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BASIC SCIENCE EDUCATION

IN

SUB-SAHARAN AFRICA

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I

INTRODUCTION

The A.I.D. Policy Paper on Basic Education and Technical Training (1982) stresses an education policy goal of improving the quality, cost-effectiveness, and distribution of basic primary education and work-related skills training in the less developed countries. Major objectives for future work in the education sector include increasing the number of children completing the first levels of schooling, assisting countries in improving the efficiency of their educational systems while moderating recurrent costs, and helping educational systems to relate more effectively to employment opportunities, so as to ensure that most adolescents and adults can acquire productive skills.

The Education and Human Resources Office of A.I.D./ Washington's Science and Technology Bureau has undertaken several primary school education projects in recent years with the intent of expanding access and improving the quality and effectiveness of primary school instruction. A radio mathematics program was produced first in Nicaragua and a language arts project is currently underway in Kenya. In order to develop a complete curriculum package, the Science and Technology Bureau is now considering programming

in the area of primary school science, with a probable focus in Africa. This study has been undertaken to assist with the planning of such an effort.

Because any effort to improve the quality of education must address the question, "What kind of education?" an effort will first be made to clarify the reasons for including science in the primary school curriculum and to discuss its special relevance for children in the less developed countries. The history of past efforts to improve basic science education in Africa will then be traced. Status reports of the current situations in Sierra Leone and Botswana will be presented, based on the writer's visits to these two countries in October, 1982. The final sections of the paper will discuss options for future USAID programming in the area of basic science education.

II.

THE RATIONALE FOR INCLUDING SCIENCE IN BASIC PRIMARY EDUCATION*

Science has traditionally been included in the primary school curricula of less developed countries because it is "modern", because it is a subject taught at the secondary school level, or because the teaching of science is associated with desirable technological development. However, the type of primary school science instruction that has been provided in many of the less developed countries has been of questionable efficacy. Rais Ahmed, former Director of the National Council of Educational Research and Training (NCERT) of India described this problem at a 1977 UNESCO conference on science education:

> The conventional meaning and scope of science in our curricula has been just as narrow as the meaning of education itself. If education has been equated to teaching for building up a stock of knowledge, science has been equated to the

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* In this paper, "basic primary education" will refer to schooling for children aged 6-14, as defined in the A.I. D. Education Sector Policy Paper (1982).

> learning of some basic laws of physics, chemistry, and biology,... completely ignoring the method of science. ...In the developing countries in particular, the traditional teaching of science degenerates into authoritative pronouncements in a bewildering variety of physical, chemical and biological descriptions (UNESCO/Bangkok, 1977, p. 186).

Such an approach to the teaching of science in primary school is not only a waste of time and educational resources; it can also have quite undesirable effects on children in less developed countries. First, it casts science as a collection of obscure facts that teachers and children alike find difficult to relate to their own experience. Second, such an approach often emphasizes abstract theories that are inappropriate to the primary school child's concrete stage of cognitive development. The chief outcome of such science instruction is often a dislike and, at worst, a fear of science.

Fortunately, this situation is changing as a result of the extensive curriculum development work that has been undertaken during the past twenty years in the area of primary school science. In sub-Saharan Africa, most of this work has been done by the A.I.D.-sponsored African Primary

Science Program and its successor, the Science Education Programme for Africa. One result of this activity has been the development of goals and objectives for primary science instruction that are much more appropriate to the needs and capabilities of primary school children. The International Council of Scientific Unions'(ICSU) Committee on the Teaching of Science has summarized these new goals for basic science instruction in a paper prepared for the UN Conference on Science and Technology for Development:

> At both the primary and secondary stages, the science teaching should be such that it encourages the student to think for himself. In many parts of the world it is now accepted that encouraging a student to rely on his own reasoning powers, to help him to appreciate how to devise his own experiments to find solutions to problems which are real to him, is substantially more important than learning formal definitions or memorizing pages of a textbook about Newton's laws of motion or the energy levels in a hydrogen atom. ...The need is for self-reliance. This self-reliance does not come through the rote memory of factual knowledge, but through experiencing what it is to be a scientist-for-the-day. (ICSU, 1978)

Cognitive Objective for the Teaching of Primary School Science

An increased understanding of the specific cognitive objectives that are appropriate for the various levels of primary science instruction has been obtained through the application and extension of Jean Piaget's research on the cognitive functioning of children. This research indicates that the following basic mental skills can be taught effectively in a primary school science curriculum throughout the early and middle primary years (Trojack, 1979):

- Observing
- Measuring
- Distinguishing spatial and temporal relationships
- Classifying
- Communicating observations

In the upper primary grades, beginning about age eleven, more complex logical thinking skills can be taught, such as:

- Organizing and interpreting data
- Controlling variables and distinguishing random variables from those that are manipulated
- Constructing rational arguments involving sequential logic

- Making inferences from observations on the basis of relationships that have been established
- Predicting future observations on the basis of relationships that have been established
- Formulating hypotheses involving observed relationships

The mental skills and processes listed above are needed for the rational handling of many types of problems, and their use is not restricted to science. However, the teaching of science offers a unique opportunity to focus on the development of logical thinking as a primary objective.

Affective Objectives Relevant to Primary Science Instruction

The teaching of science at the primary school level also offers an opportunity to develop positive attitudes that will predispose children to utilize scientific approaches to problem-solving more frequently in their daily lives. The Educational Policies Commission (1966) defined these affective objectives as follows:

- Longing to know and to understand
- Questioning of all things
- Searching for data and their meaning
- Demanding verification
- Respecting logic

- Considering premises
- Considering consequences

Again, these attitudes and values are relevant to the entire educational enterprise, and are not applicable only to science. However, other priorities in the teaching of subjects such as mathematics and language arts frequently have an adverse effect on the inculcation of these values. Science instruction offers a unique opportunity to focus on the development of these attitudes at a time when children are in the process of formulating a personal world-view.

The Selection of Specific Science Topics for Primary School Science

The teaching of science in primary schools has never become as prescriptive with respect to content as the teaching of language arts and mathematics. The extensive curriculum development work in primary school science that has taken place during the past twenty years in the United States, Great Britian, Australia, and the less developed countries has not resulted in the promulgation of any formal recommendation prescribing the specific scientific facts or concepts that should be presented to children at each grade level. However, the selection of the specific skills and attitudes can only be developed within the context of investigating a specific scientific problem, and some topics are more appropriate for investigation by children than others.

It is also important that children learn some specific scientific facts and concepts in preparation for adult life, such as principles of nutrition, the bacterial transmission of disease, and some basic information about the human body. (These topics are frequently taught separately as a part of a health syllabus in many developing countries.) In addition, there is a growing realization of the need to relate science instruction to the local environment and to address some specific societal issues; such as population growth, food production, and the conservation of natural resources. (ICSU, 1978).

In the report of the 1967 Mombasa Conference of African Educators, E. A. Yoloye commented on the importance of relating primary school science instruction to the needs of society:

> With this aim (a problem-solving approach) in mind, great care should be exercised in the selection of topics for inclusion in the science curriculum. Work on germination or the nature of soils would be relevant topics; because malaria and malnutrition are big health hazards in African countries, a study of mosquitoes and nutrition appears relevant. Given the basic hypothesis that a child is potentially capable of working with any topic, concern for the need of society should guide the

selection of topics. More important, however, is the development in the child of the realization that he can manipulate and control his environment; that he need not be the helpless victim of a changing society, but can become an innovator, capable of changing society. (EDC/CREDU,1967)

In summary, the consensus that has emerged from the past twenty years of science curriculum development work is that major emphases need to be placed on providing opportunities for developing problem-solving skills, investigating the local environment, and addressing specific societal problems. This has resulted in a move by science educators toward the teaching of "integrated science" at the primary and junior secondary school levels, and a move away from the previous practice of watering down the discipline-oriented secondary school science syllabus for use at the primary school level.

III

A REVIEW OF DEVELOPMENTS IN PRIMARY SCHOOL SCIENCE EDUCATION IN AFRICA

The Teaching of Science in African Primary Schools Prior to 1960

The chief objectives of science education in the primary schools and teacher training colleges of most African countries prior to independence have been described by Yoloye and Bajah (1981) as "the development of clean and healthy habits, and an understanding of nature (plants and animals) and some elementary facts of science." The teaching approach traditionally used was the dogmatic method, described in the report of the recent Harare Conference of Ministers of Education as "a method which is based on the authority of the teacher and the memory of the pupils." (UNESCO, 1982).

In some parts of Africa, especially West Africa, there was also an effort to introduce some simple principles and techniques of farming into the primary school science syllabus. Advocates of this approach endorsed the idea of having students do the practical work involved in planting, cultivating, and harvesting a school farm. However, in many countries the rural science movement became unpopular with children and their parents, due to the widespread practice of

assigning work on the school farm as a punishment for misbehavior in school.

At the secondary school level, science instruction was generally organized according to the traditional disciplines of biology, chemistry, and physics and was designed to prepare students for external examinations such as the Cambridge Overseas Certificate. Although not all students took science, it was generally agreed that some knowledge of science was important for certain kinds of middle-level government jobs in departments of public works, agriculture, land survey, etc.

At both the primary and secondary levels, science instruction was of a factual and theoretical, rather than a practical, nature. If any practical applications of science were included, they were usually based on an environment totally different from that with which the students were familiar.

Developments in Primary Science Education During the 1960s

The national independence movement in sub-Saharan Africa began with Ghana in 1957 and continued through the first half of the next decade; the last anglophone countries to receive independence were Lesotho, Botswana, and Swaziland in 1966. The most pressing concerns of the newly independent African nations were to establish national

identities and to modernize. Both of these concerns had implications for science education.

The drive to define national identities caused the leaders of the newly independent African nations to question the relevance of the educational systems inherited from the former colonial powers. In many countries, special attention was paid to scientific and technological education because many of the new leaders saw technological progress and industrialization as avenues to modernization.

This spirit of advocacy for educational change was evident in the final report of the 1961 Conference of Ministers of Education in Africa, held in Addis Ababa under the auspices of UNESCO:

> The present content of education in Africa is not in line with existing African conditions . . . but is based on a non-African background allowing no room for the African child's intelligence, powers of observation, and creative imagination to develop freely and help him find his bearing in the world. . . African educational authorities should revise and reform the content of education in the areas of the curricula, textbooks, and methods, so as to take into account the African environment, child development, cultural heritage, and the

demands of technological progress and economic development, especially industrialization (UNESCO, 1961).

The Ministers of Education at the Addis Ababa conference set 1980 as the target year for universal primary education on the African continent and mandated that all children would receive an education that was meaningful to them and relevant to their environment. As a result, objectives of a new kind began to appear in the curricula of many African countries. These objectives stressed that education at all levels should:

- Develop the spirit of inquiry
- Teach problem-solving using the scientific techniques of observation, experimentation, analysis, etc.
- Impart scientific literacy
- Transform the environment
- Make citizens better consumers of the science
- Contribute to the country's development (Yoloye & Bajah, 1981)

Although the goal of universal primary education was not met by 1980, and although objectives like those above proved much easier to espouse than to implement in the schools, the recommendations of the Addis Ababa Conference

did provide a favorable climate for the developments in African primary science education which took place in the following two decades.

The Formation of the African Primary Science Program

In July, 1960, the first International Conference on Science in the Advancement of New States was held in Rehovoth, Israel, sponsored by the Hebrew University of Jerusalem and the Weizmann Institute of Science. This conference brought together a number of the world's leading scientists with government officials and educators from developing countries. Two of the scholars attending this conference were the Reverend Solomon Caulker, an African who was Vice-Principal of Fourah Bay College in Sierra Leone, and Jerrold Zacharias, a physics professor at the Massachusetts Institute of Technology who was also chairman of the National Science Foundation's Physical Science Study Committee (PSSC). During the conference, there were many discussions involving high technology issues such as the provision of nuclear reactors for the less-developed nations. Caulker challenged this idea, and suggested that the conference should instead focus on a different problem:

> The problem in which you can help us is in moving from where we are to the next stage of development, economic and social. This involves the problem ... of the teaching of science. One of the

> most difficult problems of the African people ... is to even understand that there is any relationship physically between cause and effect. This is a primary problem: whether typhoid is caused by drinking dirty water or whether it is caused by someone who has bewitched you; whether your babies are dying because you are not feeding them properly, or whether they die because someone who hates you has put sickness on them. ... The problem is far more primary than many of you would realize. It is a problem, first of all, of attacking a people's world view, ... and changing their point of view.... I believe firmly that this basic need can only be met by a knowledge of science used in a very broad sense (Zacharias, 1966).

Caulker died in a plane crash in Dakar on his way home from the Rehovoth conference, but his remarks about African science education inspired Zacharias to obtain funding from the Ford Foundation and the International Cooperation Administration to convene a study conference on African Education at Endicott House in Dedham, Massachusetts during the following summer. Among the participants at this conference were fifteen African educators and governmental representaatives, Francis Sutton from the Ford Foundation, psychologist Jerome Bruner, political scientist Henry Kissinger, and

L. John Lewis from the University of London's Institute of Education.

The participants at the Endicott House Conference concluded that curriculum development work was needed in science and in other subject areas, and suggested that there was a need to mount a large scale curriculum reform program in Africa similar to the efforts that had recently been undertaken in the industrialized nations of the world. The conference recommended that an effort be made to establish institutions in Africa for the development of modern educational methods, curricula, and materials. In particular, it was recommended that funding be sought to initiate an African elementary science program under the auspices of Education Development Center (then Educational Services Incorporated).

Three years later, the African Primary Science Program was established, with initial funding from the Ford Foundation and a major grant from USAID. One of the Program's first activities was to convene a conference in Kano, Nigeria in February, 1965 to plan for possible major changes in the teaching of beginning science in English-speaking tropical Africa. The 33 African participants attending the conference represented nine countries: Ghana, Kenya, Liberia, Malawi, Nigeria, Sierra Leone, Tanzania, Uganda, Swaziland and Botswana (then the Bechaunaland Protectorate).

At the Kano Conference it was decided that the African Primary Science Program would undertake the following kinds of activities:

- o provide the support needed to set up a science center in each of the participating African countries.
- o support the development of instructional materials and laboratory experiments appropriate to the African environment, using inexpensive materials that were locally available.
- o provide financial assistance for the reproduction of materials for experimental use.
- o provide financial assistance for the training of teachers to use the experimental materials.
- o develop guidelines for an elementary science curriculum based on the experimental materials.
- o coordinate and facilitate communication between the programs conducted in each of the participating countries.

It was agreed that the activities of the Program would be reviewed and evaluated periodically by a steering committee consisting of Africans and EDC officials, and that ministry of education officials and science faculty members from the universities and teacher training colleges in each participating African country would be heavily involved in the negotiations needed to set up the science centers. It was also decided that the Program would sponsor yearly summer curriculum development workshops in Africa, to be attended by scientists and educators from both Africa and other countries, in order to stimulate the development of innovative science learning activities appropriate for use in Africa, and to encourage the sharing of ideas among the science centers.

Accomplishments of the African Primary Science Program

During the first five years of the program (1965-1970), the major emphasis was on the development of primary science curriculum materials and on the establishment of science centers in a number of the participating African countries. Three international curriculum development workshops were held: in Entebbe, Uganda (1965), Dar es Salaam, Tanzania (1966), and Akosombo, Ghana (1967).

The purpose of these summer workshops was to acquaint the participants with a variety of science curriculum development efforts that had been carried out in Africa,

the United States, and the United Kingdom; to consider the utilization of some of the ideas in these materials for wider use in African countries, and to prepare drafts of science units for experimental use by the curriculum developers in the local science centers. Although many different types of materials were developed at these workshops, there was agreement among the participants concerning the following principles of curriculum development: (1) the science units that were developed would emphasize the use of materials that were available locally, (2) both the subject matter and the concrete materials used in a science unit would be appropriate to the stage of intellectual development of the children for which it was designed, (3) the experimental units that were developed at the international workshops would be tested in primary school classrooms in more than one African country, and (4) the materials that were developed by the program would then serve as a basic resource for local revisions, each country being free to choose any part or all of the program for its own primary science syllabus.

Local science centers were established during this period in seven African countries; in Ghana, at the Ministry of Education in Accra; in Kenya, at three locations (one center was at the Ministry of Education's Curriculum Research and Development Center in Nairobi, later incorporated into the Kenya Institute of Education); in Malawi, at Domasi Teach-

ers College; in Nigeria, at three locations, viz. the University of Nigeria at Nsukka, Abraka Teacher Training College, and the University of Lagos; in Sierra Leone, at Njala University College; in Tanzania at two locations, viz. the Institute of Education in Dar es Salaam and Morogoro Teachers College; and in Uganda at the Institute of Education located at Makerere University College. These science centers were staffed by scientists and science educators; at least one science specialist at each location was supported by the EDC/USAID contract.

The initial activities of the science centers focused on the identification of materials that were available locally to teach the units developed at the summer workshops, trial-teaching the experimental units, developing new science units and materials that could be shared with other science centers at the next summer workshop, and conducting training sessions for the primary school teachers who would be trying the new science units on an experimental basis. The feedback obtained from the local science centers on the use of the new science units in actual classroom situations proved invaluable to the work of the large international workshops, and vice versa.

A large variety of materials were produced by the African Primary Science Program during this period. As of 1971, fifty-three different teacher's guides, student manuals, and

science readers had been produced by the program. The curriculum units that were developed included a series of twelve teacher's guides on activities for children in the lower primary grades which evidenced a considerable influence from the American kindergarten and British infant school movement, translated into an African setting.

For the middle and upper primary grades, ten units were prepared on biological topics, including units on insects commonly found in Africa (Mosquitoes and Ask the Ant Lion), nutrition (Chicks in the Classroom), plant growth (Seeds and Buds and Twigs), and simple microscopy, using a homemade microscope (Making Things Look Bigger). Nineteen units were completed on topics related to physical science and technology, including units on the simple qualitative analysis of commonly used chemical substances (Powders), electrical circuits (Torch Batteries and Bulbs), sound (A look at African Musical Instruments), and traditional African building techniques (Construction with Grass). Eight science books in the APSP Science Library Series were also completed during this period, including both stories about children's experience with science (Chima Makes a Clock and The Moon Watchers) and books on topics of special interest to children in the tropics, such as Stars over Africa and Tilapia. (See Appendix A for additional information and examples of APSP materials).

These materials were edited and prepared for printing at Education Development Center. They were then printed, both at EDC and at printing facilities in several African countries, in quantites large enough (2,000-5,000 copies) for a larger-scale testing of the program materials in the participating countries. In addition, camera-ready copy for all of the APSP publications was provided to the Ministry of Education in each of the participating countries, for use in making local adaptations of the materials.

From a historical perspective, USAID's support of the APSP science curriculum development project filled an important need at a critical time in the effort to improve basic education in Africa. For although the 1961 Addis Abba Conference as well as the policy goals of the new African governments stressed that an effort should be made to provide new and relevant content in the curriculum of the primary schools, little was done at the national level in most African countries to focus on this problem. It may be that the short-term goal of expanding educational opportunity was a more pressing political necessity than the qualitative improvement of education that could be achieved by long-term curriculum development and teacher training efforts.

It was therefore critical that agencies such as USAID and UNESCO were able to provide external assistance to stimulate work on curriculum development at this time. In

retrospect, it appears that the most important function of USAID's support for the African Primary Science Program was to target the long-range goals of quality and educational effectiveness at a time when most African ministries of education were preoccupied with the shorter-range goal of universal primary education.

The curriculum development emphasis of the African Primary Science Program paved the way for the later work on teacher-training that was to become the focus of the African-directed Science Education Programme for Africa (SEPA).

Establishment of the Science Education Programme for Africa

The African Primary Science Program was successful in mobilizing intellectual resources from Africa, the United States, and the United Kingdom for a program of science curriculum development that was truly regional. As a result of this regional approach, the project fostered a significant amount of communication and cooperation among the science center staffs and representatives from the ministries of education in the participating countries.

However, a regional organization like the APSP that is both funded and directed from outside the region it serves inevitably generates suspisions and distrust if it attempts to exert too great an influence on educational policies. Charges of neo-colonialism are likely to be raised in some

quarters, with the result that the making of educational decisions becomes so politically charged that little significant educational progress can be achieved.

For this reason, an African-directed organization, the Science Education Programme for Africa (SEPA), was founded in 1970 to carry on the work of the APSP project, particularly in the areas of teacher-training and program implementation. SEPA solicited funds for its basic operating expenses in the form of annual contributions from participating African governments, and obtained project funding from a variety of agencies, including both USAID and UNESCO. Thirteen African countries are now participating in SEPA, including Botswana, Ethiopia, The Gambia, Ghana, Kenya, Liberia, Nigeria, Sierra Leone, Swaziland, Tanzania, Uganda, Zambia, and Cameroon.

After SEPA was established, it embarked on several types of institution-building efforts. One important task was to identify specific projects that would enhance networking activities among the participating African countries. Efforts were also initiated to create effective lines of communication with officials in the participating ministries of education, and to establish a positive identity with the various national and international assistance agencies and foundations.

SEPA then embarked on a variety of projects related to the improvement of science education in Africa. These projects have focused on the training of science teacher educators, the development of teacher-training materials, environmental science education, educational evaluation, out-of-school science education, and cognitive research on concept-formation in science and mathematics.

In 1975, a program for the professional training of science teacher educators was established by SEPA at Njala University in Sierra Leone. The purpose of this project was to build a critical mass of manpower trained in the APSP/-SEPA philosophy and methodology of science education, so as to provide human resources for the development of science education curricula and teacher-training programs in the participating African countries. Participants in this program have included teacher training college science tutors from Botswana, The Gambia, Ghana, Kenya, Lesotho, Liberia, Malawi, Nigeria, Sierra Leone, Somalia, Swaziland, Uganda, and Zambia. After completing the one-year residential course at Njala, many of the participants have returned to their home countries to assume important positions related to science education in their national ministries of education.

