will attempt to present problems relevant to the retraining of teachers as we have experienced them in the Philippines. No attempt will be made to generalize although it is recognized that some of these problems may apply to other countries too.

To this date retraining programs for elementary school science teachers have been confined largely to sessions where teachers are introduced to the new materials that will be used in the classrooms. The emphasis has been on getting the teachers acquainted with the major concepts involved in the materials and in actually trying out the lessons which are mainly activities. Such retraining courses have been accomplished mainly through short term in-service programs such as summer sessions, 2-week conferences or Saturday classes spread out through a semester or an entire school year. The longer programs(six-week institutes) have tended to include lecturers and discussion sessions not only on the major science concepts of the course but also on the science processes which the materials are designed to develop. They also include lectures and work sessions on evaluation with stress on instructional objectives and test item construction. For teachers on the lower elementary school level (grades 1-4), this seems to suffice but for those on the higher grade levels (including grades 5-6 and the first 2 years of secondary school) some problems arise. As certain concepts have to be treated on a higher level, there is a need for someone with a good understanding of the physical sciences, the biological sciences, and the earth sciences. Since individuals with a sufficient command of all these areas who are at the same time conversant with the needs of teacher education are not easy to find, various lecturers from each of these subject areas need to be utilized. These lecturers need to be familiar not only with the elementary school science courses actually taught in the schools but also with the objectives and approach to science teaching at this level. In addition, an elementary school teacher experienced in the use of the materials is needed to conduct the laboratory sessions during which the science activities are tried out by the teachers. Thus, a person conducting a retraining program for elementary school science teachers may find that he needs the assistance of 3 or more individuals. Availability of personnel may thus become a problem because during the summer sessions so many of such training programs are offered and competition for staff is quite keen.

Another problem centers about the teacher's academic preparation. Most elementary school teachers have the same basic academic preparation -- in their preservice education program they take one or two courses on the different subjects they will eventually teach. In other words, there is no specialization. This is necessary since a teacher is assigned to teach all the courses except music to the class assigned to her. This is especially true of the lower elementary grade 1-4 . Some division along departmental lines starts at grade 5. Here teachers are a bit specialized and there are programs in some teacher training institutes which allow teachers to "specialize" in science (up to about 12-16 units[1]). Most elementary school teachers, however, have only 6-9 units of science and mathematics. This poses a problem in retraining programs. Science subjects for this group have to be dealt with on the level of an introductory college course -- a situation which in turn raises the problem of accreditation in some colleges and universities. Most teachers who participate in retraining programs have their bachelor's degree and expect to earn graduate credits for the courses they take.

A more important problem is one pointed out earlier -- that of getting specialists in the sciences who at the same time are acquainted with the problems and needs of elementary school science teachers so their science courses can become more relevant to the needs of the teachers they are retraining.

The demands of the new materials on the teacher in terms of added competency in science content, in teaching and classroom management greatly affect the attitudes of teachers. There are those teachers who prefer to teach the way they always taught -- from the book and relying mostly on question and answer, discussion and lecturing or talking to the class about the lesson. New materials may be used by such teachers especially in situations where the books are required as textbooks, but their teaching would still be mainly verbal. The teacher faithfully follows the content of the books but she teaches it in her own way, i.e. telling the students what to do at each step and seeing to it that they have the right answers. Thus the students go through all the motions of learning science concepts and processes but the spirit of inquiry is absent. Why? Because the teacher does not permit it -- she still functions as she always has -- as the source of all information, as the sole authority. No opportunity is given to students to inquire, to raise questions, and to find out the answers for themselves.

The problem of the teacher's attitude may be modified by participation in retraining programs. But it looks as if such programs should

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1 A unit is equivalent to one hour per week for 17 weeks (1 semester).

be of long enough duration so that the teachers can get a fairly good grasp of the rationale and content of the course and become adept in using the materials themselves with sample classes.

Another major problem is the great number of elementary school teachers that need retraining. It is estimated that there are 220,000 elementary school science teachers in 1969-70. Even with the proposed establishment of ten regional science teaching centers the retraining of teachers on this level poses a problem. The number of teachers is much greater than can possibly be reached by in-service programs of the regional science teaching centers. The Bureau of Public Schools has been holding 2-week regional science teaching conferences to which selected teachers are sent. These participants, after the seminar is over, return to their schools and hold "echo" conferences designed to dessiminate the knowledge they have gained in the regional seminars to their colleagues in their own and neighboring schools. A program similar to this might be worked out with the original retraining course lengthened to a summer institute of 6 weeks.

A good measure of the success of a retraining program can be gauged by what happens afterwards in the classrooms of the teachers who have undergone training. Two major issues arise -- one is related to the problem of supply of books and equipment in numbers adequate for use by the students. The second is related to the problem of whether or not a supervisor will allow her teachers to use the new materials since she may be inclined towards a different approach to science teaching.

On the question of supply of books and equipment, both BPS-PCV and SEC materials are experimental editions and are not available commercially. On the elementary school level, the equipment for both programs is simple and mostly improvised. The production of these in quantities sufficient to meet the needs of the teachers and students remains a problem. Although a number of materials can be prepared by the teachers themselves, it still is important to have this simple equipment commercially available. However, much work needs to be done on them before they can be even considered for local manufacture.

To solve the problem of gaining support for the new approach to science teaching (including securing up-to-date materials and improving classroom teaching) it is not the teachers alone who need training. Supervisors, principals and administrators need to be trained too. This training might be of shorter duration and perhaps -- one that will be of a different kind -- that which will give them familiarity with the rationale of the new materials and will enable them to understand the requirements of the new science program.

THE TEL-AVIV ELEMENTARY SCIENCE PROJECT

DR. E. KAPLAN - Tel Aviv University[1]

The task of the Tel-Aviv Project is to change Israel's elementary science curriculum from a teacher-dominated, content-oriented nature-study program to a student-centered behaviorally oriented introduction to science.

The problem of how to effect the almost complete re-orientation of the science curriculum is not confined to Israel alone. In this country the present educational system represents a microcosm of problems whose relevance to those of the emerging or developing nations is obvious; for 60% of Israel's elementary school pupils were born in Asia or Africa or are of immediate Asian or African descent.

The Target Population

Israel's elementary school population consists of immigrants or the children of immigrants from all over the world. Only 9% of the elementary school population in 1967 were children of native-born Israelis. Sixty percent of the children were from Asian and African origins and 30% from Europe and the Americas. The native born children are, to a large degree, west-oriented. In 1966 only 7% of the Asian-African population passed the high-school matriculation examination and only 3% had any university or college training.

The children of the Asian and African sub-cultures are performing poorly in the typically western-middle-class schools with their preponderance of European or American teachers and their textbooks and curricula written by west-oriented authors.

The children exhibit the characteristics of cultural deprivation. They find it difficult to recognize cause-and-effect relationships, they deal poorly with abstractions, they are often discouraged, and their aspirations are often unrealistic in the light of their demonstrated abilities.

But there are certain differences between the culturally deprived students in Israel and those of the United States or England, for example, where most of the research on training the culturally deprived has

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1 present address: Biology Department
Hofstra University
Hempstead, New York, U.S.A.

been done. For one, the children from deprived backgrounds make up the majority of the school population, rather than the 10% or less characteristic of other countries. Second, there is among the culturally deprived an immediate association of education with success. This strongly motivated attitude can be identified with the approach to education of the schoolchildren and their parents in many emerging nations. Finally, the feeling one gets from sitting in a classroom containing culturally deprived students in Israel is one of vigor and unchannelled energy. The children are responsive, eager and, by and large undefeated by their apparent poor performance, except when dealing with such abstract topics as mathematics---which, in our experience, they reject out of hand.

The enthusiasm of the children and the awareness of the government of the special needs of the culturally deprived promises to produce a climate favorable to the development of a behaviorally oriented science program.

History of the Project

The plans to develop a new elementary science curriculum evolved from recent innovations in science teaching in the United States and England. In 1967-68 two American units were translated more-or-less directly (SCIS - Measurement and ESS Growing Seeds) and tried out in Israel. These experiments demonstrated that (a) the new approaches were feasible in Israel and (b) extensive teacher re-education was necessary, both in the area of content and, more important, in the methodology necessary to permit student discovery through individual investigations. In addition, it became apparent that biological units written in foreign countries lacked pertinence to Israel's particular ecological circumstances. It became clear, then, that units in biology would have to be written in the spirit of the new programs but would require a shift in focus necessitated by the use of endemic organism and habitats.

Upon completion of the feasibility studies, a team was organized to write the new program. The composition of the team reflected a problem which has been mentioned before in other such attempts. The writers were high school, normal school or university faculty members, yet they were charged with the responsibility of writing for children from grades 1-6. This lack of congruence between the backgrounds of the writing staff and the needs of the target population was rectified by adding to the team a consultant who was an experienced elementary school teacher and who had independently developed a philosophy of education similar to that espoused by the project.