SEPA also embarked on a project to develop prototype science teacher education materials for use in primary school teacher training colleges. A SEPA Handbook for

Teachers of Science and a Source Book for Science Teachers were published in 1977, and are now being used on a trial basis in several SEPA member countries. In addition, SEPA staff members have helped plan and conduct primary science inservice training institutes and workshops for teachers in several African countries.

With the support of UNEP, UNESCO, UNICEF, and the Ford Foundation, SEPA has engaged in a number of activities related to the theme of environmental science education. In 1974, SEPA organized a UNESCO workshop for teacher educators from fourteen anglophone African countries. The workshop participants developed a detailed statement of objectives for environmental science education in Africa, curriculum guidelines in environmental science for teacher-training colleges, and strategies on the use of environmental studies as a vehicle for the development of basic skills.

A similar environmental education workshop was held for nine francophone African countries in 1975. Earlier, in 1974, SEPA had begun its relationship with francophone countries by leading a UNESCO workshop for francophone West African states on integrated science education.

SEPA currently has a contract with UNESCO for the development of multi-media instructional materials which focus on the inter-relationships of science and the environment. The project is part of a global UNESCO-UNEP environmental education program.

SEPA has also been involved in several educational evaluation projects in cooperation with the International Centre for Educational Evaluation based at the University of Ibadan. SEPA sponsored fellowships for training science education evaluation specialists during the early years of the Center, and has also used the Center's facilities to under take contractual evaluation work for UNESCO.

In recent years, SEPA has initiated several informal education projects involving the development of environmental education materials for out-of-school youth and young adults. The emphasis is on activities that will promote health, agriculture, nutrition, and resource conservation.

A SEPA project on cognitive development was initiated in 1974 when SEPA, UNESCO, and UNICEF jointly sponsored an African Regional Seminar in Nairobi, Kenya on the development of science and mathematics concepts in young children in African countries. The report of that conference (UNESCO-UNICEF, 1974) reviewed previous studies of the

cognitive functioning of children in African countries and emphasized the need to link together clinical studies of children's learning processes with future curriculum development work in science. Since that time, SEPA has organized additional meetings of a special task force of psychologists who are undertaking cognitive research studies of children in African countries. The task force is publishing a book on the intellectual development of children in Africa which will include sections on the development of language and thought, the impact of the environment on intellectual development, and implications for curriculum development and teacher training in African countries.

The Impact of the APSP and SEPA Programs on Basic Science Education in Africa

The African Primary Science Program and its successor, the Science Education Program for Africa, had at least three kinds of impact: (1) they provided a model of regional cooperation and organizational development, (2) their emphasis on manpower development created a core of people in many African countries with special expertise in curriculum development, teacher training, and educational evaluation, and (3) the materials developed by the APSP and SEPA programs had a substantial impact on primary science curricula in most of the participating African countries.

The regional curriculum development workshops and conferences sponsored by the APSP and SEPA programs produced not only primary science curriculum materials, but also a core of people within Africa with curriculum development expertise, practical experience, and a commitment to continuous curriculum renewal based on the trial-teaching of materials with children. The harnessing of such expertise, the sharing of experiences, and the cross-fertilization of ideas that occurred among the participating African countries made it possible to achieve much more than would have been possible had the program been restricted to one country. In the following years, it was then possible to utilize the network created by APSP and SEPA to pursue projects in other important areas, such as environmental education and research on cognitive development. The SEPA science educator training program in Njala University expanded the original APSP network so that now virtually every ministry of education in anglophone Africa includes at least one professional educator who is well acquainted with the potential of an activity-centered, problem-solving approach to primary school science.

The primary science units developed by the African Primary Science Program were used essentially in their original form during the 1960's as supplementary science teaching materials in many African countries. During the 1970's the

activity and problem-solving approach that characterized the APSP materials was incorporated into primary science syllabi by ministries of education in many of the participating countries. Some countries adapted science activities included in the original APSP units to their own needs; other countries developed materials on new topics that utilized the APSP/SEPA inquiry approach.

The APSP/SEPA programs have had a substantial impact on the national primary science curriculum in most of the participating African countries, including Ghana, Kenya, Liberia, Nigeria, Sierra Leone, Tanzania, and Uganda. Yoloye, in his 1977 evaluation of the APSP program, remarked that "the fact that no wholesale adoption of the APSP materials has occurred is probabaly a positive thing because, ironically, if the program has produced the right orientation among its exponents, one test of its success would be that in the coming years, its materials should be virtually completely replaced by new materials produced by the very people who have had contact with APSP" (Yoloye, 1977, p.141).

University of Lagos Professor A. Babs Fafunwa describes a specific example of this kind of impact of the APSP program on science education in Nigeria:

> APSP/SEPA has certainly had considerable impact on many African countries. In Nigeria in

particular, it has had phenomenal effect. Twenty years ago, "science" meant a senior high school subject accompanied by expensive "white elephant" equipment. What was more, science could only be taught to students who spoke English--not to Yourba, Hausa, Ibo, or Swahili speaking pupils. Today the situation has changed. We now teach kids science in Yourba and Hausa and, hopefully, Ibo will join the team before long. The use of "local materials" has become commonplace, and no one is now ashamed of collecting tin cans, raffia, etc., or of teaching any subject, be it geography, history, mathematics (matimatiki) or science (sayensi) in Yourba or Hausa.

The [new science] materials are the results of a ten-year primary school project in Yourba ... The Sayensi programme follows the APSP approach almost to the letter with local variations here and there. We also incorporated health, sanitation, and home economics in the Sayensi programme.... More than 1.5 million copies of Sayensi have been sold to Oyo State Government by the Evans publishers! At least 12 out of the 19 states in Nigeria are using the [Sayensi] project books in Yourba and Engligh (Fafunwa. 1982).

Another example of the long-term influence of the APSP primary science curriculum materials can be found in a popular science methods textbook published by Longman in 1979, for use in primary school teacher training colleges in Africa. This textbook, Teaching Primary Science, was written by B. L. Young, the British Council lecturer in science education at Amadu Bello University in Zaria, Nigeria. Many of the science activities and illustrations in this text are reproduced from the original APSP primary science units, which are now in the public domain. This book is now being used widely as the basic science teaching method text in teacher-training colleges throughout East, West, and Central Africa.

Other Developments Affecting Science Education in Africa

The creation of national curriculum development centers. In most African countries prior to the early sixties, the curricula of the primary schools and teacher training colleges were determined by ministry of education officials who compiled lists of topics that were to be taught at each grade level. The textbooks used by the primary school children and their teachers were usually written by expatriates and were usually produced by a large commercial publisher; very little attention was paid to the particular

needs of African countries. At the secondary level, the syllabus for each subject was determined by an external examining body,--originally the Cambridge Overseas Syndicate in most of anglophone Africa, and later the West African or East African Examinations Councils.

However, in the early 1960's, special centers were established in some African countries to develop curriculum materials for use in primary and secondary schools. The first of these centers was the Kenya Institute of Education, established in 1964, and the Curriculum Development Center in Monrovia, Liberia, also established that same year. These centers were followed by the creation of the Elementary Science Unit in the Ghana Ministry of Education (1965), the Nigeria Educational Research Council (1965), and the Science Curriculum Development Center at Njala University College in Sierra Leone (1968). The movement towards producing instructional materials at curriculum development centers soon spread to virtually all anglophone African countries. The centers go by different names in different countries; some are attached to universities, while others are located within the ministry of education.

The following curriculum development centers continue to be involved in science curriculum development activities in the anglophone African countries:

1. Curriculum Development and Evaluation Unit, Ministry of Education, Gaborone, Botswana

2. Curriculum Development and Book Production Division, Ministry of Education, Addis Ababa, Ethiopia

3. Curriculum Development Center, Ministry of Education, Banjul, Gambia

4. Curriculum Research and Development Division, Ghana Education Service, Accra, Ghana

5. Kenya Institute of Education, Nairobi, Kenya

6. Division of Curriculum Planning, Ministry of Education, Monrovia, Liberia

7. Mathematics/Science Centre, Ministry of Education, Maseru, Lesotho

8. Nigeria Educational Research Council, Lagos, Nigeria

9. Curriculum Revision Unit, Institute of Education, University of Sierra Leone, Freetown, Sierra Leone

10. National Curriculum Unit, Ministry of Education, Manzini, Swaziland

11. Institute of Education, University of Dar-es-Salaam, Dar-es-Salaam, Tanzania
12. National Curriculum Development Center Kampala, Uganda

These curriculum development centers went beyond the production of syllabi, and did not leave the writing of textbooks and teachers guides to the large international commercial textbook publishers. Many of the centers produced student texts, teachers guides, and other instructional materials; these materials were usually tried out in draft form in the schools and revised before large-scale production was attempted. This model of using formative evaluation techniques in the development of instructional materials is the same procedure that was used by the major American curriculum development projects sponsored by the National Science Foundation. The centers set up by the African Primary Science Program provided an impetus that stimulated the adoption of a similar "research and development" model of curriculum development in many African countries.

This "R and D" approach to curriculum development has enabled a number of African countries to provide schools with educational materials that are much more relevant to societal needs and the local environment than was the case twenty years ago. It has also helped to encourage experimentation with new approaches to teaching and to provide new

sources of input that the external examination councils are beginning to consider in designing their examination syllabi.

The role of other external agencies. The APSP/SEPA program was funded primarily by USAID. However, a number of other organizations have contributed in important ways to the improvement of basic science education in African countries. The largest single influence has come from UNESCO and the related United Nations organizations of UNICEF and UNDP. These U.N. agencies have provided equipment, books, teacher-training experts, and financial support for the training of curriculum specialists and teachers.

UNESCO has also sponsored several specific pilot projects with science education components, such as the Namutamba Rural Development Project in Uganda and the Bunumbu Rural Primary School Project. (The Bunumba Project will be described later in the chapter on Sierra Leone). The Namutamba "Project on Education Integrated with Rural Development" was begun by UNESCO in 1968 and focused on more than science curriculum development, although primary school science was an important component. The primary objective of the Namutamba Project was to help prepare students to return to occupations in the rural environment by encouraging them to embark, while in school, on agricultural science projects such as farming, raising poultry, and other forms of animal husbandry.

In 1972, the African Primary Science Program effort in Uganda and the Namutamba Project were integrated under the direction of the former APSP science educator in Uganda, David Kiyimba. The combined project, which continues to place a strong emphasis on environmental education, continues to operate at Namutamba Teacher Training College.

UNESCO also sponsored a number of international conferences on integrated science education which have had an impact on education in Africa. Albert Baez, former Director of UNESCO's Division of Science Teaching, has defined "integrated science" as an approach to the teaching of science in which "the principles of science are presented so as to express the fundamental unity of scientific thought and to avoid premature or undue stress on the distinctions between the various scientific fields" (1976, p. 136).

The main focus of the UNESCO integrated science movement was at the lower or junior secondary school level. During the 1970s, virtually all African countries developed or adapted integrated science course materials to replace the general science texts formerly used in the first two years of secondary school. In most countries, this development resulted in a greater emphasis on the processes of scientific problem-solving, and on the study of science topics that were more relevant to societal needs and the local environment.

The British Council worked with several African ministries of education in the early 1960's to organize a series of summer workshops known as "Ashby Courses." This program brought teams of science and mathematics education experts from the United Kingdom to work with African educators to conduct inservice teacher-training courses in a number of African countries. The British Council also provided longer-term educational consultants to many African countries, as well as science equipment and books.

The United States Peace Corps provided a large number of science teachers for secondary schools and teacher training colleges in many African countries during the 1960's and 1970's and continues to do this in a number of African countries. In some countries, such as Sierra Leone, Peace Corps volunteers have assumed a major responsibility for conducting inservice training workshops to improve the teaching of science and mathematics in primary schools.

The focus of the World Bank's support for science education in Africa has been primarily on the construction and equipping of science laboratories and other educational facilities. A number of bilateral assistance organizations have also provided this kind of assistance.

IV

THE CURRENT STATUS OF BASIC SCIENCE INSTRUCTION IN AFRICAN COUNTRIES

Time Allocated to Science Instruction

Yoloye and Bajah (1981) note that in the past, science traditionally has been regarded as basically a secondary school discipline rather than a primary school subject. This has affected the nature of the science taught in primary schools, as well as the amount of time allocated to science instruction.

In their survey of the amount of time devoted to the teaching of science in primary schools, Yoloye and Bajah report that the time for science varies from a minimum of 60 minutes a week in The Gambia to as much as 225 minutes in Ethiopia and Liberia, with an average of about 120 minutes per week. At the junior secondary school level, students generally receive two or three hours of integrated science instruction each week.

The situation in the teacher training colleges where primary school teachers are trained is similar, although there is less variation across countries. The time allocated to science in the training colleges varies from 120 minutes to 225 minutes per week (Yoloye & Bajah, 1981, p.19).

Methods of Teaching Science

Teachers in African countries generally use a combination of expository and activity techniques in teaching science; the extent to which activity methods are used is largely a function of the kind of training that teachers have received. However, Yoloye and Bajah believe that there are many indicators that suggest that teachers are moving increasingly toward more use of pupil-centered activities in their teaching.

As mentioned earlier, evidence of this trend can be found in the teacher's guides and science syllabi that are currently being produced by Ministries of Education in many African countries. Support for such an approach is also evident in the report of the 1982 Harare Conference of African Ministers of Education, which discusses both the need for locally-produced, low-cost materials for the teaching of science and the need for inservice teacher- training programs that stress the use of problem-solving activities in the teaching of science. Regarding the "dogmatic method" of science instruction, the Harare Conference report states:

> Too often pupils merely follow the instructions of the teacher, and are content to carry out orders and directives without using their initiative devising, setting up, and carrying out experiments...[This method] does not contribute to the

scientific training of the young African. Teachers must be encouraged to give up using it and turn to methods that call for greater participation by the pupils (UNESCO, 1982).

The Influence of Primary School Leaving Examinations

In most African countries, the need to identify those students who will be allowed to continue their education at the secondary level has necessitated the administration of a primary school leaving examination by the Ministry of Education. In countries in which this examination has included a science section, the pressure to pass the examination and the types of science questions that have been included in such examinations have sometimes had a rigidifying effect on the primary school curriculum, slowing the pace of new curriculum reforms and the introduction of new approaches to science teaching.

However, such examinations need not foster rote learning. In some African countries, the work of curriculum development projects has begun to exert an influence on the content of the primary school leaving examinations. In Kenya, as a result of the influence of the APSP and SEPA programs, efforts have been made to construct science questions for the primary school leaving examination that reflect a greater emphasis on higher-level critical thinking skills. Examples of such questions in the 1979 Kenya Primary School Examination can be found in Appendix A.

The Use of Distance Learning Systems

For a number of years, educators have been looking for ways by which modern technology might be used either to improve the quality of education in less developed countries or reduce its cost. One of the approaches that has received considerable attention during the past decade is the use of public media, such as television and radio, for "teaching at a distance." This educational use of the mass media was one of the topics discussed at the 1976 UNESCO Conference of African Ministers of Education in Lagos (UNESCO, 1976).

The expense involved in the development of quality television programming, as well as the costs of transmitting and receiving equipment, make television impractical for use as an educational medium in most African countries. However, the use of radio for educational prgramming is considerably less expensive. Radio receivers are comparatively inexpensive and can be operated on batteries in rural areas where mains electricity is unavailable. Also, if silicon solar cells continue to decline in cost, it may eventually be possible to replace the consumable batteries in transistor radio receivers with storage cells that can be recharged from an array of solar cells, thus virtually eliminating all recurrent costs except repairs.

The 1979 World Bank Education Sector Policy notes that educational broadcasting has a potential for achieving

three kinds of education objectives. First, educational broadcasting can increase educational efficiency by improving the quality of instruction, providing instruction in subjects for which there is an inadequate supply of qualified teachers, supplementing curricular reform efforts, and reducing repetition rates of slow learners. Second, distance learning techniques, usually coupled with the use of printed materials, can provide correspondance courses for individuals who either live in remote areas or cannot attend formal classes for other reasons. Third, some distance learning strategies can reduce educational costs, if the number of users is great enough (World Bank, 1979, p.34).

The World Bank analysis of educational radio broadcasting identifies four possible uses of radio in formal education, and assesses the potential benefits of each of these strategies as follows:

Uses of Radio in Formal Education

	Objectives		
	Improve Access	Improve Quality	Reduce Cost
In-School Enrichment: occasional lessons beyond the ability of the teacher to provide.	No	Maybe	No

Uses of Radio in Formal Education (continued)

	Objectives		
	Improve Access	Improve Quality	Reduce Cost
In-School, Direct Instruction: providing most of the instruction in one or several subjects.	No	Yes	Usually no
Extended Schooling: providing enough instruction that a qualified teacher may be replaced by a monitor.	Maybe	Maybe	Maybe
Distance Learning: in which technology (radio, correspondence) combines with textbooks and occasional personal contacts to replace both teacher and school.	Yes	Usually No	Yes

Source: World Bank, Educational Sector Policy, 1979, p.35

The USAID-sponsored Stanford Radio Mathematics Project in Nicaragua successfully demonstrated that radio programming could be used to improve the computational skills of children in the primary grades. Although the development of the series of daily mathematics broadcasts was quite costly, evaluation of the project revealed that student repetition rates had been sufficiently reduced to offset the program development costs (Searle, Friend, & Suppes, 1976).

As of this date, radio has not been used widely to provide basic science instruction at the primary school level in Africa, although efforts have been made in some countries to broadcast educational programs to enrich the teaching of science and health in primary schools. The reports that follow on science education in Sierra Leone and Botswana include examples of this utilization of radio broadcasts for the enrichment of science teaching in primary schools.

In general, it appears that radio is better suited to the development of basic skills through drill and practice than to the development of more complex critical thinking skills. Jamesine Friend, one of the directors of the Nicaragua Radio Mathematics Project, has suggested that radio instruction may be most effective in teaching subjects in which a fairly large structured body of knowledge is to be learned, such as mathematics, reading, and foreign language (1981, p 2). Although some college and upper level secon-

dary school science courses, (especially descriptive chemistry, biology, and geology) require the learning of a large, structured body of factual knowledge, the primary school science syllabi that most African countries have now adopted place a much higher priority on the development of scientific reasoning skills.

This idea received considerable emphasis in the report of the 1982 Harare Conference of Ministers of Education in Africa:

> Training in basic science should start at an early stage in primary and secondary schools; the contents of science courses and science teaching methods in Africa should be improved and suitably adapted in view of the developments which have and still are taking place all over the world; more provisions should be made for practical teaching and for the use of local materials.
>
> ...The teacher must be aware that science is not a series of object lessons about a piece of granite, or an old wasp's nest; ... not learning the names of the parts of a grasshopper or a flower; not learning to identify twenty trees, twenty insects, twenty flowers or twenty anything else. ...It is a study of the problems

that are found wherever children live. More formally stated, it is a study of the natural environment -- not merely pieces of chemistry and physics and biology and astronomy and geology. Its content is connected with those subjects, but it is a study of problems that pop into curious children's minds as they live and grow from one day to the next. The idea is to get pupils into the habit of interpreting situations and generalizing them so as to be able to understand the day-to-day problems in their lives. This implies that the teacher concentrates on developing the pupil's perceptive powers, teaching him to look at and examine more closely the objects and phenomena in his immediate environment (UNESCO, 1982, paragraphs 50 - 54).

It may be unrealistic to assign a major role to radio broadcasts in directing such primary science learning activities, since this type of learning requires a teacher to be very sensitive to student responses, so as to continually encourage them to make accurate observations, elicit coherent explanations during class discussions, and reinforce students' attempts at independent reasoning. Even in junior high school integrated science programs involving tightly structured student activities, it is difficult to syncronize

radio instructions so as to direct student experimental work and coordinate the class discussion of results that must follow if students are to derive much benefit from their practical work.

Recently, an interesting distance science teaching experiment at the junior secondary level was conducted in Zimbabwe. In 1980, a project was begun at the Ministry of Education and Culture to develop a practical science correspondance course for students who were unable to attend secondary school. Instead of radio broadcasts, this Distance Science Teaching Project (DiST) made use of student instructions that were recorded on tape cassettes, which allowed some control at the learning site over the timing of the recorded instructions. Such an "audio-tutorial" method has been in use for a number of years at several American universities to provide individualized laboratory instruction for students in large undergraduate science courses.

The Zimbabwe project utilized the audio-tutorial method with relatively large correspondence course study groups, under the supervision of a mentor. The DiST project demonstrated that it was possible to teach "hands-on" science in a study group context, using a tape recorder controlled by an untrained mentor to provide instruction for the students. However, considerable time and effort was required in order to develop the necessary kits of low-cost science apparatus

used in the program, a carefully sequenced study quide, and the audio cassettes which provided the essential integration of student activities and discussion.

The audio cassette controlled by the study group mentor provided the sequencing and pace-stabilizing role that is usually considered one of the teacher's functions. The teaching pattern that evolved in the DiST trial units was as follows:

(1) Simple introductory experiment under direct tutelage from the cassette. Timing and language for this mode of instruction is critical.

(2) Cassette introduction to main theme of unit, sometimes with supportive diagrams and text in study guide.

(3) Pupils carry out further experiments under instruction from study guide.

(4) Exercises based on experiments completed.

(5) Cassette reintroduced to "lead" discussion of experimental results.

(6) Final cassette summary.

(7) Summary exercise/self test to conclude the study unit (Dock, 1981, p.158).

In 1981, the Zimbabwe Ministry of Education and Culture decided to embark on an ambitious secondary school expansion

scheme in which the number of students in Form I was increased from 17,000 in 1980 to 80,000 in 1981. Existing secondary schools were encouraged to broaden their Form I intake, and some 1,100 new Form I classes were created as additions to 465 primary schools throughout the country.

As a result of this expansion of formal junior secondary education, plans for the large-scale implementation of distance science teaching to study groups was abandoned, but the DiST materials were adapted for use in the new "Zim-Sci" program for the new Form I classes. Most of the new Zim-Sci classes are being taught by trained teachers who formerly taught at the upper primary level.

Although few of the new teachers have much training in science, the developers of the Zim-Sci program found that, given the availability of detailed and structured study guides for students and a comprehinsive resource guide providing scientific background and teaching suggestions for the teacher, the need for the audio tape cassettes diminished. As a result, audio-tutorial tape cassettes are not being used in the new Zim-Sci course, and the funds saved by eliminating the tape recorder are being used instead to augment the extensive kits of locally-produced science apparatus that are being supplied to schools for use in the Zim-Sci course.

Science Materials and Apparatus

In most African countries, the primary schools have very little science apparatus or materials. The facilities at the primary teacher training colleges are marginally better, since most of these colleges do have at least one science classroom. However, these laboratories are usually very poorly equipped.

The equipping standards for secondary schools are usually much better. This is at least partly due to the laboratory requirements imposed by the external examining bodies, such as the East and West African Examination Councils. These agencies require that certain materials be made available for those students who are to take the practical examinations in science for the "O" Level School Certificate.

Due to the high cost of imported science apparatus and materials, efforts have been made in several African countries to establish local production units to manufacture and assemble low-cost science equipment. In 1970, a Science Equipment Production Unit (SEPU) was established at the Kenya Science Teachers College in Nairobi, with assistance provided by the Swedish International Development Agency. SEPU now produces kits of physics, chemistry, and biology apparatus for secondary schools throughout Kenya at a considerable cost savings. SEPU hopes to begin exporting science apparatus in the near future. (Apea & Lowe, 1977).

In Nigeria's Bendel State, a smaller center has also been established to produce simple apparatus for teaching science in primary schools. This center uses many of the designs included in the Guide to Improvised Science Apparatus produced at the University of Maryland with USAID support (Melton, 1972).

Beginning in 1976, the British Commonwealth Secretariat sponsored three regional seminars on the local production of low-cost science equipment. One of these seminars was held in Dar es Salaam, Tanzania in 1977. It stimulated considerable interest in a number of African ministries of education in the possibilities of manufacturing science materials locally, instead of purchasing expensive imported apparatus.

Two years later, in 1979, UNESCO sponsored a meeting in Manzini, Swasiland of science educators from Botswana, Lesotho, and Swaziland to investigate the possibility of establishing one or more centers for the production of low-cost science apparatus in Southern Africa. This meeting resulted in the development of recommendations for each of the three ministries of education regarding the planning that would be needed to set up such a facility in each country. However, it was recognized that to implement the recommendations, there would probably be a need for foreign assistance.

More recently, the report of the 1982 Harare Conference of African Ministers of Education again stressed the need for establishing more science materials production centers in Africa such as SEPU in Kenya,in order to reduce the costs of acquiring and maintaining school science equipment (UNESCO, 1982).

The Expansion of Intermediate Level Education

The report of the 1982 Harare Conference of African Ministers of Education emphasizes the need for African countries to move toward making education free and compulsary for all children, at least through the end of the first stage of secondary school. In most countries, this will entail a large expansion of the number of classrooms at the junior secondary level. Several Ministries of Education have already begun the process of developing new curricula and teacher-training programs for a new kind of junior secondary education. There is a considerable interest in designing an educational experience that will be both academic and oriented toward productive work and life in the community, since the expanded junior secondary program will be terminal for most students. The countries that are beginning such efforts include Botswana, The Gambia, Ghana, Guinea, Kenya, Tanzania, and Zimbabwe.

This trend has several implications for science education in Africa. First and most important, it provides a new

opportunity for providing basic education in science and technology for all children at a more sophisticated level than has been possible in the past. Early adolescence is a critical period for science instruction, since it is during this period that children can be stimulated to greatly expand their critical thinking abilities.

The second implication of the expansion of junior secondary education is that it will greatly magnify the need for teachers who are trained to teach science and mathematics at this level. The Peace Corps has already received urgent requests from the Kenyan Government to provide science and mathematics teachers to help staff the upper levels of the recently-expanded nine-year primary school system. Similar requests have been received from The Gambia, Swaziland, and Ghana. Most African countries already suffer acute shortages of teachers qualified to teach mathematics and science at the upper secondary levels; the expansion of junior secondary education will exacerbate this problem.

However, although the expanded need for science teachers at the junior secondary level poses a problem, it also presents an opportunity for more efficient teacher-training efforts. Unlike the situation at the primary school level where all teachers are usually trained to teach all subjects, a small fraction of the total number of junior secondary school teachers can be trained to be science or

science/ mathematics specialists. It is to be hoped that this will make it possible to focus teacher training efforts on those teachers most interested in, and capable of, teaching science.

The third implication of the expansion of junior secondary education is that it poses a challenge to educators to develop cost-effective solutions to the problem of providing hands-on science materials and apparatus. Unquestionably, such materials will be needed to support a practical, problem-solving approach to science that will help prepare students for life in their communities. As noted earlier, the recent work in this area in Zimbabwe has sparked considerable interest in other African countries, but most of them will need technical assistance if they are to embark successfully on such a project.

V

AN OVERVIEW OF PRIMARY SCHOOL EDUCATION IN SIERRA LEONE

For several decades, the educational system in Sierra Leone has included seven years of primary school, five years of secondary school leading to the "O" level school certificate, and two additional years of sixth form study for those students preparing for university entrance. However, a plan is currently underway to reduce the number of years of primary schooling from seven to six years.

This reduction is being effected by raising the age of entry to primary school from age five to age six, with a possible further increase to age seven in the future. The intent of this change is to stretch the available resources to cover the costs of increased enrollments at all levels. In addition, it is hoped that by increasing the age at which children leave primary school, eventually it may be possible to provide all children with some form of organized educational opportunity (including either junior secondary or vocational education) until they are fifteen (Sierra Leone Government, 1976).

Although primary and secondary school enrollments expanded rapidly in the 1960's and early 1970's, Sierra Leone

currently has lower levels of primary enrollment than two-thirds of the countries in Africa, according to World Bank estimates. The Sierra Leone government has set a goal for primary enrollment of 72.4 percent to be reached by 1985-86; however, in 1977 only 34.8 percent of the children aged 6-11 were enrolled in primary school. At the secondary level, enrollment in 1977 was 23.1 percent of the children 12-17 years of age (World Bank, 1980a).

Sierra Leone has a population of approximately three million. The adult literacy rate is also quite low in comparison with most of the other countries in tropical Africa. Only about 15 percent of the adults 15 years and older are able to read or write, possibly reflecting the fact that over three-fourths of the population live in rural areas on subsistence agriculture (World Bank, 1980b).

Sierra Leone is composed of three rural provinces, plus the western area that surrounds Freetown. The 1979 primary school enrollment statistics for these regions indicate that considerable inequities exit with respect to the educational opportunities available to girls and to children in the more remote areas:

Primary School Enrollment Statistics, 1979

Province	Total Enrollment	Males	Females
Northern Prov.	26.3%	32.9%	19.2%
Southern Prov.	41.7%	46.8%	36.3%
Eastern Prov.	41.5%	51.7%	31.1%
Western Area	80.5%	88.1%	73.4%

Source: Sierra Leone Government, Education Sector Review, 1979.

In 1979, there were 1118 primary schools in Sierra Leone, with a total enrollment of 227,815 pupils, staffed by 7088 teachers. The average pupil-teacher ratio was 32:1, although this figure was much higher (37:1) in the Western Area, due to the high enrollment percentages in the urban region around Freetown. As a result of this problem, many schools in urban areas run on a shift system, with lower primary classes attending school in the morning and upper primary children in the afternoon. A small school fee is charged for children in the first three grades; tuition is free for the upper primary classes.

The primary school curriculum prescribed by the Ministry of Education includes English language, mathematics science, social studies, religious knowledge, arts and

crafts, music, physical education, reading, spelling and home economics. The medium of instruction for all classes is English. Children in the upper class take the Selective Entrance Examination conducted by the West African Examinations Council to qualify for entrance into secondary schools. This examination includes sections on English, arithmetic, and quantitative and verbal aptitude. As a result, arithmetic and English usually receive the most emphasis by primary school teachers, especially in the upper classes.

This problem is noted in a 1976 government study of education in Sierra Leone:

> The curriculum in the primary school is dominated by the need to prepare pupils for admission to second level studies. This preparation is overwhelmingly theoretical. The majority of teachers are underqualified and tend to concentrate on the teaching of reading, English, and mathematics, which are the main subjects in the Selective Entrance Examination.
>
> ...[There is] little opportunity for children to understand what they learn. Assesment of progress consists of memory tests and predictions about performanace on the Selective Entrance [Examination]. (Sierra Leone Government, 1976, p.6)

Primary School Science Curriculum

In 1969, the Sierra Leone Ministry of Education published a new trial syllabus for primary schools. This document included a recommended science syllabus for the upper primary classes that was activity-oriented and encouraged teachers to perform science experiments. It did not refer to the activities in the African Primary Science Program because the APSP units were not yet available. The 1969 trial syllabus stipulated that science be taught in classes three through seven, with a time allotment of one hour per week in class three and two hours per week in classes four through seven.

In the early 1970's, after the APSP science units had been printed and were available in sufficient quantities to distribute to teachers, the Njala University College Science Curriculum Development Center prepared a list of recommended APSP science activities, correlated with the topics in the 1969 trial syllabus.

Throughout the 1970's, an extensive program of primary science inservice training workshops was sponsored by the Njala Science Center and the Provincial Education Offices. United States Peace Corps volunteers played a large role in this inservice training program. As a result of these efforts, many teachers became acquainted with the new approach to science teaching and began to use the APSP units supplied

by the Njala Science Center as an alternative to the activities outlined in the 1969 trial syllabus.

The 1976 government study of education in Sierra Leone reported the results of a survey of science teaching in primary schools. This survey indicated that most schools devoted an average of 84 minutes per week to science instruction. About half of the schools that responded to the questionnaire indicated that they had copies of some of the APSP units; about one-third of the schools were using APSP units, either in place of, or in addition to, the 1969 trial syllabus. About one-fourth of the schools claimed that they taught science, but used neither the trial syllabus nor the APSP units (Sierra Leone Government, 1976, p. 142).

The 1976 survey also revealed that about 42 percent of the primary schools had some storage space for science equipment. This space was usually in the classroom, but sometimes in the headmaster's office or at his home. However, most of the schools indicated that they had very little or no provision for obtaining science materials.

Only about ten percent of the primary schools reported that they had a science club. About three-fourths of the schools sampled taught agricultural science within the school compound. Most of the schools reported that they did maintain a school garden, the average size being about two

acres. However, only half of the schools with such a garden used it for any lessons related to science. Most of the schools indicated that they used their gardens to grow food for school lunches; a few schools were using their gardens to raise funds to meet school needs.

In 1981, a Science Panel appointed by the Ministry of Education drafted a new primary school science syllabus for classes 1-6 that stresses the APSP/SEPA approach to science teaching and includes many APSP activities. This science syllabus, which also incorporates agricultural and home economics topics, encourages teachers to make use of improvised materials and to relate their science teaching to the local environment. In assessing the progress of students, teachers are encouraged to evaluate the practical work that children do in class, as well as their performance on written tests. Practical suggestions are provided to assist teachers with this task.

The new syllabus is currently being reviewed by the Ministry of Education and plans are being made to introduce it in the near future. The initial draft of this syllabus is included in Appendix B.

The Training of Primary School Teachers

There are five primary teacher training colleges in Sierra Leone. These colleges prepare students to receive the Primary Teacher's Certificate. In addition, the teacher

training college at Bunumbu offers a course of study leading to a Higher Primary Teacher's Certificate, in conjunction with the UNESCO/UNDP rural community development program.

The qualifications for entry into a primary teacher training college are the completion of secondary school (Form 5) and passing marks in two subjects of the West African School Certificate Examination. For admission to the Bunumbu Higher Certificate course, teachers must have previously acquired the regular Primary Teacher's Certificate.

The period of training at all five primary teacher training colleges is three years. During this time, students take courses in all of the subjects included in the primary school curriculum, plus the psychology of education, teaching methods, and practice teaching.

Prior to 1970, the science taught in the primary teacher training colleges was content-centered and similar to the science taught in the secondary schools. In 1971, the Science Curriculum Development Center at Njala University prepared a new science syllabus for teacher training colleges. This syllabus is now used by most of the primary teacher training colleges in Sierra Leone. This syllabus has an environmental science emphasis, and focuses on the kinds of science activities that are most appropriate for the primary school child. It also includes a special section on agri-

icultural science. An outline of this teacher training college science syllabus is included in Appendix B.

About four hours per week are devoted to science instruction at the primary teacher training colleges. These classes are often taught by tutors who formerly taught science in secondary schools. At least one science tutor at each of the five primary teacher training colleges has attended the special one-year science education course at Njala University.

With assistance from SEPA, the Njala Science Curriculum Development Center has published a two-volume science handbook for teacher training colleges entitled Our Environment. These guides are being used at all of the teacher training colleges in Sierra Leone, as well as in a number of other African countries.

With support from UNESCO/UNDP, a pilot project to train primary school teachers for rural areas was initiated in 1974 at Bunumbu Teacher Training College. This project has been in operation for the last eight years. The Bunumbu program prepares teachers to serve in adult education and community development roles, in addition to teaching in rural primary schools. In the curriculum there is a strong emphasis on agricultural science and the improvisation of appropriate technology to solve rural development problems. The sections of the Bunumbu syllabus that are related to science and technology are included in Appendix B.

Prior to 1971, the certification requirement for primary school teachers in Sierra Leone was the "Teachers Elementary Certificate," which required the completion of primary school plus three years of a teacher training college course. This certificate has now been phased out. About twenty percent of the teachers now teaching in Sierra Leone primary schools have this certificate, although many have taken secondary school equivalency examinations to upgrade their qualifications.

However, more than half of the primary school teachers in Sierra Leone are considered "professionally untrained and academically unqualified," and have never attended a teacher training college. Although the number of qualified teachers has almost tripled since 1964, the even greater increase in the number of children enrolled in primary schools has resulted in only a small decrease in the percentage of unqualified teachers in the schools, as can be seen in the figures below for the period 1961-1979:

Teachers in Sierra Leone Primary Schools

	1964-65	1973-74	1978-79
Primary enrollment	126,438	182,100	227,815
Qualified teachers	1,293	2,015	3,028
Unqualified teachers	2,436	3,296	4,060
Total # of teachers	3,729	5,311	7,088
Percentage of teachers unqualified	65%	62%	57%

Source: Sierra Leone Government, IDA Project, 1980.

Educational Radio Broadcasting

The development of an educational broadcasting unit in Sierra Leone began in 1961, when a UNESCO expert was posted to the Ministry of Education to help develop radio programs for the primary and secondary schools. During the initial years, educational programming was in areas other than science, but in 1973 a project was initiated to develop a series of science lessons for primary schools.

A series of 24 weekly science programs entitled Science in Our Daily Lives, was developed for the upper primary level. Each program was twenty minutes long and the same program was broadcast several times each week.

A pupil's pamphlet and teacher's guide for these science programs were written by a Sierra Leonean scientist,

Daniel Chaytor. Chaytor, a biology professor at Fourah Bay University, had participated in many APSP and SEPA conferences and was the editor of the SEPA Sourcebook for Science Teachers.

Chaytor's pupil's pamphlet for the Science in Our Daily Lives series lists the following objectives for the radio broadcasts:

1. To sharpen pupil's observations of the environment.
2. To increase pupil's participation in investigatory activities.
3. To encourage pupils to ask questions about their environment.
4. To encourage pupils to think out likely answers to their own questions, i.e. hypothesizing.
5. To familiarize pupils with measurement of selected parameters of science problems.
6. To bring home to pupils the pervasiveness of science in their daily lives (Chaytor, 1973, p.3).

Topics included in the series of radio broadcasts included nature study, insects, farm animals, plant behavior, evaporation and condensation, light and shadows, seed germination, properties of air, measurement, density, pendulums, levers, simple electrical circuits, sound, commmon chemical substance, and suggestions on how to start a school science club. The teacher's guide for the series encouraged teachers to use the broadcasts to introduce science activities that children themselves could perform. Teachers were asked to try to provide sufficient materials for children to use, although no attempt was made to make kits of the necessary materials available from the Ministry of Education. The pupil's pamphlet for the Science in Our Daily Lives series is included in Appendix B.

Although this series of radio programs continued to be broadcast periodically during the next six years, the results were disappointing. Although the project was not formally evaluated, Ministry of Education personnel report that the programs were not utilized very effectively, because teachers were usually unable to assemble the materials that were needed prior to the radio broadcasts. The success of the project was also hampered because many schools did not have transistor radios, and those that did often experienced difficulty in receiving the weak radio signals from the Sierra Leone Broadcasting Service in areas distant from Freetown.

Each year, schools are requested to complete a registration form if they intend to utilize the school broadcasts. During the 1981-82 school year, the Schools Broadcasting Unit reported that only 51 of the approximately 1118 primary schools in Sierra Leone indicated that they were making any use of the educational radio broadcasts produced by the Ministry of Education.

During the 1981-82 school year, the weekly schedule of school radio programs included a nursery school program; primary school programs on social studies, science, and English; and secondary school programs on English literature and French. In addition, a weekly "Focus on Teacher Education" program was broadcast on Sunday afternoons and Monday evenings.

Many of the radio programs that have been produced have been broadcast repeatedly year after year, because there is a lack of personnel to produce new programs and a very limited amount of functioning equipment in the recording studio. Much of the equipment in the recording studio is out of order and difficult to repair, since most of it was purchased twenty years ago.

The effectiveness of the educational radio broadcasts has also been hampered by the fact that it is no longer possible for the Ministry of Education to provide schools with teacher's guides or pupils' pamphlets for the radio

programs. Although some funds were provided for this purpose in the 1982 Ministry of Education budget, the funds were never released by the government. The lack of supplemental printed materials has made it especially difficult for teachers to utilize the science radio programs. Due to this problem, and also because the same series of science broadcasts had been repeated for several years, the science program series was dropped from the school broadcasting schedule in 1982, and replaced with a series of primary school music programs.

Factors Affecting the Quality of Basic Science Education

Textbooks and printed instructional materials. The Sierra Leone government provides schools with funds to purchase student textbooks for mathematics and English, although these funds are seldom sufficient. Texts for subjects other than mathematics and English are provided by the government as single copies for teachers only, and must be purchased by students if they wish to use them. As a result, many primary school children have no books of their own, and must rely on copying the teacher's notes from the chalkboard, after which they attempt to commit them to memory.

Science textbooks are not generally available to children in the primary schools. About half of the schools have purchased copies of some of the APSP teacher's guides;

these guides are distributed by the Science Curriculum Development Center at Njala University and are used most frequently by teachers who have attended science workshops conducted by the Center or by Peace Corps volunteers.

Library books on science topics are not available in most primary schools. Although the Ministry of Education School Library Service has a mobile unit that visits a limited number of schools each year, in most rural primary schools, library books on any topic are virtually nonexistent. Because most parents in the rural areas are not literate, the homes of most primary school children are completely without any type of reading material.

Although novels and short stories by African authors are available in some bookstores, there is no local production of children's literature in Sierra Leone. Several Ministry of Education officials stressed the need for locally-produced books and magazines for children on science topics, such as the APSP Science Library Series and the JETS science magazine that is produced in Zambia.

The 1976 Sierra Leone Education Review study stressed that there was a pressing need to establish a book production unit to develop inexpensive textbooks for primary schools that would make more books available to school

children and reduce the current reliance on imported textbooks. The 1976 study also emphasized the need to produce textbooks that were more relevant to the local environment and to the cultural background of children in Sierra Leone.

An AID/World Bank project for the production of secondary school textbooks is now underway at the Institute of Education in Freetown. Textbooks have already been prepared for a new integrated science course that is being introduced at the lower secondary level. However, the project director is experiencing difficulty in getting the texts printed, due to a paper shortage at the Government Printing Office.

Another AID/World Bank project is currently being negotiated to support the development of textbooks for primary schools. Primary science is one of the subjects for which a series of texts is being planned, and personnel at the Njala Science Curriculum Development Center are currently preparing the first drafts of these materials. However, Ministry of Education officials report that World Bank personnel are attempting to persuade them to utilize a series of primary science textbooks produced outside Sierra Leone by a large international publisher, rather than develop materials in Sierra Leone based on the extensive local experience with the SEPA program.

Teaching materials and media. Most primary schools in Sierra Leone are equipped with a limited supply of basic

teaching materials, such as chalkboards, home-made charts, flannel boards, flash-cards, and improvised counters for use in mathematics in the lower primary classes. However, less than four percent of the government's education budget is allocated to the purchase of teaching materials, including textbooks. Primary schools receive these funds on a basis of Le 2.00 ($1.62) per student per annum.

There is very little modern equipment in the primary schools. This is due not only to the high initial cost of items such as radios and tape recorders, but also to the fact that schools cannot generally provide for the security or maintainance of such equipment.

Although some primary school teachers improvise teaching aids from local materials, teachers frequently fail to do this because they have had no training or experience in the construction of such apparatus. For this reason, the teacher workshops and the special courses for teacher training college science tutors provided by the Njala Science Curriculum Development Center have emphasized the use of improvised apparatus made from local materials to teach science. As a result, some of examples can now be found of teachers in rural primary schools who are using improvised science equipment, such as balances made of bamboo and calabashes, or magnifying lenses made from burned-out light bulbs that are filled with water.

The Njala Science Center also maintains a workshop that is used to construct simple science apparatus from local materials. However, many of the power tools in this workshop are no longer functioning, due to a lack of spare parts or repair facilities.