The Organization of the Writing Team

A major problem facing curriculum innovators in developing countries is the recruitment and training of a team of writers capable of adequately utilizing the material available in the foreign programs. Where feasible, persons can be sent abroad for indoctrination. This method is by no means as successful a solution to the problem of inadequately trained writers as one might suppose. To send potential writers abroad means (a) that their services will be lost for the duration of their training period and, more important, their indoctrination will tend to reflect the institution or project they have affiliated with, limiting their overview of the field, (b) the considerable expenditure of money to support the trainees limits the number which can be sent abroad. This means that a rigorous selection of potential trainees must be made. But what are the criteria on which to base this selection? In Israel, university students in the sciences receive little or no training in creative writing or psychology. It has been our experience that if persons are selected on the basis of their competence in science, this by no means insures that they will be successful writers for the elementary school. The risk implicit in selecting a potential writing team and sending it abroad for training is magnified further by the fact that whether or not the members of the team are capable, they will be placed in positions of influence because of the prestige of their educational experience.

The technique employed by the Tel Aviv project was to select as large a team as possible by hiring writers on a half-time basis. Each writer was required to have some kind of teaching experience in addition to a sound scientific background. Weekly indoctrination sessions plus lectures and discussions led by experts in developmental psychology, science teaching, etc. were used as a form of "on the job" training.

After a period of time there emerged a team of writers who were capable of producing viable units, selection being based on achievement, since each writer was responsible for producing his own unit.

The Philosophy of the Program

The philosophy underlying a science curriculum is not independent of the culture into which the program is to be incorporated. Each of the foreign programs clearly espouses a pedagogical point of view distinctly adapted to the children and teachers it is to serve. The adaptation of these programs to Israel's needs required a searching examination of the role of science in its culture, the attitudes of the pupils and most of all, the capabilities and backgrounds of the teachers.

Israel's schools are overcrowded, with forty children in a class being the rule rather than the exception. There is a high percentage of insufficiently trained teachers and the science program in the teachers' seminaries in the past was inadequate, as evidenced this year by a sweeping revision of content. Most important, the teachers themselves have been trained in the traditional, authoritarian mode from their childhood. Excessive homework and rote memorization are rampant in the schools and forms a strong tradition. But the modern elementary science curricula stand in stark contrast to that tradition, with their provision for independent activity and their insistence on pupil-interaction, their limitation of homework and workbooks and their emphasis on creativity rather than memorization.

How does one reach a rapprochement between such opposing orientations? Our solution was to try to retain what was suited to Israel's needs while eliminating what we believed could not be assimilated from the foreign programs. From ESS we adapted a large number of activities, since this program is particularly rich in creative experiments. From SCIS we adopted the concept of separate units based on some unifying scientific principle. From AAAS Science a Process Approach, we adopted the format of the lessons and an emphasis on behavioral objectives.

This last point may require some explanation. As mentioned above, the most important problem which appeared in the organization of the project was the limited training of the writers in the philosophy of a behaviorally oriented science program. The relatively rigid format of the AAAS project provided an ideal vehicle for insuring that the writers incorporated into the units all of the essentials of a behaviorally oriented program. A Writer's Guide was constructed around the AAAS lesson format. It explained and emphasized the role of each aspect of the lesson and established a rational system of priorities. By insisting on conformity to this structure, it was possible to provide a model which would be a guide to the inexperienced writer.

At the end of this first year of writing there appeared certain modifications of the AAAS format, notably in the direction of liberalizing the statement of behavioral objectives so that the teacher would understand that no investigation utilizes only one model of behavior to the exclusion of the others.

The Syllabus

The syllabus was constructed by a committee comprised of various experts in science teaching, members of the Ministry of Education and members of the Tel Aviv Elementary Science Project. It is integrated with the secondary science program and consists of 26 units, each comprising approximately 18 lessons. The units for the first three grades are designed to be presented in 20 minute segments, six days a week. The upper elementary classes will have three periods of science per week, each 45 minutes long.

The division between physical and biological sciences is roughly 50-50.

Procedures for Developing Units

Each unit of approximately 18 lessons is assigned to one writer who is responsible for its completion. In addition, the writer must submit a prototype kit of materials to be used with the unit. The writer has access to the rest of the members of the team for consultations in their areas of specialization.

The sequence of development of each unit is:

1. Development of a plan of the unit and a general outline of exercises. Selection of appropriate organisms for biology units. Report to full team.
2. Writing of preliminary form of the unit. Try-out of each exercise on the full team for feasibility and validity.
3. Demonstration of key lessons through micro-teaching.
4. Trial of the whole unit in three classes, one at target grade, one a grade above and one a grade below target grade.
5. Trials on a large scale (20-30 classes in various types of communities and schools).

Present Status

At this date, after one year of feasibility studies and one year of writing, five units of approximately 18 lessons each have been produced. These units have been developed through stage 3(micro-teaching) and, in addition, have been tried out in one class; they are now ready for grade placement and more extensive trials. At least two more units are in advanced stages of the writing process.

The above-mentioned units cover all of grade 1 and parts of grades 2 and 3.

Production of Kits

The problem of the preparation and distribution of kits of materials for the classroom looms large. In the haphazard curricula of the past the teachers were instructed to ask their students to, "dig up worms and bring them to class", "to collect silk-worm cocoons", "to bring a flashlight to school", etc. Primitive demonstrations were suggested in the physical sciences which were based on the simplest (and least effective) home-made equipment, and science lessons were often devoted primarily to the crafts of construction and only minimally to the use of the equipment constructed. An efficient biology curriculum was impossible because availability of living organisms was dependent on the vagaries of the environment. No rain, no worms!

The problem associated with asking the teacher to supply her own equipment and organisms has another, more fundamental ramification. Teachers in emerging countries generally have poor backgrounds in science. When they are asked to extend themselves in directions unknown to them they largely ignore the science lessons or confine their teaching to purely descriptive "nature study".

In order to circumvent the weaknesses of the teachers and their lack of involvement in science, and in order to help insure that the children get a chance to manipulate objects and solve problems for themselves, it was decided to base the writing of all units on the premise that kits of materials would be made available to the students.

Costs are not overwhelming if care is taken to tailor-make the kits to the environment and the needs of the students. Kits containing shells gathered on the seashore, feathers obtained from the chicken market and stones have equal (or greater) validity than artificially constructed complex geometric shapes when used in the elementary grades. Similarly, the most limited facilities are adequate to raise countless numbers of snails,isopods, daphnia, etc. For the upper grades, it has been demonstrated that such complex devices as ammeters, electric motors and electrophoresis kits can be constructed and marketed for no more than one dollar each.[1]

Kits available from the United States are expensive and therefore impracticable for under-developed countries. In addition, public health and Department of Agriculture regulations hamper the importation of living organisms. A kit of 8 wooden "property blocks" for teacher demonstration costs more than $ 7.00 in the United States. Similar blocks of plastic manufactured in Israel cost less than $ 3.00 for more than 170 blocks, permitting the whole class, at a fraction of the cost, to perform the activities on an individual basis, rather than as passive observers.

At this writing no center for the manufacture and distribution

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1 For further information about more than fifty different kinds of inexpensive kits contact, Dr. Isias Raw, Foundation for the Development of Science Education, Brazil

of kits for the nation's 20,000 plus elementary school classrooms has been established. Since it will take a number of years to develop the facilities for the distribution of the kits, it is conceivable that a curriculum will be ready before adequate means of equipment distribution are developed, thus placing an incomplete cart before a willing horse.

Teacher Training

Our feasibility studies have shown that the most well-conceived programs can be disrupted by inadequately trained teachers. Consequently one of our first efforts was directed towards developing an adequate teacher-training program. Our first attempt, modelled after certain American teacher-training courses, was a resounding failure. The teachers could not be weaned away from their concept that science consists exclusively of a mass of facts which are best taught by teacher demonstration. Since we were not willing to emphasize facts and the teachers were not willing to learn what they considered to be disembodied theory, the course degenerated into a tug-of-war with the teachers literally demanding more "facts" and the faculty literally bombarding them with examples of "process."

Our second attempt began with the premise that the problem of retraining the teachers was much more deep-seated than mere ignorance of the nature of science. Provision was made for a large segment of time to be devoted to what we call "group therapy". This includes a searching examination of the purposes of education and the role of science in the lives of all citizens. A number of lessons in group dynamics provided a lever which made it possible for the teachers to wrench themselves away from the traditional "frontal" or lecture lesson and, for the first time to permit their students to function on an individual basis. The groundwork was laid for the conversion of a teacher-oriented to a child-centered classroom. Unfortunately this kind of fundamental change cannot be more than approached in a three-week summer course. An index of our success in bringing about an awareness of the problem of teacher-authority versus student-independence was the fact that the teacher in the class formed a group to hire our instructor to continue the "group therapy" sessions during the academic year.

The science content of the teacher training course was confined to the units which had been prepared by our team. The instructors of the course were the writers of the units. The lessons consisted of the same exercises that the school children were to perform. It was found that by replacing abstract lectures on the theory of science with an analysis of actual lessons, it was possible to create a meaningful dialogue between instructor and teachers. When the teachers were made to wonder whether or not mould will grow on beets as well as on bread, it was easy to show them that they were "hypothesizing" and making "inferences."

In a final effort to make tangible the goals of our behaviorally oriented curriculum a model was presented for the teachers to emulate. This was a videotape of one of our lessons taught by an experienced teacher. The videotape was discussed over and over again to reveal the goals of the lesson and make them accessible to the teachers.

By allowing the teachers to re-examine their own purposes in the classroom through "group therapy" discussions, by confining our scientific material to the actual elementary science curriculum and by presenting a model for the teachers to emulate, we were able to win over a potentially antagonistic group of teachers and prepare them for the forthcoming process-centered science curriculum.

Potential International Cooperation

Israel has progressed from a predominantly agricultural nation to the threshhold of technological development in the past twenty years. During this time 51 countries have become independent. These nations as well as many others classified as underdeveloped are currently striving to educate their citizens to function in a modern, scientifically oriented world.

All children need to learn to think in a logical, rational manner. They need to understand the role of science in human society. The goals of the Tel Aviv science project are the same as the goals of science programs all over the world. But the means of achieving these goals are unique to Israel. The foreign programs present a most useful first generation of science curricula but each nation must develop the next generation of science curricula according to its own needs. Israel's role in bridging the gap between the "developed" and "emerging" nations is potentially great, for the Tel Aviv project represents a source of information and ideas born in the wealthy and sophisticated west, but tempered by the needs and attitudes of the east.

A SCHEME OF CURRICULUM EVALUATION

DR. A. LEVY - Curriculum Centre of the Ministry of Education, Israel

In the Curriculum Center of the Ministry of Education the construction of new learning materials undergoes three stages of tryout. This means that each element or episode in the program is tested in three different occasions and at each time under different conditions. In the first stage, which is called the formative stage the object of the evaluation is a brief episode, a single idea, or a brief series of interconnected ideas. At this stage printed text has not yet been prepared, and thus the new material cannot be taught in the regular classroom. The experimental material is tested by the curriculum team in their laboratory, by presenting it to a few students.

In the second stage, which is called the pilot stage a series of single ideas, which already has been tried out in laboratory conditions, is organized into teaching units, which contain five to ten consecutive lessons, and which deals systematically with a given topic and thus consists of material for regular classroom instruction. The material at this stage is taught in six regular classrooms under the close supervision and guidance of the curriculum team.

The third stage of the tryout is the experimental stage. In this stage learning material is combined together into a full one year course and is tried out in a fairly large sample, -30 to 40 classes- representing all types of schools for whom the program is designed.

The evaluation is directed towards three dimensions of the instructional process.

Pre-instructional dimension- the teacher's readiness to deal with the new material in a proper way, the existence of certain kind of skills, mastery of some prerequisites in the student population, the clarity of the experimental, its correctness from a scientific point of view, its sound structure from pedagogic and didactic point of view constitute the focus of evaluation dealing with dealing with the preinstructional dimension.

Transactional dimension- The teaching process itself, the kind of activities performed in the classroom, interactions between students and teacher, between student and student, between student and the learning material constitute the object of evaluation in this phase.

Outcomes- The changes occurred in student's cognitive and affective behavior, mastery of new skills, abilities, information, acquisition of desired attitudes pertaining to the dimensions of outcomes.

A schematic representation of the evaluation performed in the Curriculum Center of the Ministry of Education is presented below.

Dimension	Formative	Pilot	Experimental
Pre-instructional	xx		
Trans-actional	x	xx	x
Outcomes		x	xx

legend: xx comprehensive evaluation activity
x sporadic evaluation activity

The scheme presents a synoptic view of evaluation performed at the Curriculum Center . It can be seen that the diagonal cells of the scheme represent comprehensive evaluation activities, while the off-diagonal cells represent sporadic or no evaluation activities.

A great variety of instruments are used for evaluation purposes, among them: Experts' judgement, observation of teaching process, worksheets of student fill-in during teaching periods, achievement tests of various types, and attitude scales.

In spite of the great variety of evaluation procedures utilized in connection with each single project, experts in curriculum evaluation have to admit that empirical evidence can not be obtained with regard to all problems which arise during the work of curriculum construction. Evaluation consists of a collection of procedures employed to a selected list of issues. With regard to other issues one still has to rely on beliefs, values, preferences and theories.

Unless one perceives evaluation as a goal in itself, one has to adopt evaluation practices to the rhythm of curriculum production. Life does not have the advantage of a slow motion picture and neither has curriculum construction. You cannot stop at any point and say "Let us wait, let us try alternative procedures and then proceed"-because the need for instructional materials has to be satisfied in due time. This is probably the reason for most deficiencies of curriculum evaluation plans. Nevertheless one's ability to indicate what kind of empirical evidence, if any, supported some decisions, may add a great amount of clarity to the validity of each decision.

METHODS OF DEVELOPING NEW TEACHING MATERIALS
AND OF APPLICATION OF ON-GOING EVALUATION

A. H. Livermore - Deputy Director of Education,
American Association for the
Advancement of Science

There are many ways of developing new teaching materials and evaluating them. I am going to describe one method which we have used and found to be effective. I shall call this the "writing team method."

The writing team for developing new science teaching materials should include experts in content--(university scientists), experts in teaching (school teachers), and experts in evaluation (psychologists). They should be sympathetic with the objectives and the philosophy of the program, concerned about improving science education and able to write.

PRELIMINARY WORK

Before the writing team assembles, the originators of the program should prepare some carefully designed and clearly stated objectives, should decide in a general way how the objectives are to be achieved, and should plan the evaluation program. It is highly desirable to prepare preliminary drafts of a few pieces of the teaching materials and of the evaluation program before the writing team assembles. These drafts are useful to stimulate discussions within the writing group and to serve as models as the writers prepare new materials.

OBJECTIVES

The general goal of a junior level science program should be developing scientific literacy, since the majority of junior science students will not enter scientific careers. Science educators do not agree on a definition of scientific literacy. To some, scientific literacy means knowledge of a body of scientific facts. To others it means knowing major scientific concepts and being able to apply the concepts to explain natural phenomena. And to others it means being skilful in observing, inferring, measuring, and so on. These skills are sometimes called the processes of science.

On page 73 we have listed the three kinds of objectives that I have just mentioned, and indicated the nature of the evaluation for each of them. The Content objective has been the predominant one in science programs in many countries. You all know how dull a program based on memorizing facts can be. This approach to teaching science has been rejected by most of the groups in the

United States that have been developing new science programs for the schools.

The Concepts objective is used by two groups that have been developing elementary science materials in the United States. These are the Science Curriculum Improvement Study (SCIS) and the Concept Oriented Program for Elementary Science.

The elementary science program, Science--A Process Approach uses the Skills objective. The objective for Science--A Process Approach are quite detailed and are stated in behavioral terms. Because of this, evaluation of the program has also been detailed and specific, since the goal of the program is to develop specific skills that an evaluator can observe the children perform. I will have more to say about this later.

Objectives and Evaluation of Science Teaching Programs

Objectives	Evaluation
Content: The goal of this program is to teach the student scientific facts	Recall: The student will recall as many facts as possible on true-false, multiple choice, matching, completion or essay examinations
Concepts: The goal of this program is to teach the student to use scientific concepts to explain natural phenomena (for example, the properties of water)	Application: The student will use scientific concepts to explain natural phenomena that are new to him on multiple choice or essay examinations
Skills: The goal of this program is to develop the student's skills in observing, inferring, measuring, classifying, interpreting data, formulating hypotheses, controlling variables, and designing experiments to seek answers to questions	Demonstration: The student will demonstrate his acquired skills to the evaluator by making observations, inferences, measurements, and so on.

THE WRITING TEAM

Let me turn next to the activities of the writing team. The size of the team will depend, of course, on the amount of material to be written and the time available. We have used teams of 20 to 40 writers working for two months during the summer. Others have used smaller teams working throughout the year. An advantage to the summer writing team is that it is easy to get scientists and teachers to work for two months during the summer. A disadvantage is that at the end of the writing session the permanent staff of the project are left with a great quantity of material to be edited and published in the space of a few weeks for try-out in the schools in the fall.

Each member of the writing group should be assigned a specific task--usually developing one small part of the total program. Writers working on closely related materials should have ample opportunity to discuss their work with each other and to criticize materials produced by other writers. This results in vigorous and sometimes lengthy arguments out of which can come new ideas that improve the program.

Each writer should have an opportunity to teach his materials to children after he has produced what he thinks is an acceptable piece of the program. This is very important. Sometimes what a writer thinks will be a simple skill or a simple concept for the children, turns out to be much too difficult. This can be determined only by teaching the material to children during the writing session.