Inservice training problems. Personnel concerned with inservice teacher education at the Ministry of Education and at Njala University expressed considerable frustration at the obstacles that impede their efforts to improve the teaching of science in primary schools. A severe reduction in the travel funds for educational personnel has made the organization of inservice workshops in rural areas increasingly difficult. In addition, the Njala Science Center's difficulty in securing funds to support the printing of science teaching materials has severely limited the distribution of the innovative materials developed by the Center.

These problems, which have both economic and political elements, will undoubtedly continue to distress the scientists and educators in Sierra Leone who have devoted much of their lives to the improvement of primary school science teaching, and who remain convinced that effective science education is crucial to the long-term development of their country. Yet it is important to realize that much has been accomplished with regard to the development of human

resources in Sierra Leone, notwithstanding the meager financial resources that have been provided to support these efforts. Biologist Danial Chaytor of Fourah Bay University recently summarized this progress in his evaluation of the long-term effects of the APSP/SEPA programs in Sierra Leone:

> Science is recognized now as an important part of basic education and is entrenched in the primary school curriculum. This means not just nature study as before, but some attempts to relate scientific notions to daily living. It also means the progressive involvement of children in "doing things" for themselves and sometimes even on their own.
>
> ...Another significant effect I can mention is the raising of the consciousness of the teachers themselves. Today, more than at any time previously, even untrained primary school teachers are aware of the importance of elementary science activities and are eager to attend workshops organized by the Institute of Education.
>
> Perhaps an equally significant effect is the introduction of the aspect of the technology involved in the primary science activities. The fact that children can make things for themselves, on their own, and the class as a whole can

recognize the product as a scientific product, has been a great gain not just in primary science but in the basic attitude to learning as a whole. This has contributed to the orientation of primary education towards community development, especially in rural Sierra Leone.

...We should remember that the task APSP set itself was a most difficult one. ... The fact that it actually made a lasting impact is a great tribute to the power of its ideas and the dedication of its workers. (Chaytor, 1982)

VI.

BASIC SCIENCE EDUCATION IN BOTSWANA

An Overview of Education in Botswana

Botswana is a sparsely settled country, with a population of about 800,000 and an area of approximately 223,000 square miles. The Kalahari Desert comprises 84 percent of the total area of the country; much of the population is concentrated near the eastern border where the major towns, roads, and industries are located.

Since 1964, the educational system in Botswana has included seven years of primary school, followed by three years of junior secondary and two years of senior secondary school. At the present time there are 467 primary schools, 23 government-aided secondary schools (forms 1-5), and 20 community junior secondary schools (forms 1-3).

The percentage of children attending primary school in Botswana is one of the highest in Africa. According to World Bank estimates, in 1977, 86.9 percent of the children who were between 6 and 11 years of age were enrolled in primary school. Unlike most other African countries, there is a higher percentage of girls enrolled in primary schools (93 percent) than boys (80.7 percent).

An automatic promotion system is used within the seven years of primary school. As a result, there is very little

attrition between standards one and seven. When children have completed standard seven, they take the Primary School Leaving Examination administered by the Botswana Ministry of Education to determine eligibility for entrance into junior secondary school. This examination currently includes sections on Setswana, English, mathematics, science, and social studies.

In 1980, the primary school enrollment in Botswana was about 172,000 pupils in standards one through seven (Botswana Ministry of Education, 1982). Although the construction of new schools has been assigned a high priority in the national budget, there is an acute shortage of primary school classrooms; in 1980, there were 5224 classes of primary school children, but only 3441 classrooms to accomodate them. As a result, children in many areas go to school in double shifts, and in rural areas many of the children in the lower classes have their classes outdoors under a tree.

The pupil-teacher ratio in Botswana primary schools is about 32:1. In 1980, the total number of primary school teachers was 5280, of which 72 percent were female. The number of primary school teachers has more than doubled since 1972, reflecting a similiar increase in the number of children attending primary school.

The primary school curriculum includes Setswana, English, mathematics, science, social studies, and some practical skills, such as needlework. The medium of instruction for children in standards 1-4 is Setswana; in the upper three standards, English is the medium of instruction. This policy has been introduced to establish Setswana as the national lanaguage, but it creates some difficulties for students and teachers who are not native Setswana speakers.

Currently, about one-third of the chidren taking the Primary School Leaving Examination are able to go on to junior secondary school. Thus, in 1980, of the 18,334 standard seven students taking the Primary School Leaving Examination, 6081 were able to enter form one in a junior secondary school (Botswana Ministry of Educaton, 1980)

After three years of junior secondary school, students sit for another selection examination, the Junior School Certificate. About half of the students who complete junior secondary school are selected to complete the two additional years of senior secondary school required to prepare for the Cambridge Overseas School Certificate "0" level examinations.

The large numbers of children who leave school after the Primary School Leaving Examination or the Junior School Certificate Examination present a significant problem to the Botswana Government. In 1965, a project which came to be

known as the "Botswana Brigades" was started by Patrick van Remsburg at Swaneng Hill Secondary School, in order to provide on-the-job training in building construction as well as job-related technical and academic instruction to school leavers and drop-outs. Van Remsburg's efforts eventually led to an expansion of the Brigades system into training projects in agriculture, dressmaking, spinning and weaving, and carpentry.

The financing of the Brigades projects is innovative in that the earnings of the trainees are used to pay a large part of the cost of the training programs. Although the government has encountered some problems in expanding the Brigades concept (especially in the area of agriculture), the Brigades trained about 1,300 tradesmen between 1965 and 1975 and an additional 2,200 between 1975 and 1981 (Finlay et al, 1981).

One of the problems that has been encountered in the Brigades is that children leaving primary school at age thirteen are often not sufficiently mature, physically and socially, to begin vocational training. Some Brigades have dealt with this problem by establishing one or two-year "bridging courses" to help prepare students for entry into a Brigade training program.

As a result of the recommendations made in the Report of the National Commission on Education (Education for

Kagisano), a plan is now underway to expand the educational system at the junior secondary school level, so that nine years of basic education can be made available to all children. The first step of this plan involves increasing the number of junior secondary schools so that two years of intermediate level education can be provided for all standard seven leavers. The next step will be to reduce the number of years of primary school to six, and to institute a three-year "intermediate school" program for all children. The new curriculum that is to be created for these intermediate schools will be more than an extension of the primary school curriculum; it will also reflect an orientation towards life in the community and the world of work (Husen et al, 1977).

The Ministry of Education has begun to implement this plan by making a commitment to expand the number of junior secondary schools so as to accommodate 50 percent of the primary school leavers by 1990. Plans are also underway to construct a new teacher training college at Molepolole to [illegible] the process of training teachers for the new intermediate school program, and a special study has been commissioned by the Ministry of Education to plan the curriculum for this training college (Cammaerts, 1981).

The effort in Botswana to expand the number of years of basic education to be provided to all children, and to make

the terminal years of this basic education more relevant to the world of work, parallels similar developments in other African countries, including Kenya, Tanzania, Zimbabwe, Guinea, Ghana, and The Gambia. There is a critical need to develop new types of science curriculum materials that will be appropriate for use in the terminal years of such expanded programs of basic education. This issue was the focus of much discussion at the 1982 UNESCO Conference of African Ministers of Education in Harare, Zimbabwe (UNESCO, 1982).

The Primary School Science Curriculum

The National Policy on Education, prepared by the Botswana Ministry of Education in response to the 1977 Education for Kagisano report (Husen et al), defines the following goals for primary education in Botswana:

> Primary education will aim to make children literate, first in Setswana, and then in English; to provide a basic command of mathematics; and knowledge of science and social studies. The syllabus and curriculum will orient children toward the realities of life in Botswana and prepare them for life in the physical and social environments they will experience after they leave school (Botswana Government, 1977, p. 3).

In 1977, a Curriculum Development unit was established at the Ministry of Education and subject panels were

appointed to prepare new syllabi for Setswana, English, mathematics, social studies, science, and religious education. These subject panels were composed of school inspectors, primary school teachers, teacher training college instructors, and curriculum development officers from the Ministry of Education.

The Primary Science Syllabus that the Science Panel completed in 1982 contains the following long-range objectives that children are expected to attain through their work in primary school science:

1) express awareness of, and interest in, the natural world surrounding them.
2) develop observation skills through activities such as examining plants, animals and non-living things and develop the additional skills required to record the observations through oral and written reports, as well as drawings and diagrams.
3) develop the ability to express themselves clearly in a scientific manner, which includes using a logical order, using scientific terms appropriately, and using relevant illustrations.
4) find out information for themselves by observation and investigation while using the teacher's assistance in drawing conclusions.

5) gather knowledge which will enable them to understand science concepts likely to be met in everyday life.

6) develop skills in using simple scientific apparatus such as rulers, thermometers, etc.

7) express awareness of the involvement of science in other school subjects and everyday life.

8) express awareness of science contribution to the social and economic life of the community (Botswana Ministry of Education, 1982, p. 1).

The new science syllabus stresses that children should learn science by doing, not primarily by listening to the teacher:

> The major concern is to make sure that pupils are physically and mentally involved in the science activity. Pupils must be encouraged to touch, smell, listen and examine in every way, the world about them. They should compare their findings, look for meaningful relationships and differences, and record what they find. As the guide to these kinds of experiences, you must provide ample time for children to tell you, and one another, what they have discovered. If possible, display the pupils records of observations in a prominent part of the room....

> It is important to remember that science learning, like most learning, is accomplished by doing. Encourage your pupils to participate by selecting activities that involve you least. Do not spend much time telling your pupils; let them find out for themselves through careful observation, measurement and classification. Make sure that every pupil has a part to play in making the activity a success. If it is not possible to have each pupil perform the activity, select the smallest groups possible to ensure greater involvement of individual pupils in the learning experience (p.4).

The Primary Science Panel is currently engaged in the task of preparing teacher's guides that include suggested science activities for each level of the primary school curriculum. As of this date, the guides for standard one through four have been completed.

The science activities for standards one and two are designed to develop skills such as the use of the senses, collecting and describing natural objects found in the environment, and recording and discussing these observations. In standard three, work on the development of these skills continues, with a further emphasis on the study of local plant and animal life, health, and nutrition.

At the standard four level, the focus turns to the description and analysis of natural phenomena such as weather and the seasons. Students are given practice in using skills such as observing, classifying, and measuring to analyze these phenomena. They are also encouraged to develop a sense of responsibility for their environment.

In standard five, the physical science concepts of light, heat, and electricity are introduced. In standard six, work on these topics is continued, as well as the study of health problems caused by communicable diseases and infant malnutrition. Simple machines are introduced in standard seven, as well as a variety of topics related to human reproduction and parenting.

In the primary schools, science is usually taught during two thirty-minute periods each week. However, what is taught and how it is taught varies greatly from school to school. The inspectors of schools generally agree that topics related to nature study are usually well-addressed, although teachers often completely ignore the natural environment outside their school and instead write notes on the chalkboard for their pupils to copy and memorize.

The teaching of topics related to physical science and technology is usually a source of much confusion for both teachers and children, and generally succeeds primarily in convincing children that science is boring, incomprehen-

sible, and definitely not something that they should consider pursuing as a career. It is therefore not surprising that a very small percentage of students elect to specialize in science, both in secondary school and at the University of Botswana.

The Training of Primary School Teachers

There are three primary teacher-training colleges in Botswana; they are located in Lobatse, Francistown, and Serowe. In 1980, the total enrollment of these three colleges was 844 students.

A fourth college is now being planned, which will be located in Tlokweng, near Gaborone. It is the goal of the Ministry of Education to produce 600 trained teachers per year by 1986, when Tlokweng will graduate its first class of primary school teachers.

In 1980, there were 5,280 primary school teachers in Botswana. However, 37 percent of these teachers were "unqualified"; i.e., they had never attended a teacher training college. Most of the teachers in this group are standard seven leavers or junior secondary school drop-outs hired by the Ministry of Education because it has no other way to staff the rapidly expanding primary school system. In the future, in order to give these untrained teachers the opportunity to become fully qualified, twenty percent of the teacher training college openings will be reserved for cur-

rently unqualified primary school teachers with at least two years of teaching experience.

The requirements for admission to a primary teacher training college are: (1) the completion of three years of junior secondary school, or completion of standard seven and at least two years of successful teaching experience, (2) the successful completion of the Primary Teacher's Entrance Examination administered by the Ministry each year, and (3) a successful interview at the college of choice.

In the teacher-training colleges, students follow a two year course of study, leading to the Primary Teacher's Certificate. The curriculum includes an emphasis on all of the subjects taught in the primary schools, as well as courses on teaching methods and educational psychology. However, the content of these courses varies considerably, partly because many of the Teacher Training College instructors are expatriates who are usually posted to teach in Botswana for only two or three years. The resulting rapid staff turnover makes it difficult for the Ministry of Education to implement significant changes in the curriculum of the teacher-training colleges.

The Education for Kagisano report is critical of the training currently provided to primary school teachers, and notes that training colleges seem to focus on giving teachers "a great deal of background education and pedagogial

theory and far too little development of the practical skills needed in the classroom..." (Husen et al, 1977, p. 68). The Education for Kagisano report also stresses that most teachers have an insufficient science background to teach the primary science course as outlined in the 1969 primary science syllabus, which was quite academic and attempted to cover many of the topics that are included in the secondary science syllabus.

However, there are some indications that publication of the new 1982 Primary Science Syllabus is having a positive effect on science instruction in the teacher training colleges. At Lobatse Teacher Training College, the science instructor is currently using a text entitled Teaching Primary Science, written by B.L. Young at Ahmadu Bello University in Nigeria. This text has many references to the African Primary Science Program materials and the SEPA approach to primary science teaching, and it was encouraging to find it in use in Botswana.

However, other than the use of this book, there is not much evidence in Botswana primary schools of the utilization of science as a vehicle for the development of self-reliant problem-solving skills in children. Although the Primary Science Panel stresses this approach in the new teacher's guides that are being prepared, the Science Curriculum Development Officer in the Ministry of Education believes that

much inservice education and additional curriculum development work will have to be done if the new science syllabus is to be successful.

Educational Radio Broadcasting

The Botswana Ministry of Education formed a Schools Broadcasting Unit in 1967 with the intent of producing educational radio programs that would enrich and supplement classroom teaching. The Broadcasting Unit is a part of the Department of Curriculum Development and Evaluation, but uses the recording studios and transmitter of Radio Botswana, the government radio station.

The Schools Broadcasting Unit provides programming for 54 fifteen minute program segments each week. Most of the fifteen minute programs are recorded in advance and are broadcast twice during the week in which they are scheduled. The primary school subjects for which programs are produced include Setswana, English, social studies, science, mathematics, and religious education. The timetable for the programs that were broadcast during the third term of 1982 is included in Appendix C.

Fifteen minute science programs are broadcast each week for children in standards four, five, six, and seven. The medium of instruction for these science programs is English, although an effort is currently underway to develop some science programs for the lower primary grades on the wild-

life of Botswana that will be broadcast in Setswana. The topics of the science programs broadcast during the third term of 1982 are also included in Appendix C.

Reginald Salisbury, the British director of the Schools Broadcasting Unit, stresses that his intent in developing the science programs has been to provide interesting supplementary information relevant to some of the topics in the science syllabus, so as to stimulate children's imagination and improve their listening skills. He does not believe that radio is an appropriate medium for teaching abstract science concepts or developing problem-solving or manipulative skills, but does think that radio can provide some up-to-date information that should be of interest to children.

The science programs produced by the Educational Broadcasting Unit are currently being written by a British primary school teacher from the English Medium School in Gaborone, which is attended primarily by the children of expatriates. The broadcasts are produced by having two Botswana children alternately read a script in which they ask each other questions about science and describe science experiments that they are pretending to be doing.

An effort has been made to select topics for these science programs that lend themselves to the use of interesting sound effects. Thus, in the program for standard four

on floating and sinking, the discussion of boats includes a section on the sounds that different boats make, such as the sound of a speed boat on a river, or the sound of the Hovercraft that is used in the Okavango Delta swamp.

The Schools Broadcasting Unit has encountered several problems related to its attempt to broadcast educational programs to schools. One problem is that the reception of Radio Botswana is poor in rural areas that are distant from Gaborone. In addition, few rural primary schools are able to afford the purchase of a shortwave transistor radio, and the need to purchase batteries to operate such a radio is also a problem for some schools. In addition, some teachers find that it is difficult to arrange their teaching schedules so as to take advantage of the broadcasts at the time that they are scheduled.

As a result, the Director of the Schools Broadcasting Unit intends to develop an alternative distant education approach, involving the use of educational programs recorded on tape cassettes that will be provided to the schools. This kind of an approach is considered feasible as a result of a gift of several hundred battery-powered cassette recorders from the government of Japan. These cassette recorders are currently being distributed to primary schools throughout Botswana, and the Schools Broadcasting Unit hopes to be able to produce tape-recorded programs that can be distributed to schools in the near future.

Unlike the situation in Sierra Leone, visits to primary schools and discussions with teachers and primary school headmasters revealed that a significant number of teachers were listening with their classes to the science programs produced by the Schools Broadcasting Unit. It appeared that many teachers were listening to the broadcasts because they were not sure what they should be teaching in science and had no other science materials available to them.

However, teachers seemed to be quite confused about the purpose and content of the science broadcasts. Most teachers seemed to assume that the radio programs would teach the children everything they needed to know about the science topics in the syllabus. As a result, many teachers would try to write down everything they could glean from a science broadcast on the chalkboard and then would direct their pupils to copy and memorize it. Because no written materials were provided, the teachers and school children were frequently confused about the meaning of new words that were introduced, such as "Hovercraft."

Many teachers were concerned about their ability to provide accurate notes for the children after hearing a program themselves for the first time. It appeared that much of their anxiety was due to the fact that a science paper had recently been added to the Primary School Leaving Examination, and teachers were very concerned about how their pupils were going to perform.

Members of the Primary Science Panel and science curriculum development personnel in the Ministry of Education expressed some reservations about the educational value of the science radio broadcasts, and some were concerned that the broadcasts might tend to undermine their efforts to introduce hands-on problem-solving science activities into the primary schools. The science instructors at the teacher training colleges had similar views, and most said that they usually discouraged students in their classes from using the radio programs to teach science.

However, a few science instructors said that they believed there might be some value in providing tape recorded programs on some descriptive science topics to schools, for use as supplementary resource materials on selected topics. However, they stressed that visual instructional materials such as pictures, teacher's guides and student booklets would also need to be provided with each cassette.

Problems Affecting the Quality of Basic Science Education in Botswana

Teacher training problems. In the past, there has not been an attempt in Botswana to mount the kind of teacher-training effort that would be necessary to implement an effective primary school science program. Because the Ministry of Education has been primarily concerned about the fact

that over one-third of the primary school teachers have no professional training of any kind, it has been difficult to focus special attention on the need to improve the teaching of science.

As mentioned earlier, at the pre-service level, the problem of introducing a new science curriculum in the teacher-training colleges is complicated by the fact that most of the training college science instructors are expatriates on short-term contracts. The rapid turnover of the faculties of these institutions tends to make any efforts to introduce curriculum change through the teacher-training colleges quite ephemeral.

The Ministry of Education and the University of Botswana have recently initiated a "Primary Education Improvement Project" with the assistance of USAID. One of the objectives of this project is to provide university-educated Botswana staff members for the three (soon to be four) primary teacher-training colleges.

In conjunction with this project, a new four-year Bachelor of Education program is being created at the University of Botswana that will admit about 30 students per year. A team of five consultants from Ohio University, provided by USAID, is helping to set up this new degree program at the University of Botswana. However, because none of the Ohio University consultants has a science education background,

it seems unlikely that significant improvement in the quality of primary school science education will result from this project.

Therefore, the chief mechanism that must be relied upon currently to effect improvements in the teaching of science in primary schools is inservice teacher education. Because there is no national institute of education in Botswana, the Ministry of Education is directly reponsible for the inservice education of primary school teachers.

In the recent past, a special inservice education team of school inspectors was organized within the Ministry to assist district education officers in providing a program of inservice training for primary school teachers. Some of these inservice education inspectors were attached to teacher resource centers that were established at several locations.

Several Botswana school inspectors and education officers indicated that the inservice education program provided by this team had been reasonably effective. However, the Ministry of Education's inservice team was disbanded when the USAID/OHIO University Primary Education Improvement Project was begun in 1981, because the new project was to include an inservice, as well as a preservice, education component. Unfortunately, the inservice workshops provided by the Ohio University team have not been well received by

primary school teachers. In addition, the Ohio University team seems to have generated a considerable amount of hostility and distrust among district education officers and inspectors of schools in the regions in which they have been working. The general concern seems to be that the Ohio University consultants are not very sensitive to the local culture and are not making a sufficient effort to seek advice from Botswana educators.

As a result, the current prospects for providing an effective inservice teacher-training program to improve the teaching of science in primary schools through the University of Botswana are not very bright. However, there is another inservice teacher education effort in Botswana that is showing considerable promise. The series of workshops for primary school teachers sponsored by the Teaching Aids Production Unit (TAPU) in Francistown is having a considerable impact on teachers throughout Botswana, and will be discussed in more detail in the next section.

Lack of instructional materials for teaching science. In Botswana, the funds budgeted for instructional materials are several times larger than those provided in many other African countries. In 1983, an allocation of 16 Pula ($14.58) per pupil was provided to each primary school for the purchase of textbooks and instructional materials. However, visits to primary schools revealed that in the

past a very small percentage of this allocation has been spent on science instructional materials or supplies.