After trying other methods, we finally found it best to have each writer prepare evaluation materials for the part of the program he was writing. This had a good effect on our program in the following way. Each writer had been asked to write behavioral objectives for each teaching unit that he developed. After writing the unit he then wrote evaluation items that could be used to determine whether the skills specified in the objectives had been attained. This forced him to review the teaching materials he had written to see whether they did, indeed, provide a learning situation in which the child could be expected to develop the skills. Sometimes they did not, and the writer revised what he had written.

Another important activity of a writing session is developing prototypes of equipment and specifying other supplies that are needed to teach the program. Since the new approaches to teaching science in elementary and junior high schools require the students to carry on investigations in the classroom, equipment and supplies of various kinds are required. We have found that it is necessary to assign one or more persons the task of obtaining supplies (nuts and bolts, chemicals, biological materials, and so on) for the writers, and of arranging for the construction of equipment and the procurement of supplies to be furnished to the try-out teachers.

THE TRY-OUT

In a heterogeneous society, the schools in which the new materials are to be tested should be selected carefully. All of the new programs in the United States have been produced for all the children in the schools from the affluent to the poor. For this reason try-out schools have ranged from those in wealthy suburbs to those in urban ghettos. The results of the try-out in this wide range of schools have been extremely encouraging. Each of the groups that have produced new teaching materials have found that their programs can be used successfully with children from the highest to the lowest economic levels.

The try-out teachers need help of various kinds. They of course need the teaching materials. They also need supplies and equipment, which should be supplied to them in kits. This is important. Teachers should not be expected to spend time finding their own supplies. The teachers need the sympathetic and active support of the school principal. Teaching a new program for the first time is not easy for a teacher, and it can be extremely difficult if the principal is apathetic or antipathetic.

The try-out teachers also need some in-service training--preferably by someone who has been involved in producing the program. We have used members of our writing team as consultants to the try-out centers. In the early years of try-out the consultants met every two weeks with the teachers to discuss problems and successes and to give advice on teaching the program. Later we developed a series of training sessions which are now being used to inform the teachers about the philosophy of the program and how it should be taught.

EVALUATION

The purposes of a try-out program are to find out whether the new materials are teachable, to determine whether the children learn what you expect them to learn and to obtain information about needed revision. To find out whether the materials are teachable, we have used feedback forms which each teacher filled out and returned to us after he had taught each exercise. In this way the teachers gave us their subjective impressions--were the children interested or bored, were they able to use the equipment, could they understand the concepts--as well as specific suggestions for changes in the activities, changes in the equipment, or additional activities that were found useful.

To find out whether the children learned what we expected them to learn we supplied the teacher with a competency measure for each exercise. Each competency measure consisted of several tasks that the teacher asked the child to do-- weigh an object, determine the volume of a rock, and so on. Each task in the competency measure corresponded to one of the objectives of the exercise, and thus measured the child's acquisition of a specific behavior. The teacher returned to us the results of his evaluation of each child tested.[1] The combined evaluation results of all the children in the try-out program gave us an objective measure of the effectiveness of each part of the teaching materials.

REVISION

Both the subjective information from the teachers and the objective data from the competency measure tests were used by the writers in deciding whether exercises should be revised and in which way. Revision of the teaching materials was done by writing teams during each summer of the five year experimental period. At the end of that time the teaching materials had been thoroughly tested and the program was made available to all schools through a commercial publisher.

ON-GOING EVALUATION

There is a danger in publishing new teaching materials commercially. The danger is that evaluation of the materials will stop. This is not desirable, because the effectiveness of any teaching materials must be studied continually for the program to remain vital.

On-going evaluation requires evaluation instruments and a program for collecting and analyzing data. We have included evaluation instruments (competency measures) in the commercial editions of our elementary school science materials, but have not yet set up a program for processing evaluation data. When we do, the evaluation data will be used as the basis for revision of the commercial program just as it was for revision of the experimental materials.

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1 To save the teacher's time, a sample group of three children from his class was tested after each exercise. The sample was selected randomly and was changed for successive exercises. During the try-out year each child in the class was tested at least once, and frequently twice.

ON THE TEACHING OF MATHEMATICS AS A MODEL FOR NEW APPROACHES TO CURRICULUM DEVELOPMENT AND METHODS OF INSTRUCTION

Prof. A. Minkowich - The Hebrew University, Jerusalem

The model for teaching mathematics in the elementary grades might well serve as a general model for teaching sciences and perhaps other subjects as well, especially in relation to the disadvantaged child. This is because the structure of mathematics is systematic and clear and its logic is well suited to various theoretical ideas, particularly Piaget's, concerning the intellectual development of the child.

This discussion is focused on three aspects of mathematics instruction: goals, content, and methods of teaching. Within the first category, three major goals can be delineated.

1. The acquisition of basic skills.
2. The development of functional arithmetic knowledge; that is, the ability to deal quantitatively with practical everyday situations.
3. The development of mathematical thinking - the formation of intellectual operations and mathematical concepts.

Traditionally, the acquisition of basic skills was considered the most important objective. It was assumed that these skills were needed by everyone and that "real" mathematics should be taught at a later stage. The inevitable instructional method was mechanical exercises. This approach did not adequately prepare even the bright students for the understanding required at later stages and, in many cases, even the primary objective (acquisition of basic skills) was not achieved. A negative outcome of boredom, resistance, and "mathematics phobia" was common.

Approaches of progressive education attempted to rectify the situation by introducing more functionalism and by drawing upon every-day experiences in the teaching of problem solving. Since, at this stage, the experience of the child is narrow, it was not possible to use this experience as a base for all topics in instruction of mathematics. The context chosen was frequently more complex than the mathematical operations involved; consequently both tasks suffered. Further, no real change was made in the curriculum.

Contemporary approaches have led to great revision in the goals, content, and methods of instruction. Basic skills and application to life situations are viewed as secondary goals and as byproducts of the new emphasis.

The major goals have become 1) the general development of mathematical thinking necessary to logical and abstract mental operations; and 2) the acquisition of basic concepts, relationships, and principles in the realm of numbers.

The new approach acknowledges that it is technically impossible to transmit all or even most of the facts and concepts in all subject areas during the school years. The primary concern is to help the child progress to a higher level of cognitive functioning. An emphasis is placed on developing instructional programs that will equip the child with the necessary abilities to continue learning by himself.

This more dynamic view of knowledge reflects an increased sophistication and detailed awareness of the course of cognitive development. Piaget has shown that, for a child, the progression of developmental stages is a sequential process requiring exposure to appropriate experience. The child must actively encounter situations, manipulate objects and perform transformations that will enable him to discover new relationships at a more advanced level of thinking.

It is clear that the traditional school instruction, primarily verbal in nature, does not contribute much to cognitive development. Indeed, if rote learning is emphasized, it may hamper the child's development by forcing him to function on a lower level. The child is not encouraged to learn to organize experience by means of more logical and abstract modes of thinking.

One of the most important objectives of the school for all children, and particularly for those of disadvantaged backgrounds, is the stimulation of intellectual development. All subjects should serve this purpose. This is true particularly for mathematics, especially for the first steps of instruction.

We turn now from the discussion of formal objectives to some of the important changes that have taken place in curriculum content. The contemporary trend is to bring the child closer to an appreciation of the structure of knowledge, rather than emphasizing the acquisition of facts and basic skills. The main condition of this approach is that the form of presentation of any material must be an appropriate match to the child's level of cognitive functioning.

It is not enough to extend subject matter and decide on objectives without a radical change in presentation of subject matter and methods of instruction. Any new curriculum taught by traditional verbal expository methods may do more harm than good. The child, especially the slow learner, will not grasp most of what is taught, nor will he progress in concept formation. He will not even acquire the basic skills emphasized by traditional curricula.

It is very difficult, in the context of this limited discussion, to elaborate the proper presentation of subject matter and methods of instruction for the new approaches to mathematics and other subjects. We can, however, briefly list seven principles that appear essential for achieving the new goals of education.

1. A greater emphasis on active learning, problem solving, learning by discovery instead of expository instruction.

2. A greater emphasis on manipulatory activities in concrete situations instead of demonstration or verbalization or other types of abstract symbolization.

3. More emphasis on conceptualization and meaning rather than on facts and skills.

4. More taking into account of the pupil's readiness and rate of learning in the making of decisions about presentation of subject matter and method of instruction.

5. Gradual transition from activities performed by the child himself to observation and attentive listening.

6. Gradual transition from concrete three dimensional situations to two dimensional iconic and symbolic representation.

7. Care should be taken that a child's activities and operations with objects are relevant to the concepts, relationships or principles to be formed.

THE APPROACH OF THE BRAZILIAN FOUNDATION FOR SCIENCE EDUCATION DEVELOPMENT (IBECC) BRAZIL

PROF. I. RAW - Scientific Director IBECE, Brazil

Primary school education (less than four hours a day, half a year, for less than five years) is the maximum over half of the children from underdeveloped countries can expect of education today. In the context of this sole opportunity for formal learning, science education means scientific literacy. The acquisition of scientific behaviour is fundamental and probably could not be obtained later, even if the pupils were to remain in school. This acquisition is also a basic prerequisite for fitting into modern society. We do not want the child just to be able to use the modern Aladdin lamps science has made possible. He has to be capable of understanding them, and of selecting from what progress has to offer. The scientific illiterate is unable to think scientifically, and is every day more condemned to be a subhuman primate, coexisting with us, but unable to understand or judge, or even to benefit properly from our development, since he does not fit into human society.

Even the more pragmatic subjects in primary school education have no chance of getting across under present circumstances. What is the result of so-called health education, transmitted as a dogma in the few hours at school, when the child at home finds strongly established explanations which do not agree with those of the teacher? Why should a child believe he may have a worm which he has never seen, as a result of swallowing eggs which are invisible? The "educated" citizen believes similarly in a virus, which he knows cannot possibly be seen, in the same way that some "educated" citizens believe in astrology. If one has to fight traditional superstitions one cannot expect to do so using present educational methods in primary school education.

We believe science education should be centered on an active process of learning by doing well-selected experiments. We should ask the pupils to rediscover, accepting the evidence themselves, and being able eventually to convey it to their families. For a large majority, in developing countries, topics should be chosen with an important bearing on their daily life; such topics better than any others, can be exploited to teach a scientific attitude. I would propose that public health and food production are of top priority, as valuable to their development. The understanding and use of electricity, as an indispensible tool, should also be considered. We are giving special attention to some very elementary principles of probability, that are indispensible for the understanding of anything that cannot be proved by a "yes or no" experiment and that are not yet a normal part of the thinking process even in the developed countries, (these principles are essential for fighting magic medicine, and other preconceptions).

We are tackling this problem by preparing units that contain a self instructional booklet, and low cost materials to do experiments to discover answers for questions posed by the booklet. Those units cost one dollar, and are to be used by a group of 3-5 children. Several are now ready and in use. They have the advantage of fitting any curriculum.

Another attempt being made is to build a set of new textbooks, also basically asking questions that can be answered by drawing conclusions from experiments using simple equipment. The textbook fits better the present trend of publishers and educational authorities, but its conversion to units is envisaged as a development which makes possible a more unstructured set of materials to fit the needs and interest of particular classrooms in different conditions.

A few more sophisticated units, such as are also being developed by other groups, are being prepared for the bright students. We accept that if one wishes to prepare future scientists, one cannot expect to teach historically, moving during their education from old theories to new ones. Early teaching of some fundamental aspects of modern science is indispensible. Taught later, they became accepted by the students as an imposition from advanced scientific knowledge, and, never becoming part of their thinking process, form a handicap to progress.

PSYCHOLOGICAL FOUNDATIONS OF SCIENCE EDUCATION

DR. S. STRAUSS - Tel Aviv University

The mechanisms or processes governing conceptual progress have long been a central area of concern in cognitive, developmental, and educational psychology. Among other problem areas, this concern has recently become focalized on the question of how the child progresses through the stages of conceptual development delineated by the research of Piaget and his co-workers.

The problem is to determine the rules of transformation of the child's cognitive structures at one stage of development into those of the next, more advanced stage. A major method of investigating the rules of transformation is to attempt to induce conceptual progress by short-term training procedures that simulate what is thought to ordinarily occur in the child's cognitive development.

This paper is designed to review current postulations concerning rules of transformation in cognitive development. There are two basic reasons that make such an assessment timely. The first is the recent burgeoning of short-term training research that is directly related to the theory of cognitive development. The second is the resurgence of concern by developmental psychologists with the theory and practice of education. These two concerns are related insofar as the optimum practice of the instruction is dependent upon our understanding of the child's changing capacities to acquire knowledge in the course of growth; while our ability to teach is an important measure of our understanding of cognitive development.

As Roger Brown from Harvard pointed out with respect to education, and Jonas Langer from Berkeley indicated with respect to development, the basic issue is how does the child progress from an initial stage A to a more advanced B? This question contains at least two parts. The first concerns the child, and requires answers to questions such as: what is the initial stage A of the child? what is the aimed-for stage B of the child? what are the mechanisms or processes that facilitate change from stage A to B? what are the sources of difficulty in moving from stage A to stage B? how can such sources of difficulty be removed? The second part requires answers to the many questions involved in developing instruction so that (a) the change from the initial to the aimed-for stages will be as optimal as possible, and (b) the sources of difficulty will be minimized as much as possible. If one can isolate factors which facilitate or stimulate transition, one might be better able to understand (1) the nature of intellectual structures and mental operations composing the stages preceding and following the transition and (2) the rules of developmental transition from one stage to the next.

To facilitate our expositon and discussion of current psychological theory underlying scientific concept attainment, we will first present the most pertinent features of the stage theory of cognitive development. Then we will discuss the rules of cognitive transformation through the process of equilibration.

Stage Theory

Although there are several models of organismic development, there are elements common to all of them. Basic to the organismic view point is the holistic philosophy. Its major assumption is that an organism is an organized totality. Within this perspective, synthesis of parts into a structured whole is viewed as a more productive method of investigating and understanding psychological behavior than the analysis of parts. That is, when we analyze parts of human behavior we must recognize that these parts are embedded in and derived their meaning from a total organization. This does not negate the importance of analysis of parts. Instead, we view the parts as subordinated to the context provided by the whole.

An attendant assumption is the role of adaptation to the environment as a psychological as well as a biological phenomenon. From a biological viewpoint, physical structures have evolved which allow the organism to function effectively within its environment. Analogously, mental structures underlie cognitive functioning. It is in this sense that intelligence is seen as an adaptation to the environment. Thus, a change in the mental structure to a higher form of intellectual functioning is a change to a more adaptive functioning. From both the biological and psychological perspectives the parts underlying functioning are organized in a well co-ordinated whole.

With this brief philosophical outlook, it is possible to view stage theory with a unifying theme. Within this theme there are three major approaches to the investigation of stage theory:(1) origins of intelligence, (2) intellectual organization, and (3) structural transformation. Each is consistent with the others and, at the same time, adds new dimensions to the perspective.

Regarding the origins of intelligence, organismic psychologists agree that the neonate is born with a structuring capacity which is the basis for the new-born's initial interaction with his environment. This capacity is both assimilatory (i.e., the organism structures its environment) and accommodatory (i.e., the organism structures itself). Thus, structuring has a logic in the sense that it is organizing and organized. This autoregulatory mechanism suggests that the interaction between the organism and its environment (both physical and social) is one in which the mind is an active constructor of the environment.

There has been a tendency to oversimplify the second approach-structural organization at each stage. A stage should be viewed as an organized whole. However, this is often misinterpreted to mean that, at any point in time, a child is at only one level. Instead, evidence indicates that a child may be at several levels at once.

It is in this light that Turiel and Piaget discuss stage mixture and decalage, respectively. Turiel has found that a child can simultaneously be at several levels of Kohlberg's moral development model. Similarly, Piaget shows that although the operations governing conservation are available to a child so that, for example, he is operational for conservation of continuous quantity, he might not be able to apply these operations to a more complex conservation problem; i.e., he might be preoperational for conservation of volume. Therefore, a stage can be viewed as a co-ordination or coherent organization of different levels of action. In view of the phenomenon of stage mixture in the case of moral reasoning and the law of hierarchic integration (to be discussed later), a stage can be characterized as a modal distribution of levels of reasoning. The apex of the mode is the preferred or dominant mode of action.

This characterization leads us to the third approach which is the focus of this paper; i.e., stage transformation. Whether the direction of the transformation is progressive or regressive it can be viewed as a shift in preferred modes. Other characteristics of stage transformation are as follows. First, the organismic viewpoint postulates structural discontinuity. That is, ontogenesis can be viewed as a succession of structural reorganizations which are not additive or incremental but, rather, are qualitative in nature. In addition, the succession of stages is universal and occurs in an invariant order. Any deviation from this sequence is considered pathological. The postulate of an invariant sequence is a derivative of the concept that each successive stage is a logical extention of the prior stage.

Rules which govern stage transformation have been postulated by Werner and Piaget. Werner's orthogenetic principle posits two basic laws of development:(1) increasing differentiation and (2) hierarchic integration. Basic to the first law is the concept that the functioning of less developed systems is relatively syncretic; i.e., fused in a relatively global organization. An indication of progressive development is the differentiation of parts of the syncretic organization. These parts become internally integrated to form new organized wholes. Conversely, and indication of regression is the fusion of formerly differentiated parts into a more global organization. Regarding the second law - hierarchic integration - the most advanced systems functionally subordinate and regulate less developed systems. Essentially this means that none of the less developed systems are lost. Instead, their organization becomes controlled by more highly developed systems. Again we find the converse in cases of regression where the integrated whole which was formerly co-ordinated by a more developed system becomes regulated by a less developed system.

In a theory which complements Werner's, Piaget has developed a probabilistic model of stage transformation. He suggests that the equilibration process governs stage transformation. For short-term local development, the child's scheme is equilibrated when the functional forms of action (accommodation and assimilation) are equilibrated. Local disequilibrium occurs whenever assimilation or accommodation dominates the child's actions. When this occurs, the other function is likely to be brought into play, and a return to, equilibrium at a higher level is the probable result. At each successive level of organization the organism is better adapted to its environment until it reaches the final, most adapted state.