The Ministry of Education's 1983 catalog for primary school textbooks and supplies does not list any children's science books or other printed science resource materials for use by teachers, although a variety of such materials are listed for other subjects. The catalog does include a requisition form for science supplies and equipment that lists seventeen items, including some simple apparatus that might be used for student experiments, such as thermometers, batteries, flashlight bulbs, insulated wire, and magnifying lenses. However, the requisition list also includes a number of expensive pieces of imported equipment, such as a beam balance ($27) and a ball and ring expansion apparatus ($10). Due to the high cost of such items, when schools purchase these items, they buy only a single piece of apparatus that is then used for teacher demonstrations. As a result, children seldom have a chance to engage in "hands-on" learning experiences themselves.

The problem of supplying schools with low-cost science apparatus and supplies has been solved in some developing countries by creating a local science materials production center. In Botswana, the Teaching Aid Production Unit (TAPU) established by the Ministry of Education in Francistown has begun to work on this problem. TAPU has a broad

mandate to design simple low-cost teaching aids for primary schools, such as portable blackboards, clock faces, number rods, abacuses, flannelgraphs, etc. A few simple pieces of science apparatus have been designed and produced at TAPU, such as battery holders, bulb sockets, switches, insect cages, wind vanes, and simple two-pan balances.

The TAPU staff conducts workshops throughout the school year in many different locations in Botswana. At these workshops, teachers are taught to assemble their own teaching aids from pre-cut materials manufactured by TAPU at its Francistown facility. In addition to producing such apparatus, TAPU also operates an offset printing shop that produces printed instructional materials for use in primary schools. These printed materials include several student booklets on applied science topics, such as Protecting Our Earth, a children's book on erosion written by a U.S. Peace Corps volunteer, and Vehicles of Botswana, a lower primary booklet on traditional and modern forms of transportation in Botswana. (These TAPU materials are included in Appendix C.)

The need for a Science Materials Center in Botswana. A 1979 UNESCO-sponsored meeting of Ministry of Education officials from Botswana, Lesotho, and Swaziland resulted in the formulation of a recommendation that the TAPU model be used to establish a center for the design and production of science materials and apparatus in Botswana. The report of

this meeting also suggested that the Botswana Brigades might be involved in the production of some items of apparatus, possibly on a sub-contract basis.

Ideally, in addition to production facilities for the manufacture of science apparatus, such a Science Materials Center should also include a science curriculum resource library, media facilities for the development of printed instructional materials, a simple offset printing facility, and classroom space for conducting the teacher-training workshops that would be needed in conjunction with the pilot testing of materials developed at the Center. In addition, it would be desirable to set aside a limited amount of space to create a small children's science and technology center, where visiting children and teachers could observe and engage in a number of hands-on science learning activities.

Such a Science Materials Center would provide facilities for the development of instructional materials for the teaching of science in primary schools. The Center could also begin work on the new intermediate school science program that must be developed in preparation for the planned expansion of basic education at the junior secondary level in Botswana.

George Makunga, Science Education Officer in the Ministry of Education, is anxious to establish such a Science Center for this purpose and is looking for a source of foreign

aid to enable the Ministry to proceed with such a project. It has been suggested that it might be feasible to locate such a Science Materials Center at Tlokweng, adjacent to the new teacher training college that is now under construction.

VII

RECOMMENDATIONS FOR FUTURE USAID SCIENCE EDUCATION PROGRAMMING

The Need for USAID Programming to Improve Basic Science Education

A paper prepared by the International Council of scientific Unions (ICSU) for the 1979 UNCSTD conference stresses the need to improve the quality and effectiveness of science education in the less developed countries and provides a clear rationale for new programs targeted at the improvement of basic science education:

> It is our opinion that the healthy growth of science and technology in any country depends critically on the availability of technically and scientifically trained manpower and that it is the responsibility of the indigenous educational system to provide such manpower.
>
> Furthermore we would maintain that the successful exploitation and assimilation of scientific and technical developments can only proceed with the support of an interested and informed public. The responsibility for fostering this interest, and for ensuring that the public is properly informed rests

clearly wth the educational system of the country concerned. Any policy that fails to recognize the importance of these two factors can, at best, produce only short term improvements; at worst the country concerned could experience serious failures in technological development.

Long term sustained growth can be assured only if the money invested in science and technology is matched by the provision of funds for complementary educational programmes directed both to the preparation of scientists and technologists and to the improvement in scientific literacy of the population as a whole (ICSU, 1978, p. 5).

The ICSU report indicates that the following kinds of efforts are needed:

In order to promote self-reliance and understanding there needs to be a massive reappraisal of the content of existing courses, ...if they are to reflect the needs of the developing countries.

It is also accepted that there is a need to change attitudes and this requires the development of new teaching techniques.

> For this there must be substantial assistance for the provision and support of teacher-training and teacher retraining....
>
> There is also a considerable need for the development and production of low-cost locally-produced equipment and teaching aids. A number of developing countries are working on this, ...but further support is necessary (ICSU, 1978, p. 10).

The previous chapters of this study have noted numerous examples of the past involvement of American scientists and educators in efforts to improve the quality of science education in African countries during the past two decades. However, in more recent years, USAID activities in the area of science education have dwindled. As a result, some momentum has been lost, and some science educators in African countries that were originally trained in USAID-sponsored projects have become isolated, both from new developments in science education and from the expertise of colleagues in the United States who might be able to assist them.

The following recommendations suggest some ways by which USAID might help remedy this situation by intiating new programs to improve basic science education in sub-Saharan Africa.

Recommendation 1: Initiate projects to develop science curriculum materials and apparatus for use in the terminal years of schooling in countries where basic education is being expanded to include early adolescence (ages 12-14). In addition to developing self-reliant reasoning skills, such curriculum materials also need to be focused on the relationship of science and technology to the world of work, to improvements in the quality of life in rural communities, and to the preservation of the natural environment.

Although much as been said about this need at UNESCO conferences of African ministers of education, few African countries have the fiscal or scientific manpower resources to produce the new types of science curriculum materials that will be needed for terminal education programs at the junior secondary level. Because in the United States there has been a considerable amount of interest in recent years in the issue of scientific literacy and in the development of science curriculum materials appropriate for the middle and junor high school levels, science curriculum development centers in the U.S. have acquired a considerable amount of experience and expertise in this area. It is therefore appropriate that USAID should capitalize on their expertise by initiating programs to assist African countries with the development of new junior secondary school science curriculum materials.

Recommendation 2: Undertake a project to determine the feasibility of establishing a local science materials center in a less developed country to design and produce low-cost instructional materials and apparatus for the teaching of basic science.

The British Commonwealth Secretariat has sponsored three conferences in recent years to discuss alternative approaches to the local design and production of school science equipment; these regional seminars were held in Nassau, Bahamas (1976), Dar es Salaam, Tanzania (1977), and Lae, Papua New Guinea (1979). The reports of these conferences have been published by the Commonwealth Secretariat (1977a, 1977b, 1979), as well as a report which describes in detail four existing materials production centers which are now functioning in the less developed countries (Apea & Lowe, 1979).

A UNESCO meeting held in Manzini, Swaziland (1979) has made specific recommendations regarding the establishment of science equipment production centers in the countries of South-Central Africa. More recently, the report of the UNESCO Harare Conference of African Ministers of Education (1982) stressed the need to establish more science materials production centers in Africa in order to reduce the costs of acquiring and maintaining science apparatus.

These reports indicate that a local science materials production center can be a viable and useful element in a country's development efforts, and that many African countries would like to establish such a center. Because the United States has considerable expertise in the design and production of low-cost science apparatus, this is an appropriate area for USAID to provide assistance. The outcomes of such a project could include feasibility data, designs for apparatus that can be manufactured from local materials, and information on manufacturing techniques that are appropriate for the small-scale production of science apparatus in developing countries. This information could be published and shared with science education centers in other regions of the world, and would provide an opportunity for the transfer of technology appropriate to the local situation.

Recommendation 3: Sponsor a project to develop a structured program of inservice workshops to (a) help prepare primary school teachers to utilize science teaching as a vehicle for the development of self-reliant thinking skills in children and (b) familiarize teachers with some aspects of science and technology that are relevant to local problems of economic and community development.

The development of new approaches to the in-service training of science teachers is essential if curriculum improvement programs are to result in substantive changes in

the way that students are taught. Although the large-scale implementation of programs in the less developed countries must ultimately be carried out by local personnel, there is a need to learn more about how science education programs that have been found to be effective on a trial basis with small groups of teachers and students can be implemented effectively with large numbers of teachers. Studies of effective implementation strategies and research into the processes involved are both needed.

There is also a need to support the development of new teacher-training materials to introduce primary and intermediate school teachers to new approaches to the teaching of science and technology. Some excellent teacher education materials have been developed by several projects in the United States, such as the Intermediate Science Curriculum Study Individualized Teacher Preparation Program modules (ISCS, 1975) and the Science Teaching and the Development of Reasoning units developed at the Lawrence Hall of Science (Karplus et al, 1977).

Recommendation 4: Initiate an experimental project to develop children's literature, such as booklets and magazines, on science topics for young people in African countries and make use of the mass media, such as newspaper features for children and children's radio programs, to popularize science and scientific approaches to the solution of

local development problems. The materials produced by such a project could be used both out-of-school and in-school for the enrichment of basic science instruction.

Educators in many African countries have stressed that there is a critical need to provide reading material on topics related to science and technology for young people in African countries. Most African children have virtually no access to children's literature other than textbooks, and in most countries, science textbooks are not provided to primary school chidren. USAID could help to remedy this situation by supporting the development of a series of children's books or a magazine for young people focused on science and technology. Such publications could include information on applications of science and technology that are appropriate to the local situation, descriptions of the work of local scientists and technologists, and stories about young people who find ways to solve problems through the use of science and technology.

Several small books of this type have already been published as a part of the Science Library Series of the African Primary Science Program. The many "how to do it" booklets published in the United States for 4-H clubs could provide another model on which to base publications for junior secondary school age children.

Efforts could also be made to develop a variety of newspaper feature pages for children on science and technology topics. Such features could be distributed efficiently through the newspaper distribution networks that already exist in many African countries, and it might be possible to find ways to enlist the support of local advertisers to underwrite some of the production costs. A similar approach might be used to produce a series of educational radio programs that focus on science and technology topics, similar to the science features that are included in "All Things Considered", the Public Broadcasting System's magazine-format radio news program. Topics which might receive special emphasis included local applications of science and technology, scientific explanations of traditional technologies, and biographies and news reports about local scientists and technologists.

Regarding the potential use of distant education approaches to teach science in the schools, the following summarizes the conclusions reached in this study:

- If audio science instruction is to be provided, the use of tape cassettes is preferable to radio, so that the pace of science instruction may be controlled at the listening site to mesh with students' investigations and their discussion of their results.

- Because it is essential in the teaching of science that teachers be able to respond to students' individual observations and responses, the need for teacher-training is not significantly diminished by using radio or tape cassettes to augment science instruction.
- When audio cassettes are used to provide science instruction, past experience indicates that carefully structured teacher's guides and student activity booklets are also needed. The development of such well-designed printed and visual materials requires considerable time and effort. However, when such structured printed materials are made available, as in Zimbabwe, the need for tape cassettes diminishes, because the recorded audio instructions become redundant
- The use of radio or tape cassette technology is therefore not very appropriate to the task of directing basic science instruction, although it might be useful for enrichment purposes, as described earlier.

It is therefore not recommended that USAID embark on a project to demonstrate the use of distant education techniques for formal science instruction.

Recommendation 5: Establish a Science Education Resource Center that would help keep educators in the less developed countries up-to-date on recent developments in science and technology education. In addition to developing a network through direct correspondence, such a center might publish a quarterly newletter on science and technology education topics such as the design of low-cost apparatus, new develpments in science teaching in various parts of the world, and new developments in science and technology especially relevant to the problems of less developed countries.

The networking function of such a science education resource center would be most effective if funds were provided for it to sponsor periodic summer study conferences on science and technology education issues, similar to the conferences sponsored in recent years by the British Commonwealth Secretariat. In addition to seminars for the study of current science education problems, such summer study conferences could also generate prototype instructional material on science and technology topics relevant to life in sub-Saharan African.

Such instructional materials are urgently needed in most African countries, but few countries have the scientific manpower needed to develop them. The summer workshops sponsored by the African Primary Science Program in Entebbe,

Akosombo, and Dar es Salaam could be used as a model; these workshops succeeded in generating a considerable amount of innovative primary science curriculum materials by providing an opportunity for collaborative work involving African and American scientists and educators.

* * *

In making the above recommendations, an effort has been made to consider the current realities affecting basic science education in sub-Saharan Africa, and to respond to some of the critical needs that have been identified by African educators and scientists. However, some African educational leaders have expressed a concern that USAID might initiate science education activities that would not mesh with past and current indigenous efforts to improve basic science education, or be counter-productive to the achievement of locally-defined program goals.

To dispell such concerns, it is essential that USAID enlist the involvement of African scientists and educators in the design of future science education projects much earlier than the site selection phase. Such collaborative planning would yield important dividends, not only in the reduction of distrust, but also in the design of USAID program efforts that would have a greater long-term effectiveness, and a greater potential for replication in a number of African countries.

The Endicott House Conference on African Education, convened with United States government support prior to the initiation of the African Primary Science Program, demonstrated that such an approach to project planning is a feasible option for USAID. The long-term impact of the APSP and SEPA programs provides evidence that such a collaborative approach to project planning can also be cost-effective, and produce lasting benefits.

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BASIC SCIENCE EDUCATION

IN

SUB-SAHARAN AFRICA

APPENDICES

Douglas M. Lapp

February, 1983

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APPENDIX A

Materials Related to the APSP and SEPA Programs

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A Teachers' Guide To The African Primary Science Program

APSP

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A Teachers' Guide to the African Primary Science Program represents the collective ideas and classroom experience of many people in several African countries: science educators, teachers, tutors, writers and others who have worked in the Program and developed and trial taught the curriculum materials.

This guide is based on a similar one produced for Sierra Leone by the Science Centre at Njala University College.

Comments and suggestions for making this booklet more useful to teachers are welcome. Correspondence should be addressed to your nearest Science Centre, or to:

Science Education Program for Africa (SEPA)
P.O. Box M 188
Accra, GHANA

Science Centres:

Elementary Science Unit
Ministry of Education
P.O. Box M 188
Accra, GHANA

Natural Sciences Education Section
Kenya Institute of Education
P.O. Box 30231
Nairobi, KENYA

Science Centre
Domasi Teachers College
P.O. Domasi, MALAWI

Science Curriculum Centre
Department of Education
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A TEACHER'S GUIDE TO THE AFRICAN PRIMARY SCIENCE PROGRAM

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INTRODUCTION

The African Primary Science Program has produced a collection of materials that introduce new ways of teaching science. The Program has been based at Science Centres in Ghana, Kenya, Malawi, Nigeria, Sierra Leone, Tanzania and Uganda during the past six years.

A large number of people have contributed to the Program in various capacities as advisors, administrators, science educators, developers and evaluators. And countless numbers of teachers and tutors have helped shape the Program by joining in teacher training workshops, trial teaching materials in the classroom and making valuable contributions to the contents and activities in the written units.

The teaching materials described in this guide have had extensive use in primary schools in Africa before appearing in their present printed trial editions.

Pupils, Teacher, and Classroom

The Program believes that children learn best, and understand more about their environment, when they are actively engaged in their own investigations and working with local materials of all kinds. With some guidance from the teacher, children are given the freedom to choose their own ways of using materials and finding answers to their own questions.

In this way of teaching, the child becomes the doer, learning from the materials he works with, and the teacher becomes the listener and guide, teaching by posing questions and suggestions when the child seems in need of them.

Children also need to share ideas and learn from one another, as well as from the materials and the teacher. In Lower Primary classes, this sharing builds slowly from experience. Older children can begin to look at questions asked by other children and the teacher, and can share and discuss problems. They are prepared to spend more time observing experiments and questioning results. They find reason to keep accurate records of their findings, and compare and argue their findings with those of others. It is suggested that Upper Primary classes work in small groups of four or five children.

Two booklets will help the teacher get started in teaching science in this free inquiry, activity-centered way. These are *Making a Start* and *Introduction to Lower Primary* which are described more fully on pages 4 and 5.

Choosing a topic of study and reading the units in that area of interest will also be helpful to the teacher. It is suggested that teachers try the activities in a unit themselves before beginning work with their pupils.

In order to teach science by providing many activities, a variety of materials are needed for children to manipulate and explore. Most can be scrap or used materials and need not be purchased. Many of these can be collected locally, and children can help the teacher collect things needed for a particular unit. Identifying and collecting useful materials and making equipment are themselves an important part of science learning for children.

There are certain materials that are valuable to have available continually in and around the classroom.

Containers:

Cardboard cartons, large basins or pails, clay pots, jam jars, bottles, a variety of tins including large petrol tins, calabashes, coconut shells, match boxes, cigarette boxes

Papers and other materials:

Newspapers, newsprint, cardboard, foil from cigarette boxes, cloth, netting, wire screening

Woods and grasses:

Planks, poles, tree branches, a variety of small pieces of wood, slender long twigs, reeds or thick grasses, pieces of bamboo

Liquids and powders:

Water, paraffin, oil, fats, sugar, salt, starches, soap

Other useful items:

Sand, pebbles, flowers and roots for making paints, dyes, raffia for making brushes or as a substitute for rope, cotton thread, string, rope, cotton thread spools, bottle tops, wire of various kinds, plastic tubing, old tyres and inner tubes, nails, nuts and bolts, drawing pins

Tools and equipment:

Hammer, saw, drill, machete or panga, balance, collecting nets, hand lenses, microscopes, a timing device, candles, matches

Many of the tools and pieces of equipment can be made by teacher and pupils. Suggestions, descriptions and in some cases patterns for constructing a variety of classroom equipment can be found in several of the units.

Home-made balances are described in *Balancing and Weighing*. The two "Measuring Time" books have suggestions and patterns for making timing devices. "Making Things Look Bigger" provides patterns for making cardboard magnifiers and microscopes and suggests ways to make longer-lasting microscopes. *Tilapia, Chicks in the Classroom*, and *Small Animals* include ideas for making an aquarium, cages and incubators, insect cages and catching nets.

One entire unit, *Tools for the Classroom*, gives directions for making a quite complete set of classroom tools from tree branches, scrap wood and bamboo with small expenditures needed for saw blades, nails, and nuts and bolts.

The Units

Just as the Program emphasizes flexibility and freedom for the child, the teacher is free to decide how best the units can be used for maximum learning and management of his classroom.

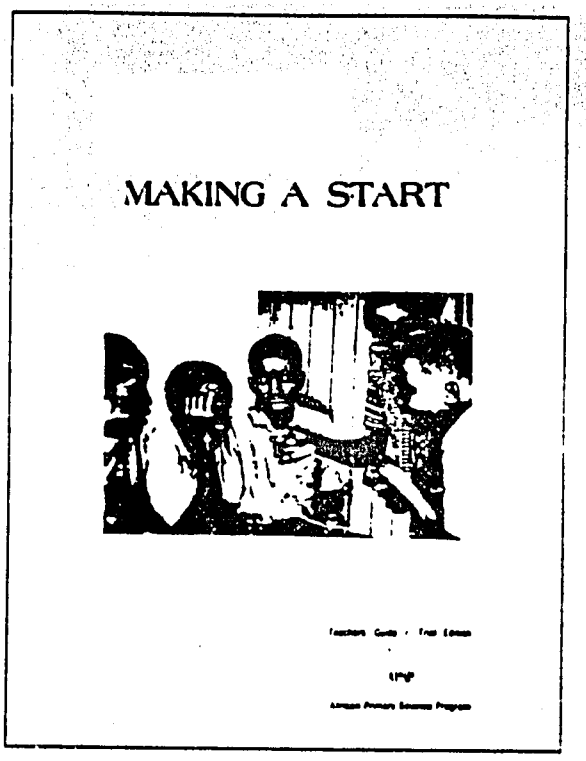
The summaries which follow describe the essential purpose and activities of each unit. From these, a teacher can choose which of the topics can be a beginning point. The units can be related in a variety of ways other than those suggested, and the teacher will know into what areas the children's investigations lead them.

Materials needed to teach a unit are listed, but substitutes and additions could be made.

The APSP units may be used at age ranges other than those suggested. The teacher is encouraged to try any of the topics that meet his class requirements.

Estimated times are meant to indicate possible duration of unit activities, but this again depends on the classroom needs and the interest of the children.

The unit description section has three divisions. The first describes the Lower Primary Activities. The second describes Upper Primary Biological Sciences, and the third, Upper Primary Physical and Chemical Sciences. The units in the latter two divisions are listed in order of suggested class levels.



Making a Start was written as a guide for teachers using the units of the African Primary Science Program at all levels of the primary school. This booklet gives guidance and suggestions for organising classrooms, and for encouraging children to manipulate materials and to pose and solve problems. This way of working allows pupils to become, in part, responsible for their own learning and to develop many skills — counting, reading, writing, drawing, painting, and learning facts and how to find knowledge that is helpful.

From *Making a Start:*

"We talk a great deal about the importance of science in the development of countries and the need to include science in the Primary School curriculum. Many people in education have explored ways of doing this. Each has emphasized the need for children to be actively involved, working with materials and gaining understanding from these experiences.

"The African Primary Science Program has been developing approaches to science teaching during the past five years. You may have seen some of the teachers' guides using these new approaches, or have been to an in-service training program.

"You may be considering teaching science in your classroom. If so, you may find this booklet of help. It is written to help you, the teacher, begin work in your classroom."

INTRODUCTION TO ACTIVITIES FOR LOWER PRIMARY

Activities for Lower Primary

Introduction

This is an introduction to the use of activities as a way of teaching science in lower primary classes. The ideas, however, will be useful to teachers at all levels of the primary school.