The stages of development can be briefly characterized as follows:

Preoperational Thought

Sensorimotor Stage (0 - to about 1-1/2 years)

Thought is not representational and is limited to the field of the child's actions. At this prelinguistic stage, intelligence is bound by immediate reality; e.g., absent objects cannot be mentally evoked.

Preconceptual Stage (about 1-1/2 to 4 years)

This stage begins with the onset of language. Thought becomes representational and reality becomes closely tied to language. Consequently, intelligence is no longer completely bound to immediate reality. Thought is egocentric in that the child is unable to view a problem from any perspective other than his own. The first, rudimentary forms of reasoning emerge. Although the idea of a permanent object has been formed, thought is still not conceptual.

Intuitive Stage(about 4 to 7 years)

Conceptualization begins at this stage. Thought is still prelogical in the sense that logical mental operations are not functional and are incomplete. The child is still perception-bound as is evidenced by the children's focusing their attention upon the static end state of transformations. The coordination of relations is impossible at this stage.

Operational Thought

Concrete Operations Stage (about 7 to 11 or 12 years)

Mental operations become functional. The emergence and coordination of operations and relations enable the children to conserve quantity, weight, volume, etc. Thought, however, is still tied to the concrete situation. If the same problems are presented in verbal form rather than with the objects, these same children are usually incapable of solving the problems.

Formal Operations Stage (from about 11 or 12)

In this stage one can reflect or operate upon the operations which emerged in the previous stage. Reasoning unrelated to reality can now take place; e.g., in abstract mathematics. Here one can begin with premises which are hypothetical and may have no empirical validity. From these hypotheses, deduction of conclusions can take place.

Cognitive Transformation-Equilibration

The equilibration process can be described as comprising four phases. Each of these phases has no clear line distinguishing it from the others. Yet, for the sake of expository simplicity, we shall regard them as being distinct.

The first phase can be most adequately described as intellectual stage virtuosity. As mentioned earlier, intelligence is a mechanism whose purpose is to maintain an equilibrium between the human being and his environment. Although the child is limited by the cognitive structure he possesses at any level of intellectual development, he can still become a virtuoso at that level. That is, between the time the child acquires cognitive structure X and the time that structure is transformed to Y, the child becomes able to accurately predict and account for events in his environment.

Virtuosity, in turn, prepares the intellectual system for the second phase of structural transformation - perturbations. As suggested previously, a child's actions upon his environment feeds back to his mental structure. There are three main types of feedback. First, if the incoming information "fits" the existing structure we may assume that there will be no perturbation of the system. Second if the incoming information is "too far above" the structure, we may assume again that the system will not be perturbed.

Third, if the assimilated environmental information "partially fits" the existing structure, we may assume that the system has been perturbed. Recent experiments by Schwartz and Langer from Berkeley and Turiel from Harvard have demonstrated this point. It should be noted that if the child was not a virtuoso, he could not accurately predict events in his environment and, consequently, what would be perturbations might be seen as "noise" extraneous to the system and discarded.

If the perturbation is both organizational and affective, we can predict that the child will be in a state of disequilibrium.- the third phase of stage transformation. Organizational or structural disequilibrium has just been described. This should result in a conscious or unconscious "uneasiness" with the partial fit which, in turn, should energize activity towards the creation of a system of rules which could account for the perturbation. "Necessity is the mother of creation" is an apt expression which describes this relationship between the affective and organizational parameters of development.

As you know, a major principle in science suggests that a system in a state of disequilibrium tends to readjust itself so that a new state of equilibrium is re-established. In the case of intellectual development, the re-established equilibrium is qualitatively different than the previous equilibrium state and it is at a higher level since, among other things, the new system can potentially account for events which the previous system could not; e.g., perturbing events. The new system is potential without actualization; i.e., the child is not a virtuoso at this newly acquired level. As you can see, this leads us back to the first phase of the model of equilibrium.

A final point of interest related to this discussion concerns the relationships between learning and development. We have described intellectual development as a progressive series of more adapted structural transformations. The mental structures' potentials set the limits of logical reasoning. The actualization of the potential or, in other words, the gradual attainment of virtuosity within the structure is what we can refer to as learning. Thus, in this view, learning is subordinated to development.

Unfortunately, the theory is considerably beyond the art of the experiment. For example, at this point we are not certain how we can detect and measure levels of virtuosity, nor can we consistently create conditions which are perturbations to existing mental structures. Often we must rely upon analogies from other disciplines; e.g., T.S. Kuhn's analysis of the history of scientific concepts.

SCIENCE CURRICULUM IMPROVEMENT STUDY

DR. H. D. THIER - Assistant Director, SCIS

The Science Curriculum Improvement Study is developing ungraded, sequential physical and life science programs for the elementary school -programs which in essence turn the classroom into a laboratory. Each unit of these programs is carefully evaluated by SCIS staff as it progresses from early exploratory stages to the published edition. The units originate as scientists' ideas for investigations that might challenge children and that illustrate key scientific concepts. The ideas are then adapted to fit the elementary school and the resulting units are used by teachers in regular classrooms. Thus they are tested several times in elementary schools before they are published.

Central to these elementary school programs are current ideas of intellectual development. A child's elementary school years are a period of transition as he continues the exploration of the world he began in infancy, builds the abstractions with which he interprets that world, and develops confidence in his own ideas. Extensive laboratory experiences at this time will enable him to relate scientific concepts to the real world in a meaningful way. As he matures, the continual interplay of interpretations and observations will frequently compel him to revise his ideas about his environment.

The teaching strategy is for the children to explore selected science materials. They are encouraged to investigate, to discuss what they observe and to ask questions. The SCIS teacher has two functions: to be an observer who listens to the children and notices how well they are progressing in their investigations, and to be a guide who leads the children to see the relationship of their findings to the key concepts of science.

Children are introduced to knowledge of scientific content through their experiences with diverse physical and biological materials. And, in the course of their investigations, they engage in observation, measurement, interpretation, prediction, and other processes.

Interaction. Central to modern science, and therefore also to the SCIS program, is the view that changes take place because objects interact in reproducible ways under similar conditions. Changes do not occur because they are pre-ordained or because a "spirit" or other power within objects influences them capriciously. By interaction we refer to the relation among objects or organisms that do something to one another thereby bringing about a change. For instance, when a magnet picks up a steel pin, we say that the magnet and the pin interact. The observed change itself, the pin jumping toward the magnet, is evidence of interaction. Children can easily observe and use such evidence. As they advance from a dependence on concrete experiences to the ability to think abstractly, children identify the conditions under which interaction occurs and predict its outcome.

Major scientific concepts. The four major scientific concepts we use to elaborate the interaction viewpoint are matter, energy, organism, and ecosystem. Children's experiences and investigations in the physical science sequence are based on the first two; the last two provide the framework of the life science sequence. Additional concepts are described in the appropriate teachers' guides for the individual units in the program.

Matter, perceived as the solid objects, liquids, and gases in the environment, is tangible. It interacts with human sense organs, and pieces of matter interact with each other. Material objects may be described and recognized by their color, shape, weight, texture, and other properties. As children investigate changes in objects during their work in the SCIS physical science program, they become aware of the diversity of interacting objects and of their properties.

The second major concept is energy, the inherent ability of an animal, a flashlight battery, or other system, to bring about changes in the state of its surroundings or in itself. Some familiar sources of energy are the burning gas used to heat a kettle of water, the unwinding spring that operates a watch, and the discharging battery in a pocket radio. The counterpart of an energy source is an energy receiver, and a very important natural process is the interaction between source and receiver that results in energy transfer.

The third concept is that of a living organism. An organism is an entire living individual, plant or animal. It is composed of matter and can use the energy imparted by its food to build its body and be active. The organism concept therefore represents a fusion of the matter and energy concepts, but it is also broader than these, so we identify and describe it separately.

As children observe living plants and animals in the classroom or outdoors, they become aware of the amazing diversity of organisms and their life cycles. They observe how plants and animals interact with one another and with the soil, atmosphere, and sun in the vast network of relations that constitute life. The focus of the SCIS life science program is the organism-environment relationship.

The study of life focused on organism-environment interaction leads to the ecosystem concept. Thinking about a forest may help you understand the ecosystem. A forest is an assemblage of trees, of course, but it is more than that. Living in the shade of the trees are shrubs, vines, herbs, ferns, mosses and toadstools. In addition the forest swarms with insects, birds, mammals, reptiles and amphibians. A forest is all of these plants and animals living together. The animals depend on the plants for food and living conditions. The plants use sunlight, carbon dioxide, water, and minerals to make food to sustain themselves and other organisms in the forest. The complex interrelations among plants, animals, sun, air, water and soil constitutes an ecosystem.

Process-oriented concepts. In addition to the scientific concepts described above, four process-oriented concepts are also extremely important. They are property, reference frame, system and model. These concepts together with others that relate to specific units, are at the heart of the processes of observing, describing, comparing, classifying, measuring, interpreting evidence, and experimenting.

We have already referred to the properties by which an object may be described or recognized. A property is any quality that enables you to compare objects. Properties also enable you to compare concepts. For example, place value is a property of digits in the decimal number system, the climate (hot, cold, temperate) of a region summarizes the properties of the weather there, and the ability to produce food is a property of green plants.

Every description and comparison of natural or social phenomena reflects the observor's point of view or frame of reference. For the young child, who relates objects to himself rather than to one another, the discovery of other frames of reference is a source of excitement and challenge,

In science, where the position (location) and motion of objects are important subjects of study, the reference frame idea has been developed into the awesome relativity theory. Yet the basic concept, as included in the SCIS program, is simple: the position and motion of objects can be perceived, described, and recognized only with reference to other objects. When you say, "The car is at the south end of the parking lot," you describe the location of the car relative to the parking lot. In this example, the parking lot and compass directions serve as a reference frame. However, when you say, "The car is to your left," the listener's body serves as a reference frame. A child who considers several reference frames thereby overcomes the egocentric viewpoint of most elementary school children.

The third process-oriented concept is that of a system, which

SCIS defines as a group of related objects that make up a whole. It may include the battery and circuits that make up an operating pocket radio, or it may consist of a seed and the moist soil in which it was planted. The system concept stems from the realization that objects or organisms do not function in isolation, but exist in a context while interacting with other objects or organisms. A subsystem is part of another system. Thus, moist soil is itself a system comprised of clay, sand, water, and decayed matter, It is at the same time a subsystem of the seed-moist soil system. The seed, with its coat, embryo, and stored food is another subsystem.

Sometimes it is hard to decide what to include when defining a system: does the soil-seed system include the air that permeates the soil? Ordinarily children would not include air since moisture is usually the most important factor in germination. However, if a child were to deprive the soil-seed system of air, the result would make him aware of its importance to plant growth.

A system becomes a new system whenever matter is added to or removed from it. When nothing is added or removed a system retains its identity, even though it may change in form or appearance. When selecting a system, children focus their attention, organize their observations, and relate the whole system to its parts (objects or subsystems). In addition, they become skilful in tracing a system through a sequence of changes.

The fourth process-oriented concept, the scientific model, may be illustrated by the example of an automatic vending machine that dispenses candy. You insert a dime into a slot, push one of several buttons, and out falls a particular candy bar. You could imagine that the dime unlocks the buttons and that the button pushes your candy off its shelf and down the chute. Such an imagined system would be a model. A scientific model is a mental image of a real system to which you assign certain parts or properties that you can not see directly. The successful model provides a possible explanation of how the system functions, but it may not give an accurate description of what really happens in the system. Usually the model is simpler than the real system it represents.

Scientific models permit children to relate their present observations to their previous experiences with similar systems. Models satisfy the children's need for thinking in concrete terms. Models also lead to predictions and new discoveries about the system being investigated. You may, for instance, make predictions and test your candy-machine model by pushing a different button, or by pushing two buttons at once.

Physical science sequence. The unity of the SCIS physical science sequence comes from the fundamental concepts of change and interaction. The six basic units, Material Objects, Interaction, Systems and Variables, Relativity of Position and Motion, Energy Sources, and Models for Electric and Magnetic Interaction, introduce and develop the scientific and process-oriented concepts necessary for scientific literacy. The investigations conducted by the children are sampled broadly from the rich and challenging diversity of physical and chemical phenomena.

Life science sequence. The units in the life science sequence pay continuing attention to organism-environment interactions. The six basic units, Organisms, Life Cycles, Populations, Environments, Communities and Ecosystems, make use of the scientific and process-oriented concepts, but add the special considerations appropriate to the study of life. The Ecosystems unit achieves a synthesis of the children's investigations in physical and life science.

Optional units. The entire SCIS program is not a neatly wrapped package, but rather a beginning, a foundation for explorations of many fascinating happenings. Optional units are being planned to extend the basic sequences in physical and life science.

The description of the SCIS program given above is adapted from various publications of the Study. Further information is available from SCIS, Lawrence Hall of Science, University of California, Berkeley, 94720. The Science Curriculum Improvement Study is supported by a grant from the National Science Foundation.

APPENDIX A

Department of Education
BUREAU OF PUBLIC SCHOOLS
Manila

ELEMENTARY SCIENCE CURRICULUM
DEVELOPMENT STUDY
(BPS-PC/Philippines Joint Project)

Grade III	Grade IV	Grade V	Grade VI
Suggestive Scope and Sequence Guide		Topic: Living Things	
PROCESSES: Observation Description Classification	Measurement	Inference Hypothesis Graphing	Prediction Controlling Variables Experimentation
CONTENT: Part I			
A. Characteristics of Living Things 1. Differences and similarities of living and non-living things 2. Differences and similarities of living things - plants, animals, man	A. The Rice Plant 1. Germination and growth of rice seeds a. Characteristics of rice seeds b. Factors affecting germination of rice seeds	A. Plants and Their Environment 1. How plants live a. Absorption of water in plants through the process of osmosis and capillarity b. Transpiration in plants c. Respiration in plants	Interdependence of Living Things A. The Web of Life 1. Communities a. Structure of community b. Food relationships c. Balance of nature
B. Needs and Care of Living Things 1. Plants - air, sunlight, food, water (favorable environment) 2. Animals, air, food, water (favorable environment)	2. Parts of plants and their characteristics a. Stems (covering, nodes and internodes, size, texture, etc.) b. Roots(fibrous or tap) c. Leaves(size, shape, veination, color, texture) d. Flowers, fruits and seeds	2. Adaptations of plants a. Structure and leaf arrangement as factors of the adaptations of plants b. Defense mechanisms in plants 3. Plant pests and diseases a. Common plant pests and diseases and their characteristics b. Ways of controlling plant pests and diseases	2. Survival and community growth a. Plant reproducing b. Animal reproduction B. Man's Interference in Nature to Improve His Environment 1. How man overcomes the influence of microorganisms 2. Control of his food supply a. Better plant production (1) Enrichment of soil
C. Life Processes 1. Reaction to stimuli 2. Movement 3. Growth 4. Reproduction	3. Functions of different parts a. Food making		

b. Food getting
c. Food storage
d. Food transportation

e. Reproduction

Supplementary Unit: The Corn Plant
1. Germination and Growth of corn seeds
2. Parts of plants and their characteristics
3. Functions of different parts

B. Animal Growth and Development
Life Cycles of:
The Mosquito
The Butterfly
The Cockroach
The Frog
The Chick
1. Stages in the development
2. Relationships between structure and function of animals
3. Adaptation to environment

C. How Man Fi·ds Out His World
1. Sense Organs
a. Functions of individual sense organs

B. Animal Adaptation to Environment
1. Animal environment
a. Adaptation of animals
b. Habitat of animals
2. Food-getting adaptation
a. Type
b. Locale of food
3. Protective and defense mechanisms
a. Coloration and mimicry
b. Food-getting adaptation
c. Locomotion
d. Estivation(and hibernation)

C. How Man Uses His Food
1. Food
a. Food tests

2. Digestion
a. Mechanical breakdown of food
b. Effects of digestive juices on food
c. Movement of foods through the digestive tract
d. Use of oxygen in the digestion of food
3. Absorption and distribution of digested foods
a. Passage of foods

(2) Artificial propagation(reactions for)
(3) Conservation

b. Better animal production
(1) Selective breeding
(2) Improved diet

	b. Coordination 2. Nervous system a. Parts of the nervous system b. Relation of the brain to the senses c. Reflex actions d. Comparison of animals' abilities to solve problems 3. Skeletal system a. Structure and function b. Coordination of muscular and skeletal system in producing movement	through the intestinal wall b. The blood as wastes c. The heart 4. Elimination of wastes a. Kinds of waste materials b. Passage of waste materials out of the body	

Topic: Matter, Energy and Motion			
PROCESSES: Observation Description Classification	Measurement	Inference Hypothesis Graphing	Prediction Controlling Variables Experimentation
CONTENT: Part II A. Things (Matter) 1. Shape, size, color, texture and weight of things 2. Forms of matter	A. Matter 1. Properties of matter a. Has weight b. Occupies space 2. Physical changes	A. Electrical Energy 1. Circuits 2. Parallel and series connections 3. Reversing current	A. Waves produced by a fork B. Thermal expansion