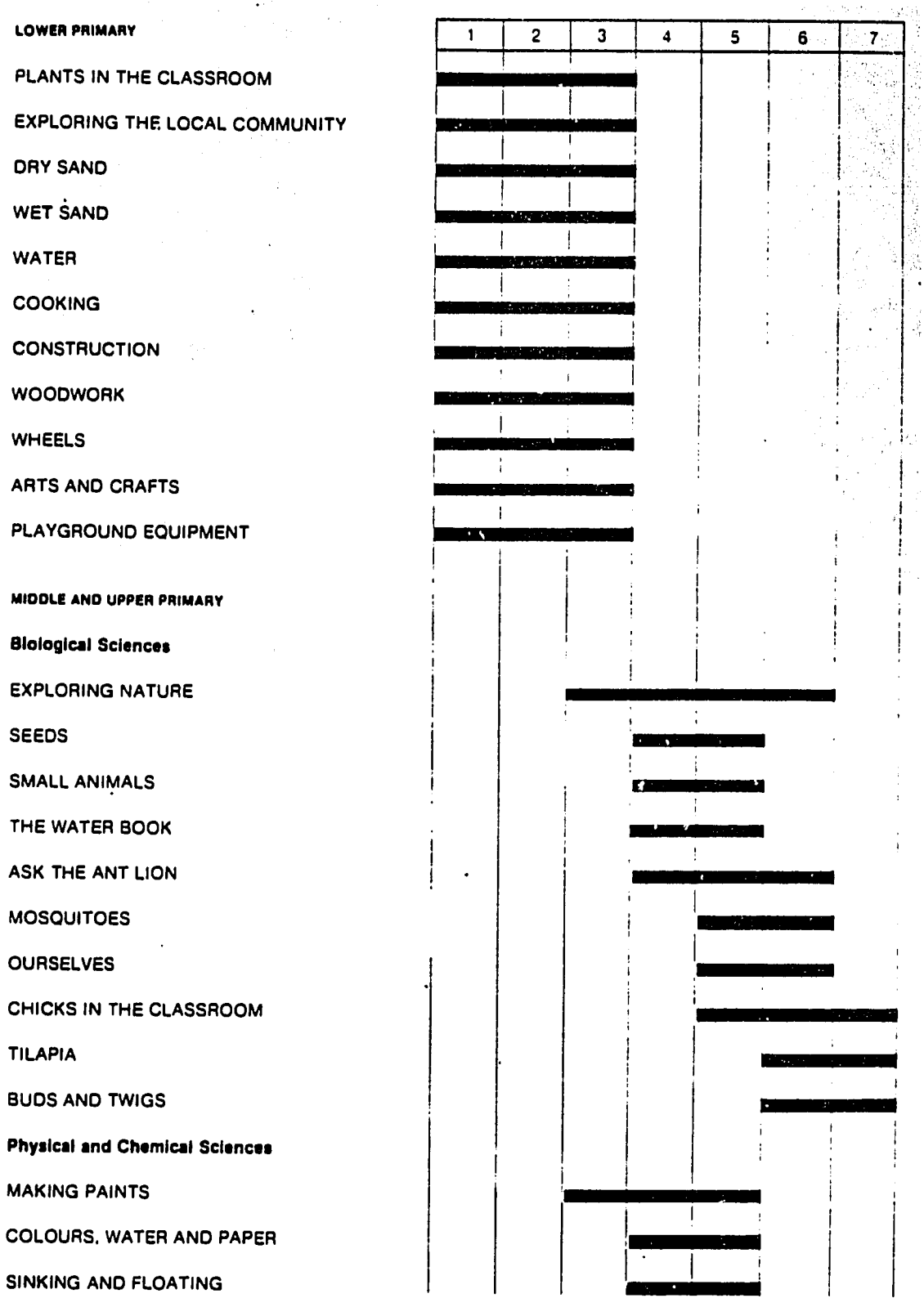
The booklet discusses the value of activity periods and possible solutions to the problems teachers may encounter. Comments are made on how a teacher can provide activities which are based on the earlier experiences of the child.

The role of the teacher in finding and organising materials, introducing activities, and observing and recording the involvement of pupils is discussed. Ideas for developing language skills through dramatic play and mime are also suggested. Hints are given for gathering and storing materials and for displaying the work of the children.

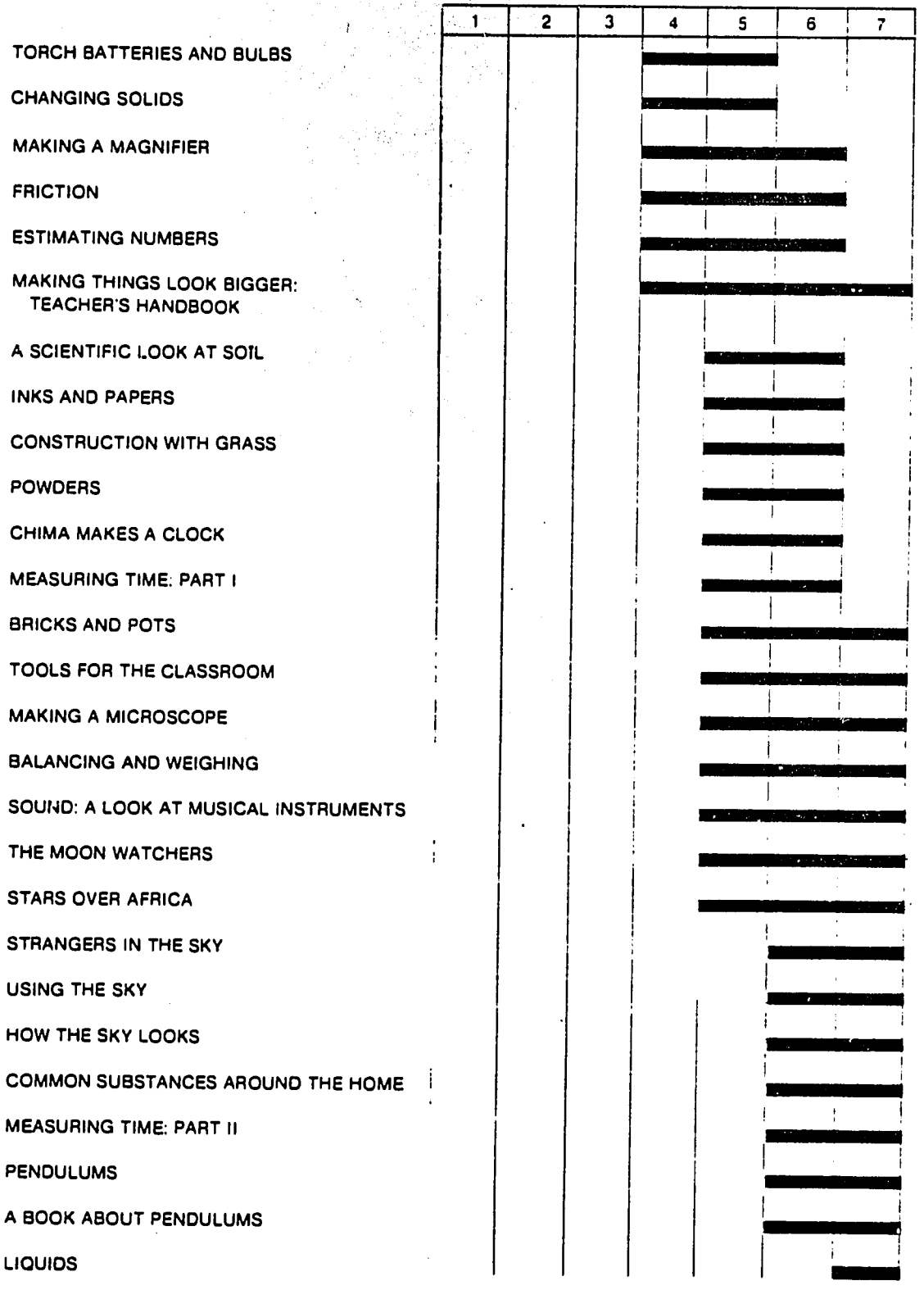
The amount of time needed for activities is discussed, and the variety of ways the activities in the ten separate units can be inter-related is described. Each unit in the series suggests ways of observing pupils as they work so that the teacher can raise questions which lead to further development of the children's discoveries and skills.

The Lower Primary series is regarded as a variety of continuing experiences and activities for children which are extended over a two-year period.

SUGGESTED CLASS LEVELS



SUGGESTED CLASS LEVELS



Lower Primary

PLANTS IN THE CLASSROOM

Activities for Lower Primary

Plants in the Classroom

Description

This booklet presents a variety of activities for children. Young children can collect seeds, leaves and plants of various sizes, colours and shapes, and work with them. They can make models of the country-side, an activity which will help them to observe their natural surroundings more closely.

The unit suggests a series of problems and experiments designed to make children more familiar with growing plants. They discover that every plant grows in its own way, yet there are similarities. Skills such as measuring, weighing and recording are developed.

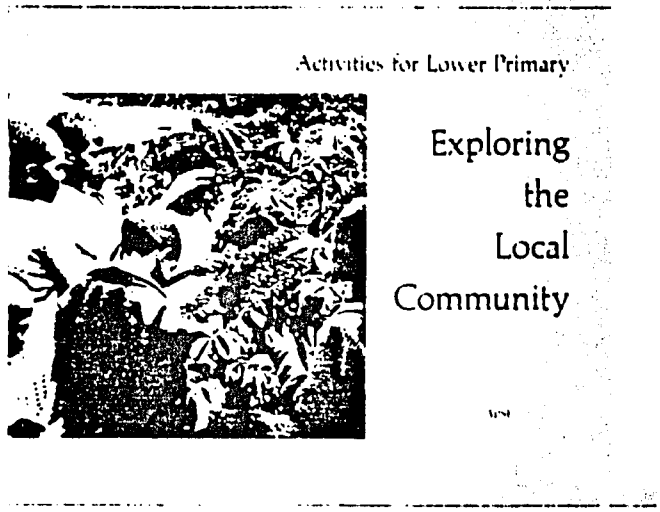
Materials

Sandy soil, clay soil, farm soil, rocks and stones, seeds, leaves and twigs, old tins, scraps of wood, additional things children choose as they are out collecting

Class levels

1, 2, and 3

8



Description

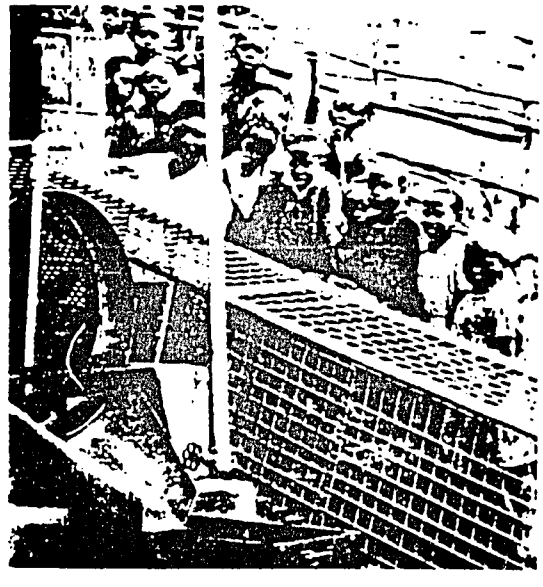
The activities suggested build upon the children's natural interest in the community. Observing the nearby environment and collecting materials can be a starting point for many investigations. Teacher and pupils might visit the blacksmith or the tailor, or such places as the market, a local farm, or a secondary school. When the children return to the classroom, pictures can be painted, models can be made, and stories told and acted out.

Materials

The community

Class Levels

1, 2 and 3



Activities for Lower Primary

Dry Sand

Description

Working with dry sand is an activity which will appeal to many children. They enjoy the feel of dry sand; they can draw in it, and they can fill and pour with it as they do with water. As children work with sand, there are many possibilities for using mathematics when they are measuring and filling. There are opportunities to develop language and science as the children experience the qualities of the material.

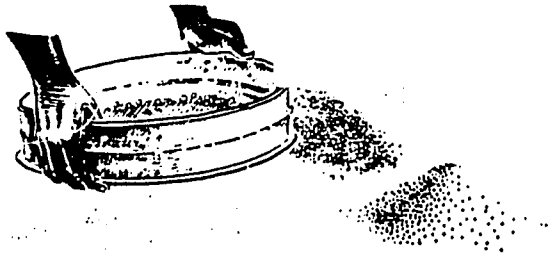
Materials

Dry fine sand and coarse sand or gravel, tins, gourds, funnels, troughs, sieves or sifters, tins of various sizes, large container for sand, a simple balance which can be made as described in the unit

Class levels

1, 2 and 3

Differences in Sand



Wet Sand

Description

Wet Sand provides outdoor activities for children. Activities such as building model roads and houses, making cakes and making patterns in wet sand will help children to develop the ideas of number, volume, capacity, shape and size. Activities could include comparing colours, textures, and other properties of different types of soil.

Materials

If the activity is done indoors, a large wooden box or tub is needed for the wet sand. Also provide wide-mouthed tins and jars, coconut shells or gourds, sticks, leaves, seeds, rocks, shells, bottle tops, cups, plates, things to dig with.

Class levels

1, 2 and 3

Activities for Lower Primary

Water

Description

Water is an exciting material which attracts children naturally. Water play will provide pupils with an opportunity for mathematics and language work, as well as giving experiences in science. Children work with containers, sieves, funnels and water. They can pour and measure, discover water pressure and water flow. They can try to float and sink objects, mix colours in water and make soap bubbles.

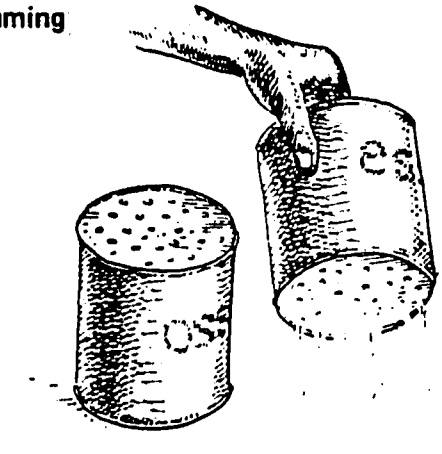
Materials

Water, soap, sieves, funnels, tins of all sizes, tubes, sections of bamboo, colouring such as ink, large containers for water

Class levels

1, 2 and 3

Streaming



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Activities for Lower Primary

Cooking

Description

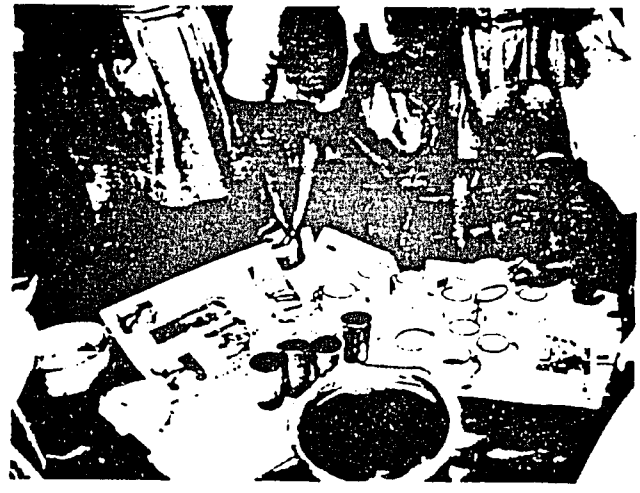
Classroom cooking can be a valuable learning experience. As the children are cooking, there will be opportunities to learn about air, heat and fuel, numbers, measurement and volume. The children come to appreciate good health habits. This unit suggests the preparation of coffee, but children can cook many other things. Each teacher will know what is available and what can be managed in his or her school.

Materials

Ingredients for whatever is to be cooked, stove or stones on which to build a fire, charcoal or wood, pots, small containers, utensils, something to measure time

Class levels

1, 2, and 3



Activities for Lower Primary

Construction

Description

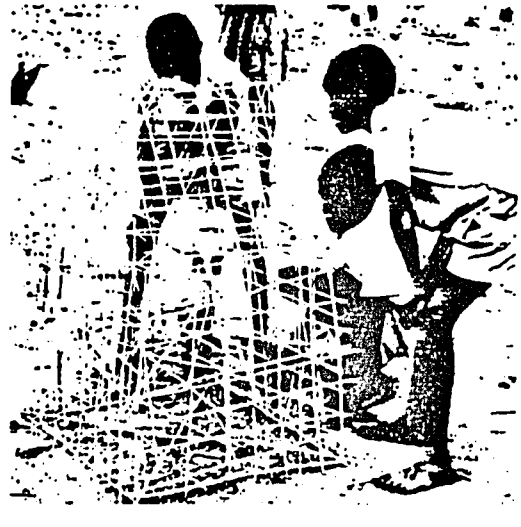
Construction allows children to use many materials: woods, tins, clay, local grasses, stones and other things. They can build structures, furniture, or toys. Through handling the materials children receive an introduction to such ideas as balance and weight, shape, size, strength and texture of materials.

Materials

Scrap wood, cigarette boxes, match boxes, tins, grasses, clay or bricks, sticks and bamboo, cardboard, wood blocks, raffia or string, any other construction materials the children choose when they are out collecting

Class levels

1, 2 and 3



Activities for Lower Primary

Woodwork

Description

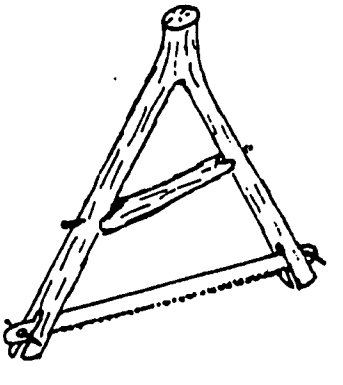
Children are given tools (hammer, saws, etc.), wood and nails. Under supervision, they are allowed to become familiar with the use of tools, and experiment with how to build things with these tools. Working with tools helps to develop manipulative skills. As children hammer and saw, they learn about friction and texture. As they build, they meet problems of design and balance. Children also match and measure and develop mathematics as they count and estimate amounts of materials needed.

Materials

Branches of trees, pieces of wood of all shapes and sizes, nails, simple tools, which could be made from directions in the APSP unit *Tools for the Classroom*

Class levels

1, 2 and 3



Activities for Lower Primary

Wheels

Description

Wheels is one of the booklets in the Lower Primary series, but the activities suggested can be tried and expanded for use with children at all primary levels.

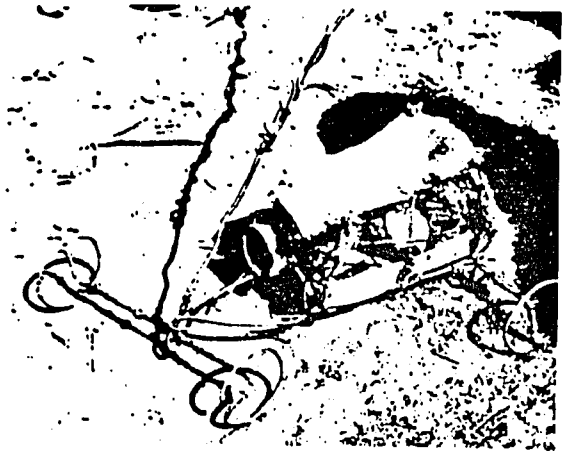
Wheels provide an endless number of problems. Children gain experience on which future science and mathematics can be built. Stability, centre of gravity, ratio of diameter to circumference, gears and gear ratios, and friction are some of these areas. Important also are the smaller immediate problems of constructing movable cars which the children are able to work out to their own satisfaction and enjoyment.

Materials

Wood, twigs from trees or sticks of various length and thickness, reeds or grasses, wire, string or plant fibres, clay, bottle tops, tins, paper, pieces of metal, and objects which could be used as wheels such as cotton reels, used film reels or typewriter ribbon holders

Class levels

1, 2 and 3



Activities for Lower Primary

Arts and Crafts

Description

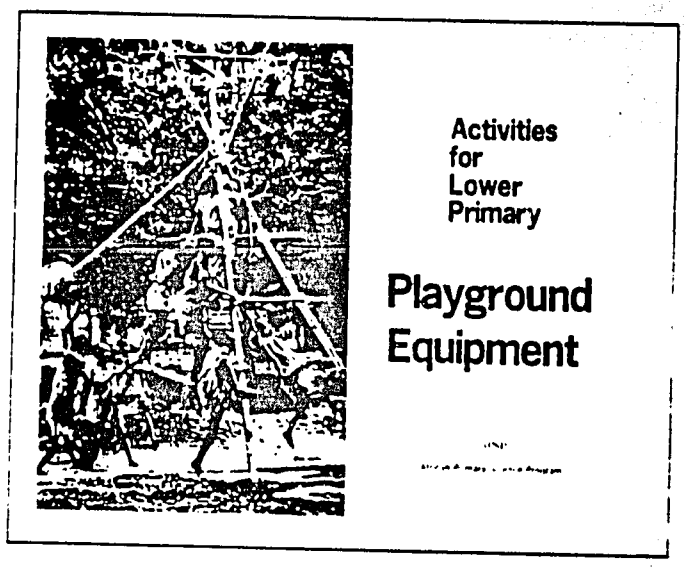
Presented in this unit are many suggestions to help children explore different ways of creating through arts and crafts. Children will help collect local materials which they can use in their work. Activities include finger painting, block and leaf printing, modelling, papier-mache, sewing and weaving. Children also will be developing manipulative skills and will be learning about textures, shape and design.

Materials

Paper, paint, sand and clay, sisal, cloth and needles and thread, wood, bamboo, a variety of local materials which can be collected

Class levels

1, 2 and 3



Description

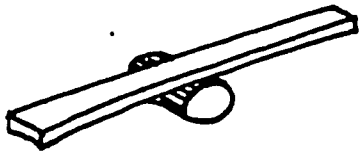
Playground equipment can be part of every school compound. This booklet was written to help teachers to build equipment for lower primary age children, but older pupils can help build the equipment as well as use it. The equipment described includes swings, see-saws, climbing towers, sliding poles, and large outdoor balances. Each piece of equipment will take one or more sessions to make and this building can take place throughout the year. Children can experience with their whole bodies some aspects of science — friction, levers, change of speed, storage of energy, elasticity, symmetry and weight.