B. Things Move 1. Why things move 2. How things move C. Some Forms of Energy 1. Heat 2. Magnetism 3. Electricity	a. In size and shape b. In form 3. Matter defined B. Matter-Energy Relationships 1. Mechanical energy a. Motion and force b. Work c. Simple machines 2. Heat energy a. Production of heat b. Effects on heat on matter c. How heat travels d. Uses of heat 3. Magnetism and electricity a. Magnetic and non-magnetic materials b. Magnetic lines of force c. Attraction and repulsion between poles d. Electric circuits e. Conductors and insulators f. Electromagnets	B. Chemical Energy 1. Evidence of chemical change 2. Heat in chemical changes 3. Types of chemical changes 4. Changing to other forms C. Structure of Matter D. Motion and Force 1. Speed 2. Acceleration 3. Gravity 4. Friction 5. Inertia 6. Momentum 7. Action-reaction 8. Centripetal force and centrifugal reaction	C. Refraction in different liquids D. Mass and Acceleration E. Balanced and unbalanced forces

Topic: Earth and Space			
PROCESSES: Observation Description Classification CONTENT: Part III A. Surface Features of the Earth Around Us 1. Types of land forms in the local area 2. Rocks and soil a. Types of rocks according to physical characteristics b. Types of soil according to composition 3. Water forms a. Types b. Direction of flow 4. Air and its characteristics 5 Water cycle 6. Simple weather instruments B. Space 1. Heavenly bodies 2. The motion of the earth and the moon	Measurement A. Weather 1. Variables 2. Measurement of the weather B. Rocks 1. Physical properties 2. Classification C. Weathering 1. Action of growing plants 2. Action of animals 3. Changes in temperature 4. Action of water D. Soils 1. Formation of soils 2. Physical properties 3. Types of soils E. Erosion 1. Wind erosion 2. Water erosion 3. Factors affecting rate of erosion	Inference Hypothesis Graphing A. Surface Features of the Earth's Crust 1. Land masses 2. Water masses Optional Topic: Theories on the Movements of the Earth's Crust B Internal Forces that Shape the Different Land Features 1. Folding 2. Faulting 3. Volcanic action C. Rocks and Minerals 1. Formation 2. Composition D. Effects of Heavenly Bodies on the Earth's Surface 1. Tides 2. Winds and ocean currents 3. Climate 4. Season 5. Monsoons	Prediction Controlling Variables Experimentation Our Earth in the Universe A. Our Solar System 1. Planets a. Distance of planets from the sun (1) Temperature (2) Revolution b. Rotation and size c. Orbits 2. Shooting stars and comets B. Stars and Constellations 1. Stars a. Vast numbers of stars b. Distance (1) Brightness (2) Size (3) Temperature-color relationship 2. Constellations a. Names b. Positions c. Movement d. Ways of observing

	4. Prevention of erosion F. The Earth and the Moon 1. Surface of the moon 2. Movements and phases of the moon		C. Galaxies and the Universe (Optional) 1. Milky Way Galaxies a. Members b. Shape c. Size d. Movement 2. Other galaxies a. Shapes b. Movement c. Relationships in universe D. Origin of the Solar System (Optional) 1. Theory 2. Structure

APPENDIX B

SCIENCE EDUCATION CENTER, UNIVERSITY OF THE PHILIPPINES, QUEZON CITY - PHILIPPINES

ELEMENTARY SCHOOL SCIENCE I

I. Things Around Us

A. Properties of common objects (non-living)
B. Similarities and differences among objects

II. Living and Non-living things

A. Grouping things
B. Differences between living and non-living things

III. Plants and Animals

A. Differentiating plants from animals

IV. Diversity in Plants and Animals

A. Diversity among plants
B. Diversity among animals

V. Relationships Between Plants and Animals

A. Plants and animals as food
B. Other types of animals dependence on plants and other animals

VI. Relationships Between Organisms and Physical Environment

A. Plants and physical environment
B. Animals and physical environment
C. Man and physical environment

VII. Solids, Liquids and Gases

A. Grouping objects
B. Common properties of solids and liquids
C. Gases

VIII. The Earth We Live In

A. Land - the solid portion of the earth
B. Soil and rocks
C. Water - the liquid portion of the earth
D. Air - the gaseous portion of the earth

IX. Things Up in the Sky

A. Looking up
B. Motion
C. Measurements of lengths and distances
D. Motion of things in the sky

X. Day and Night

A. Daytime and night-time
B. Time and temperature and the apparent movement of the sun

ELEMENTARY SCHOOL SCIENCE II

I. Forces

A. The Meaning of force
B. Forces applied by the earth - "earth pull"
C. Using spring to measure force
D. Using the equal arm balance
E. Measuring the earth pulls (or heaviness) of liquids

II. Similarities in Plants and Animals

A. Similarities and differences in plants
B. Variations in plants of the same kind
C. Similarities and differences in animals

III. Changes in Plants and Animals During Growth

A. Changes in plants as they grow
B. Changes in various animals as they get older

IV. Our Senses and our Surroundings

A. Our senses and sense organs
B. Sight
C. Taste
D. Perception of odors (smell)

V. Sound

A. Production of sound
B. Transmission of sound
C. Characteristics of sound

VI. Light and Temperature

A. Sources of light and their characteristics
B. Measurement of temperature
C. Light as related to heat

VII. Water Cycle

A. Evaporation of water
B. Condensation

ELEMENTARY SCHOOL SCIENCE III

I. Constant Speed

A. Measurement of speed

II. Volume and its Measurement

A. Measurement of volumes of solids
B. Measurement of volumes of liquids
C. Calculating volumes of solids and containers

III. Reactions of Plants and Animals to Changes in the Environment

A. Reactions of plants to changes in the environment
B. Reactions of animals to changes in the environment

IV. Communities

A. Plant and animal interactions in communities
B. Physical factors affecting communities

C. Conserving plant and animal life in a community

V. Erosion and Deposition

A. Erosion - the effects of moving water
B. Deposition

VI. Light

A. Light and seeing
B. Reflection of light

VII. Shape of the Earth

A. Understanding shadows
B. The Earth is like a ball

VIII. Motion of Heavenly Bodies

A. The stars
B. The moon

ELEMENTARY SCHOOL SCIENCE IV

I. Plants as Primary Producers

A. What is food ?
B. Starch as food produced by plants
C. Raw materials for starch production
D. Storage and use of starch by plants

II. Animals as Consumers

A. Food-getting
B. Digestion of food
C. What happens to digested and undigested food

III. Exchange of Gases Among Plants and Animals

A. How plants use and produce gases
B. Respiration in animals
C. Interdependence of plants and animals
D. Transpiration in plants

IV. Heat and Temperature

A. Heat exchange in some solids and liquids
B. Heat vs. temperature

V. Effects of Heat

A. Effects of heat on liquids
B. Effects of heat on solids
C. Effects of heat on gases

VI. Sources of Heat

A. The sun
B. Man-made sources of heat
C. The interior of the earth

VII. Sound

A. Production of sound
B. Characteristics of sound
C. Transmission of sound

ELEMENTARY SCHOOL SCIENCE V

I. Changes in Motion

A. Motion ca·· change in speed and direction
B. Circular and vibratory motions
C. All changes in motion caused by forces
D. Effects of no force on a body
E. Effect of two or more forces applied to an object

Depends on: direction, magnitude, and point of application

F. Force required to stop or start motion of an object depends on its heaviness and speed and also on the time in which the change occurs

II. Energy

A. What is energy?
B. What kind of things can produce motion
C. Things that can produce motion cannot continue to do so without an input of energy

III. Do Living Things Come from Living Things?

A. Where do living things come from?
B. Implications to health of the habits of houseflies

IV. Animals Reproduce and Increase in Number

A. Reproductive behavior of some animals
B. How some animals are born
C. Other ways of reproduction

V. Grouping Animals

A. Based on morphological characteristics

VI. Plants Reproduce and Increase in Number

A. Observing the growth of new plants
B. Observing how plants are propagated by pollination
C. Observing other ways of reproduction

VII. Grouping Plants

A. Based on reproductive structure

VIII. Seasons

A. Angle of sun at different times of the year
B. Variation in places where the sun rises and sets

IX. Seasons and Abundance of Plants and Animals

A. Differences in the time of flowering and fruiting of certain plants
B. Differences in the time of breeding, spawning of certain animals

ELEMENTARY SCHOOL SCIENCE VI

I. Growth of a Population

A. A plant population
B. Water flea population
C. The fruit fly population

II. Relating the Dynamics of Population Growth to the Human Population

A. Analyzing population growth of the Philippines
B. Comparing regions of the earth in population growth rates
C. Factors affecting population growth rates
D. Predicting trends and accounting for differences
E. Mechanisms for keeping population growth rates low

III. The Human Organism and Disease

A. Analyzing health statistics of the Philippines
B. The development of the germ theory
C. Body defenses
D. Pollution

IV. Ecology of a Rice Paddy

A. Analyzing data on food and population in the Philippines
B. Identifying living forms in a flooded rice paddy
C. Influence of factors on production

V. Bending of Light

A. Tracing the path of beams of light incident on some reflecting surfaces
B. Is the direction of light changed when it passes from one medium through another?

VI. Mixing Substances

A. What happens when some solids are placed in liquids
B. What happens when some liquids are poured into other liquids
C. Chemical changes produced by mixing materials

VII. Electricity

A. What is an electrical circuit?
B. Producing electricity
C. Electromagnetism