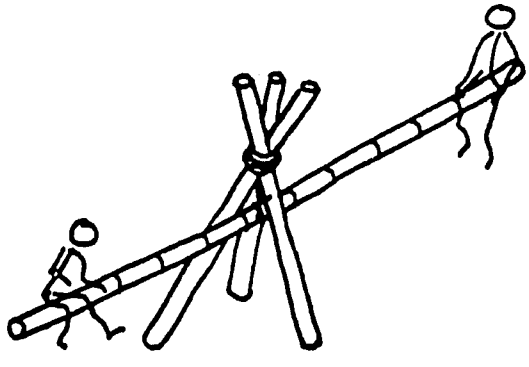
Materials

Old motor tyres, old inner tubes from bicycle tyres, rope of all sizes in quantity, long poles and pieces of bamboo, pieces of wood of various sizes, large and small stones

Class levels

1, 2 and 3

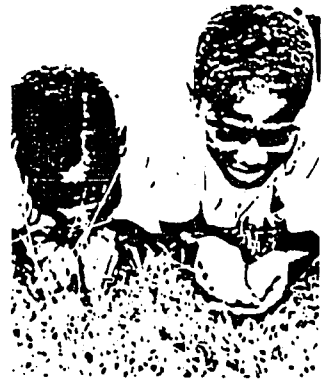




Middle and Upper Primary

BIOLOGICAL SCIENCES

EXPLORING NATURE



Exploring Nature

Description

This is a resource book for teachers and the ideas in it could be used with pupils of all ages. The suggestions are meant to stimulate children to think of activities they can undertake to find out more about their natural environment. The book covers such topics as light, shadows, clouds, the sky, soil and puddles, beaches, small animals, bones, seeds, barks and stems.

Materials

The teacher will not need to collect materials; they can be found by the children in the environment.

Estimated time

The activities included can be continued over a long period of time. Some of the activities need extended observation.

Suggested class levels

3, 4, 5 and 6

Related units

A Scientific Look at Soil, Seeds, Buds and Twigs, Ask the Ant Lion, Small Animals, Stars Over Africa, The Moon Watchers, The Water Book

SEEDS

Description

There are many questions and problems associated with the study of seeds which children can answer by handling and observing seeds. Activities in this unit include collecting and classifying seeds, studying variation, and learning about seed and fruit structure. The children can also investigate how seeds travel, how seeds germinate, and what environmental conditions affect seed growth.

Materials

A variety of kinds and sizes of seeds, water, jars, tins, oil, razor blades or knives, sand and other kinds of soils, saw dust, twigs

Estimated time

Activities can go on from time to time in a school year and continue as long as pupils' interest is sustained.

Suggested class levels

4 and 5

Related units

Plants in the Classroom (Lower Primary); A Scientific Look at Soil, Exploring Nature, Buds and Twigs, Making a Microscope

Small Animals

Description

Small Animals is written as a resource book for teachers to use whenever children show an interest in insects and other small animals. The children's interest can be encouraged and developed by such activities as catching, raising and preserving small animals. The unit has descriptions and drawings of the grasshopper, caterpillar, earthworm and many others. Each animal description raises questions and suggests activities to answer such questions as: what does it eat, how does it reproduce, how does it defend itself, is it a benefit to man?

Materials

Small animals, cartons, tins, bottles, pins, pieces of wood, twigs, and netting to make cages and catching nets

Estimated time

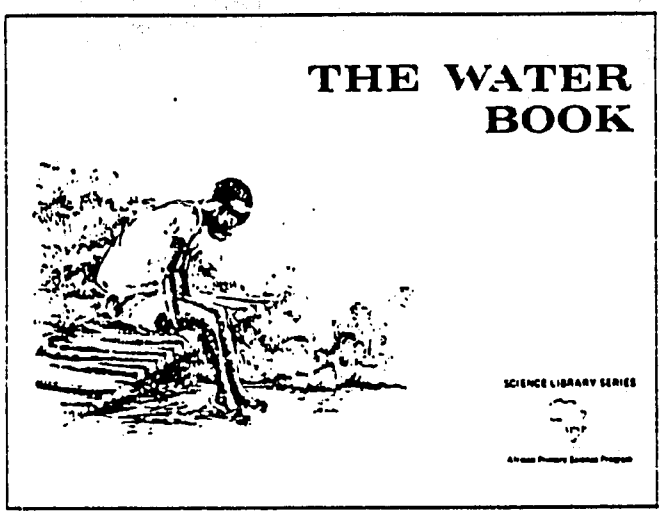
Activities can go on from time to time in a school year and continue as long as pupils' interest is sustained.

Suggested class levels

4 and 5

Related units

A Scientific Look at Soil, Ask the Ant Lion, Exploring Nature, Making a Magnifier, Making a Microscope



Description

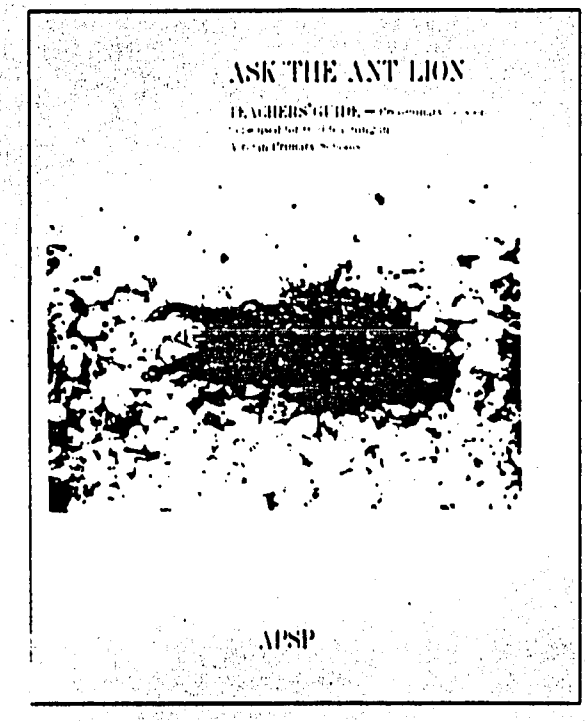
This is one of a series of Science Library readers for children. The booklet describes various uses of water as well as some of the problems caused by water. This is primarily a picture book, and the vocabulary used in the brief story has been kept simple so that children beginning English can read words while enjoying the book visually. Older children may want to make a magnifier or a microscope to look at the small things found in water.

Suggested class levels

4 and 5

My baby sister, Ngozi, plays with water and pours it into bottles and tins. I like to blow soap bubbles for her.

ASK THE ANT LION



Description

The ant lion is a small creature which may keep a class of children busy for days. It is an insect larva, and can be found in dry, sandy soil. The ant lion has the peculiar characteristic of always moving backwards. The activities suggested in this unit encourage children to observe many interesting things about the ant lion. At the same time, pupils are learning how to gather information and record what they find out from their observations.

Materials

Ant lions, sand, soil, tins, jars, or cartons and boxes

Estimated time

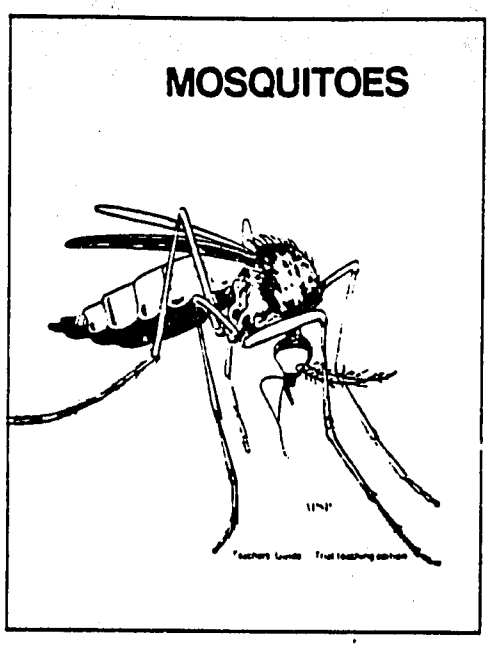
Eight to ten lessons, more as interest is sustained

Suggested class levels

4, 5 and 6

Related units

Small Animals, Exploring Nature, A Scientific Look at Soil



Description

Teachers and pupils collect larvae, pupae and eggs of mosquitoes from natural surroundings. A hand lens or microscope is used to study the structure of eggs, larvae, pupae and adults. The pupils build simple mosquito cages or containers, and the stages in the life cycle are then watched. Through feeding and breeding the mosquitoes, and investigating local areas where mosquitoes breed, children gain an awareness of the role mosquitoes play in disease and how they might be controlled.

Materials

Clean jam jars, hand lenses or home-made microscopes, drinking straws or bamboo sticks, water, kerosene, oil, netting to cover jars or to make breeding cages, basin or bucket or other large containers, mosquito larvae

Estimated time

Observation through the life cycle could go on for about three weeks or more.

Suggested class levels

5 and 6

Related units

The Water Book, Exploring Nature, Making a Microscope

OURSELVES

Description

The suggestions in this unit follow a child's natural curiosity to help him find out about his body. Every child in the class will not be interested in every activity in the unit, but there are a variety of topics from which to choose. A set of Pupil Cards provides small group activities so that the class can work on several problems at the same time. Subjects of exploration include senses and sense organs, external features, finger prints, breathing and inherited characteristics. The activities also help children to develop skill in measurement and comparison, and in making and reading simple graphs.

Materials

Graph paper, newsprint, string, rulers, water, cooking pans, large glass jars, bells, pieces of cloth for blindfolding, sweet and bitter things for tasting

Estimated time

Activities can go on from time to time in a school year, and continue as long as interest is sustained.

Suggested class levels

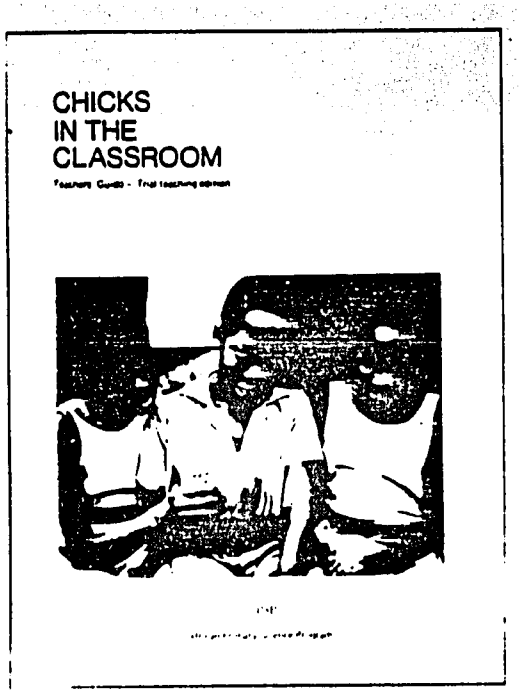
5 and 6

Related units

Playground Equipment, Friction

Ourselves

Activities and Experiments



Description

This unit shows the teacher and pupils how to keep and raise chicks in the classroom. The children observe and discover through experimentation the effect of good nutrition on growth and maintenance of life. Children learn how to handle chicks, and the importance of proper care of such animals. They also develop other manual skills associated with design and construction of cages, nests and artificial incubators.

Materials

10 to 12 one-day-old chicks, cages, heat source, water, feed, trays, balances, eggs for incubation

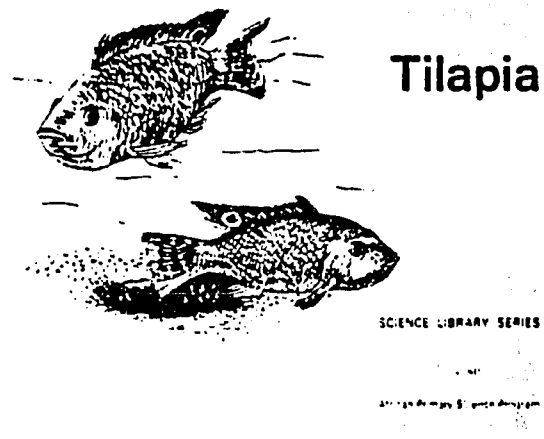
Estimated time

Chicks are raised until age five to six weeks.

Suggested class levels

5, 6 and 7

TILAPIA



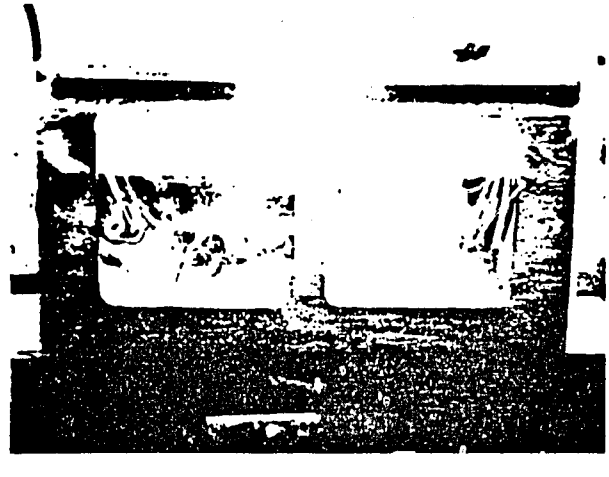
Description

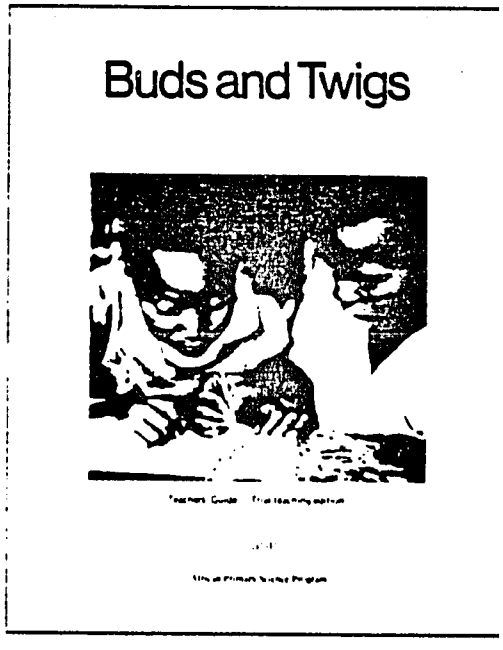
This is one of a series of Science Library readers for children. *Tilapia* can also be used as a resource book by the teacher. It gives information about where tilapia are found, the importance of these fish, and their behaviour and life cycle. It also describes how they are caught, smoked, dried, sold and used as food, things which the children may observe around their communities and in local markets.

Included in the book is a method of making tanks for keeping and observing tilapia.

Suggested class levels

6 and 7





Description

Investigations into the world of plants are suggested in this unit: the conditions needed for plant growth, budding and flowering. Types of wood can also be investigated. Suggestions are included for collection and storage of plants, observation of plant growth, absorption and grafting techniques. The unit gives opportunity for varied approaches to the study of plants in the local environment.

Materials

Twigs, plants, razor blades, containers such as bottles, tins, calabashes, etc., coloured water

Estimated time

These activities are best done over a long period of time. After work has begun, other units could be used while pupils make daily or weekly observations and recordings about their twigs and plants.

Suggested class levels

6 and 7

Related units

Plants in the Classroom (Lower Primary); A Scientific Look at Soil, Seeds, Exploring Nature

MAKING PAINTS

Description

Making Paints provides an opportunity for pupils of all ages to work with local materials and to learn how to make dyes and paints. Children learn that simple processes like crushing and boiling can often make important changes in the colour of things. Children also learn how to identify useful plants from which to make colouring matter and how to concentrate the colours. As pupils paint upon a variety of common materials, they become familiar with the different properties of these materials.

For older pupils, this unit could be followed by those listed below under "related units." There is also a section "Painting, Using Flowers and Liquids" in the unit *Common Substances Around the Home* which is suggested for use at class levels 6 and 7.

Materials

Leaves, flowers, fruits, bark, roots, soil, seeds, ashes, rocks, charcoal, pots, bottle tops, sticks, knives, paper, fibres, water

Estimated time

This unit could cover a series of several lessons, but the activities are ones which would interest children from time to time during the school year.

Suggested class levels

3, 4 and 5

Related units

Colours, Water and Paper; Inks and Paper

COLOURS, WATER AND PAPER

Description

This unit encourages children to explore ways to make different colours by mixing, and to try to separate colours by using strips of paper. Activities are suggested for the study of the behaviour of colours in liquids such as water, salt water, oil and paraffin. Children gain skill in observation and recording the results of what they see.

Materials

Paints or coloured liquids made by pupils, dyes and inks, bottles, pans, tins, hollow straws or reeds, various kinds of paper, liquids or solids such as oil, paraffin, spirits, salt

Estimated time

Groups of children might work on the problems whenever they occur in other activities such as water, or arts and crafts. Or, the whole class could work together on the problems for several consecutive lessons as long as interest is sustained.

Suggested class levels

4 and 5

Related units

Making Paints; Inks and Papers; Liquids

Sinking and Floating

Description

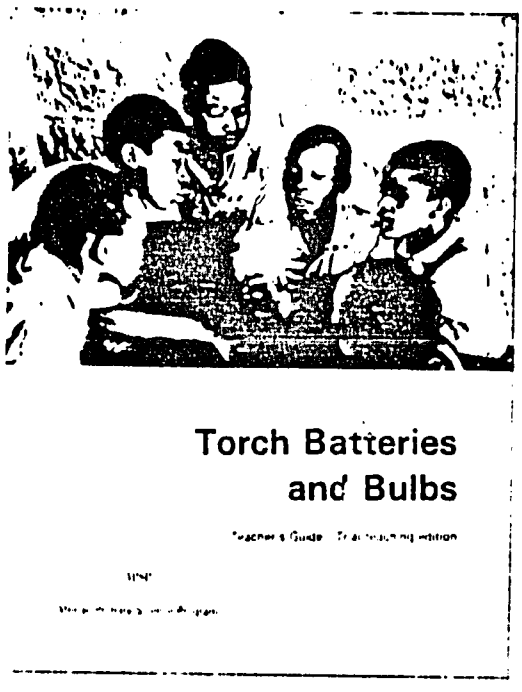
The class works in small groups, each group with a miscellaneous collection of materials, and they are asked to find out which of the objects float and which sink. They compare and discuss their results. Pupils explore how the shape, weight or size of a material affects its ability to float; they increase their understanding of buoyancy and balance by constructing and playing with various types of boats.

Materials

Reeds, nails, wood, dry stalks or stems, fruits and vegetables of various kinds, tins of all sizes, stones, string, paper, large containers to hold water

Suggested class levels

4 and 5



TORCH BATTERIES AND BULBS

Description

This unit is an introduction to electricity. Children use the materials in a variety of ways and discover for themselves what is inside a battery and a bulb and how to make a circuit. They learn which materials conduct electricity and how to vary the current. Pupils will also have an opportunity to make a torch and discover how it works.

Materials

Wire, wood, nails, steel wool, small pieces of metal, plastic and glass, bamboo, bulbs, batteries and torches (which the children can be asked to bring from home and can still be used when returned). Have extra bulbs, batteries and torches if possible.

Estimated time

About ten lessons of 40 minutes each; more as interest is sustained

Suggested class levels

4 and 5

Changing Solids

SOLDERING

Description

This unit is about heating solids. Pupils build their own heating torches and try to heat, melt or burn some common substances. They record and compare their results. They can use the heating torches for soldering wire and joining metals or for minor repair jobs and making sculptures.

Materials

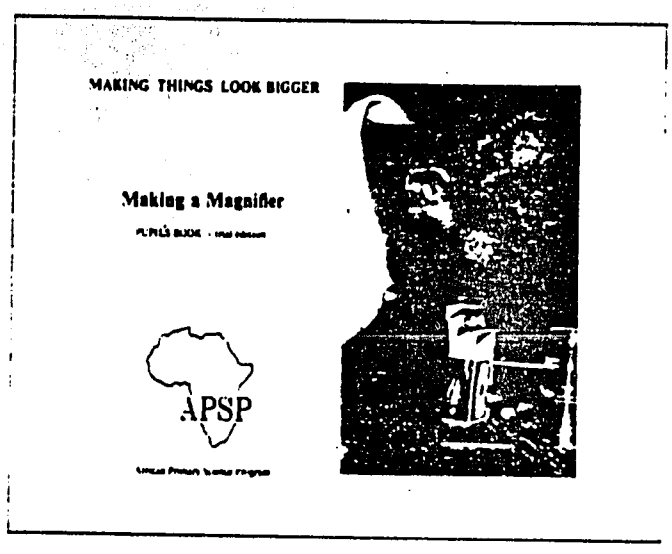
Tins, hollow stems, cloth for wick, matches, nails, pins, soldering wire, metals, solids such as wax, animal fat, salt, sugar, pieces of maize stalk, stone, wood, etc.

Estimated time

The unit can be done by a few pupils in a class, over several days, while the rest of the class is engaged in other activities. The unit may be carried out for many weeks until all the class has had a chance to participate.

Suggested class levels

4 and 5



MAKING A MAGNIFIER

Description

This is a Pupil's Book and should be accompanied by the Teacher's Handbook *Making Things Look Bigger. Making a Magnifier* is an introduction to the instruments needed for children to examine the microscopic world. The book contains patterns for the cardboard cut-outs the pupils will use. Children begin exploring magnification with pin-hole and water drop magnifiers. With the magnifiers, pupils can examine coins, cells, hair, print on paper, and so on.

Materials

Hard paper, pins, water, vaseline, match boxes, coins, and small objects to examine

Estimated time

Four to ten lessons, but the magnifier can continue to be used as a tool in other units

Suggested class levels

4, 5 and 6

Related units

Making Things Look Bigger: Teacher's Handbook; Making a Microscope

FRICTION

Description

This unit suggests activities for pupils to do which will help them learn about friction. Activities include running and sliding on different surfaces, sliding things on tables or boards, games with blocks, games with ropes, studies of wear and of heat caused by friction.

The unit is accompanied by Pupil Cards so that several small groups of children can work on different activities at the same time. There is a Teacher's Information section with each Pupil Card which suggests materials which can be used, reports of what other children have done and further questions. The activities provide opportunities for pupils to control variables, obtain reliable results, and compare and record what they have done.

Materials

String, rubber bands, paper clips, drawing pins, tape, cloth, tins, bottles, seeds, grass, sand, notebooks, blocks, boards, rope, large stone, a bicycle if possible

Estimated time

Eight to ten lessons, more as interest is sustained

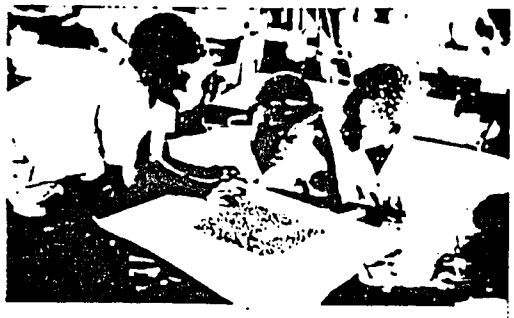
Suggested class levels

4, 5 and 6

Related units

Playground Equipment,
Wheels (Lower Primary)

Friction



Estimating Numbers

Description

The activities in this unit are designed to help children acquire skill in approximating large numbers. Pupils are encouraged to make accurate estimates of quantities by counting layers and rows of seeds, by weighing and grouping, and by sampling parts of areas to determine total volume. Suggestions are made on how to help the children use their new knowledge in and around the school. Such questions as, "How many bricks were used to build the school?" or "How many drops of water are in a bottle of water?" or "How many eggs will a flock of chickens produce in one month?" will provide stimulating problems for the children to strengthen their ability to understand large numbers.

Materials

Small baskets, glass jars, paper cups, tumblers, bamboo sections, jar lids, bottle tops, rice, salt or sugar, seeds, nuts, fruits, large sheets of paper such as newspaper, balances

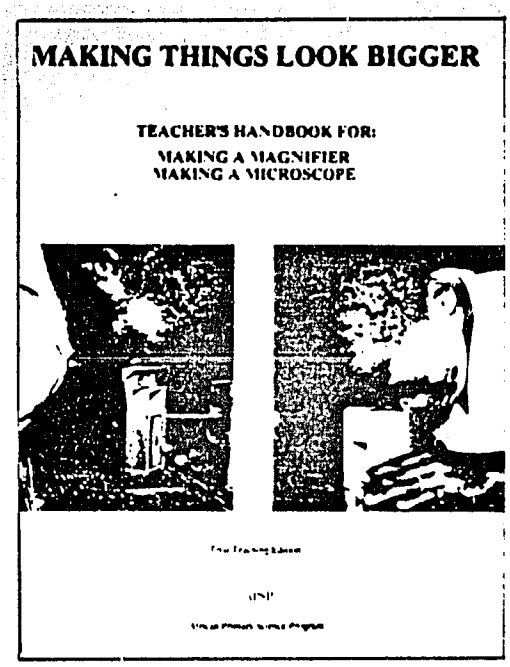
Estimated time

Eight to twelve lessons (double periods if possible)

Suggested class levels

4, 5 and 6

MAKING THINGS LOOK BIGGER: TEACHER'S HANDBOOK

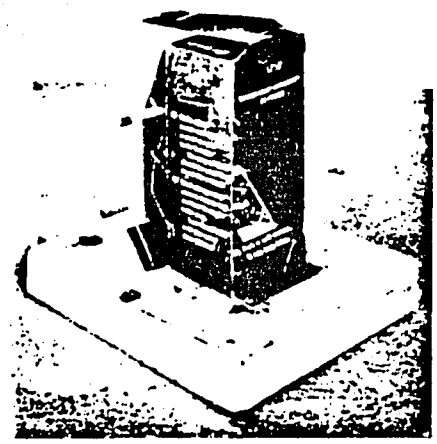


Description

This teacher's handbook accompanies the two Pupil's Books: *Making a Magnifier* and *Making a Microscope*. The book contains instructions for making the magnifier and the microscope. Patterns for these are included. The book also discusses class preparation, materials, record keeping and the construction of a durable microscope, and gives the teacher additional information on magnification and how the Pupil's Books might be used.

Suggested class levels

4, 5, 6 and 7



A Scientific Look at Soil

Teachers' Guide-Preliminary version to be used for trial teaching in African Primary Schools

Description

In this unit, children are encouraged to make observations and solve problems concerning soils, and to make records of what they find out. They learn ways to determine what soils are made of, how to compare soils, and how water acts in different types of soils. Pupils might also investigate air content, water-holding ability, the microscopic appearance of the soil, types of soils most favourable to plant growth, and animals that live in the soil.

Materials

Sand, clay, loam soil, tins, boxes, jars, glass tubes or paw-paw stems, sieves, funnels, hand lens or magnifier, newspaper

Estimated time

Eight to ten lessons

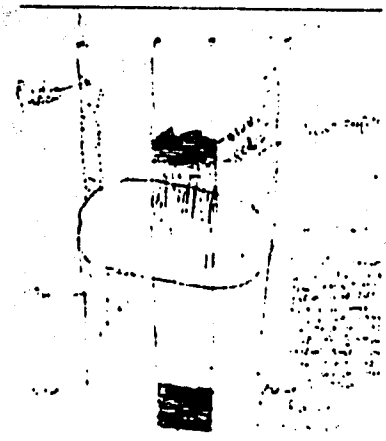
Suggested class levels

5 and 6

Related units

Small Animals, Ask the Ant Lion, Exploring Nature, Seeds, Bricks and Pots, Making a Magnifier, Making a Microscope

Inks and Papers



Description

Simple materials such as blotting paper, ink powders and common liquids are used in this unit to explore the chemistry of colours. Pupils are encouraged to build their own apparatus for measuring the flow and separation of colours. "Why does one ink travel higher up a piece of paper than another ink?" and "Which ink is heavier?" are the kinds of questions pupils will explore in this unit.

Materials

Inks of different colours, blotting paper, newspaper and other kinds of paper, bottle tops, thin sticks or grass, tins, pins or thorns, liquids such as paraffin, cooking oil, spirit, tea, coffee, water, powders such as sugar, salt and soap, Bic pens of different colours if possible

Estimated time

Eight to ten lessons

Suggested class levels

5 and 6

Related units

Making Paints; Colours, Water and Paper; Liquids

Construction With Grass

Description

Various kinds of grasses, reeds or tree branches are used by children for constructing models, shapes, toys and houses. The unit poses problems for pupils such as stabilizing a frame or testing the strength of a model house. The construction activities can also be used in mathematics and arts and crafts. Classes doing the unit *Bricks and Pots*, and wishing to make roofs for brick structures, will find ideas in *Construction with Grass*.

Materials

Tall grasses, sticks, reeds or poles, pins or thorns, tins, sand

Estimated time

Eight to ten lessons, more as interest is sustained

Suggested class levels

5 and 6 for the activities on structures, but children of all ages can work with grasses in various ways

Related units

Construction (Lower Primary); Bricks and Pots

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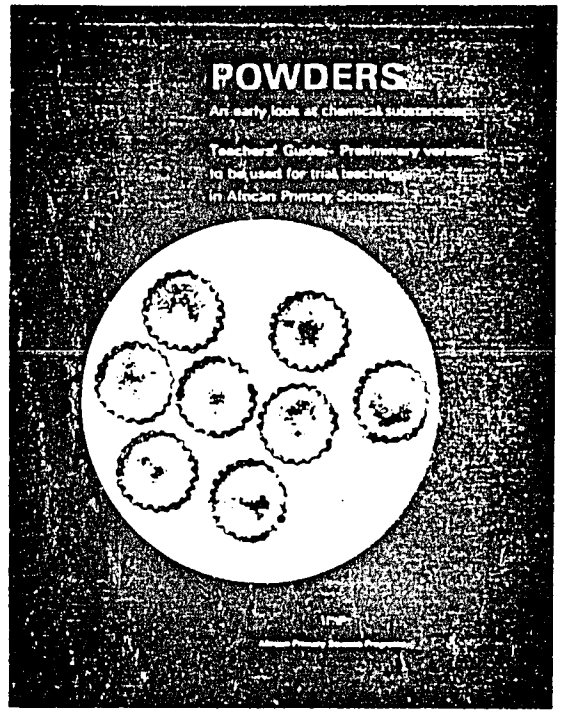
POWDERS



Description

This unit is designed to encourage children to take a close look at some common powders. Pupils try to identify the contents of packets containing starch, salt, baking soda, sugar and mixtures of these. They distinguish powders by appearance, feel and taste. Later, other tests are needed to identify the substances. Pupils keep records of their experiments and learn to identify the different qualities of powders.

Materials

Starch, salt, baking powder, sugar, white vinegar, iodine, straws or hollow grass or reeds, bottle tops, pieces of newspaper, small tins or jars, water

Estimated time

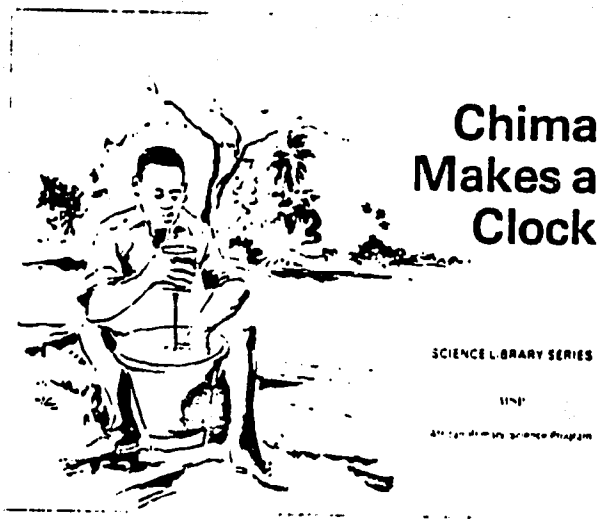
Ten to twelve lessons

Suggested class levels

5 and 6

Related units

Common Substances Around the Home



Description

This is one of a series of Science Library readers for children; it relates to the unit *Measuring Time: Part I.* This reader tells the story of a boy who makes his own clocks after being late for school because he does not own a watch. The clocks he builds are similar to those that pupils make in the unit *Measuring Time.* This book shows how activities in the science class can have application in everyday life.

Suggested class levels

5 and 6

Measuring Time

Part I

Making Many Simple Clocks

Description

Pupils build different types of simple time-measuring devices: swinging clocks, burning clocks, water clocks and sun clocks. The clocks are compared to one another to determine their accuracy. They can be used as a tool in other units.

Materials

Candles, glass jars, tins, deep containers, water, string, matches, a watch (if available).

Estimated time

Eight to ten lessons

Suggested class levels

5 and 6

Related units

Chima Makes a Clock; Measuring Time: Part II; Pendulums

BRICKS AND POTS: Activities with Clay

Description

The activities in *Bricks and Pots* are suggested so that a teacher can help his pupils try various ways of making bricks and other things with clay. Children are given freedom to work in their own ways and are encouarged to experiment with a variety of materials and methods of using those materials. Sections in the unit on Making Forms for Bricks, Burning Bricks, Testing Bricks and Weighing Bricks allow children to develop the skills of measuring, weighing, comparing and recording. There is also opportunity for children to construct their own materials and tools and to build things with either small or large bricks.

Materials

Water, various kinds of soils, materials to add to soils, wood, tree branches, some tools which can be made, nails or pegs, a balance or one made as described in the unit

Estimated time

Double periods — for as many weeks as a teacher feels interest is sustained

Suggested class levels

5, 6 and 7, but younger children will enjoy some of the activities

Related units

Wet Sand, Construction (Lower Primary); Construction with Grass, A Scientific Look at Soil

Bricks and Pots

Activities with Clay

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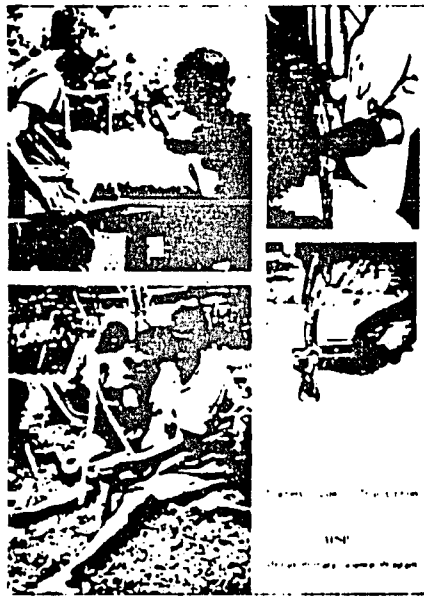


Tools for the Classroom

Description

Useful and durable tools can be made from local or inexpensive materials. This unit gives directions for making hammers, drills, saws, bench hooks, tongs or tweezers, a chisel and a screw driver. With help from the teacher, children make these tools and learn to keep them in good condition. Pupils can use the tools for constructing apparatus needed for activities in other units. If enough materials are available, some children may wish to make a set of tools to use at home.

Materials

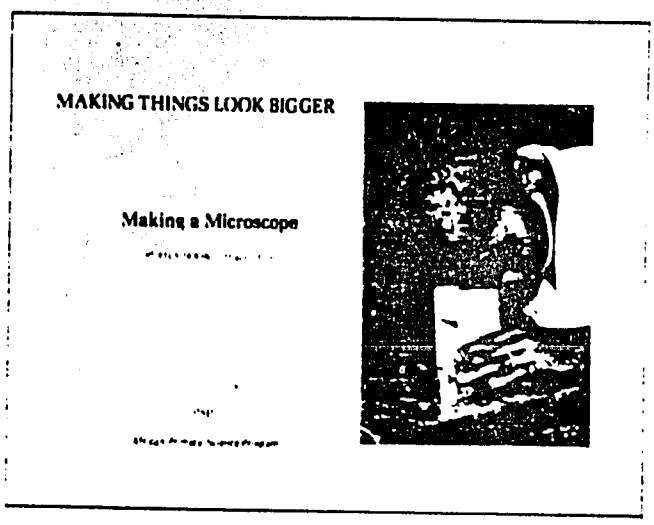
Branches of trees, short lengths of scrap wood, nails, nuts and bolts, saw blades, metal strapping, pieces of bamboo, twine or raffia, tins, rulers

Estimated time

Eight to ten lessons, but time will be spent throughout the year as the children show interest in making more tools

Suggested class levels

5, 6 and 7



Description

This is a Pupil's Book and should be accompanied by the Teacher's Handbook *Making Things Look Bigger*. The Pupil's Book shows a child how he can make and use his own microscope. A pattern is included for constructing the lightweight cardboard microscope. Not only do pupils manipulate and learn how to use a microscope, but they develop accuracy in focusing and observing. Children will be able to use the microscopes to discover details of hair, insects and cells.

The microscope can be used as a tool when children are doing a variety of activities in other units.

Materials

Cardboard or hard paper, transparent plastic, aluminium or silver paper, string, match sticks, vaseline, clean water, things to look at such as hair, insects, feather, spider's web

Estimated time

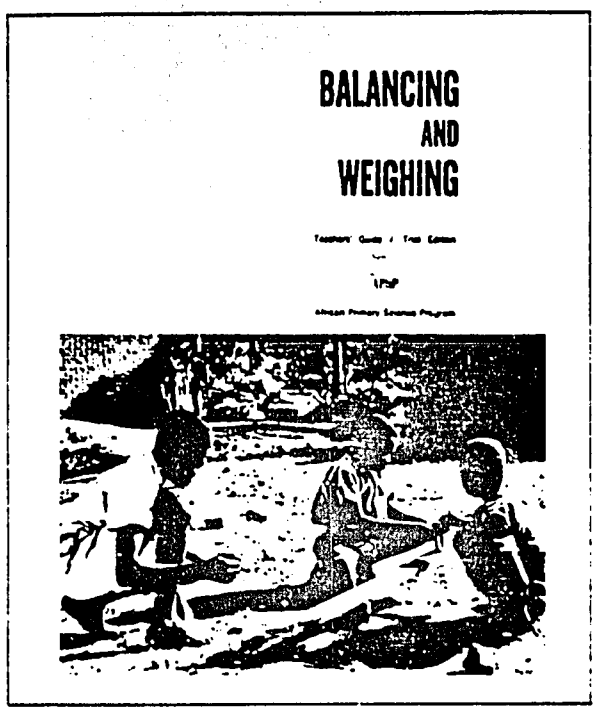
Two to three lessons to make and become familiar with the microscope, more as interest is sustained in examining the microscopic world

Suggested class levels

5, 6 and 7

Related units

Making Things Look Bigger: Teacher's Handbook; Making a Magnifier



Description

In this unit, children have the chance to explore and extend their ideas about balancing and weighing. They begin with a see-saw in the school compound. In the classroom they work with smaller balances and are presented with problems to investigate. They can use several types of balances to compare and predict unknown weights. Children should devise their own units of weight. There are many suggested activities, such as making mobiles and toys that will balance, and testing the strength of string. The balances can be used in activities in other units.

Materials

Boards, small pieces of wood of various sizes, bamboo, nails, bottle tops, rope and string, and a series of things to compare and weigh, such as fruits, stones, dried stalks, match boxes of sand, etc.

Estimated time

Twelve lessons or more

Suggested class levels

5, 6 and 7

SOUND: A LOOK AT MUSICAL INSTRUMENTS

Description

This unit is about sounds: low sounds and high sounds, soft sounds, loud sounds and sounds that are musical. The children are given opportunities to make and play musical instruments, form bands and enjoy the experience of making music in groups. Other activities are presented for the children to explore the ways in which different sounds are made. Simple equipment, interesting questions, and problems are suggested to encourage exploration, construction and experimentation.

It is suggested that traditional instruments be collected, when possible, for use in the lessons, but home-made instruments will serve as well. Tools for making the instruments can be made by the teacher and pupils. Directions for making tools can be found in the APSP unit *Tools for the Classroom*. The lessons can be followed as presented or activities can be re-arranged in ways which the teacher decides will encourage both learning and enjoyment in his classroom.

Materials

Bottles and tins of various sizes, clay pots, pieces of split and unsplit bamboo, local grasses or reeds, wood, tree branches, string or plant fibres, wire, pieces of scrap metal, traditional instruments or home-made ones.

Estimated time

Nine to twelve lessons, plus unlimited time for making instruments

Suggested class levels

5, 6 and 7, but younger children will enjoy some of the activities

Sound:

A Look at Musical Instruments

THE MOON WATCHERS

Description

This booklet is one of a series of Science Library readers for children. *The Moon Watchers* is a science story about a boy and his grandfather who watch the moon from their village near the banks of the river Niger. Wise Ezeulu knows the moon well and he encourages his grandson, Eze, to find out about the moon for himself. Eze watches the moon and its changes, makes drawings and talks about them with his grandfather and his teacher and classmates at school.

This booklet will give children ideas for observing the moon rising, setting, and changing over their own village, and how they might make records of what they see.

Suggested class levels

5, 6 and 7

MY MOON WATCHING CALENDAR

FEBRUARY							MARCH						
SUN	MON	TUE	WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI	SAT
			1	2	3	4				1	2	3	4
5	6	7	8	9	10	11	5	6	7	8	9	10	11
12	13	14	15	16	17	18	12	13	14	15	16	17	18
19	20	21	22	23	24	25	19	20	21	22	23	24	25
26	27	28					26	27	28	29	30	31	

DAY 1 FIRST SAW NEW MOON

THE STAR BOOKS

Description

These four books are readers in the Science Library Series and are meant for Upper Primary age children. However, the books can be used by the teacher as a resource to help younger children become familiar with the night sky. These books should be used as guides throughout the year; they are divided into sections showing what can be seen on a particular night. After using *Stars Over Africa*, each book can be used with the others over a long period of time.

Suggested class levels

5, 6 and 7 for the first book; 6 and 7 for the other three books

BOOK I: STARS OVER AFRICA

This book should be read first. It can be used to find four important groups of stars at different times of the year. The book tells the names of these groups of stars and some African stories about them.

BOOK II: STRANGERS IN THE SKY

This book gives help in finding more stars, and tells some stories about them. It is also a guide to locating planets in the sky at different times of the year. The new stars and the planets are found by using the four big groups of stars introduced in *Stars Over Africa*.

BOOK III: USING THE SKY

How the movement of the stars across the sky can be used to tell the time of night, the seasons, and as a guide for travelers is described in this book.

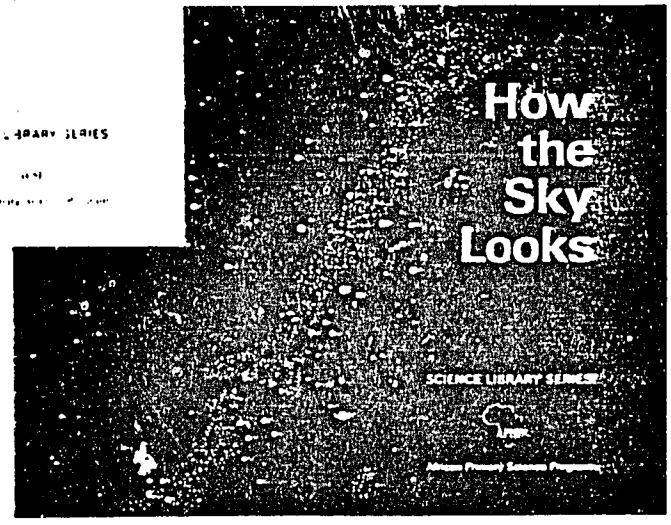
BOOK IV: HOW THE SKY LOOKS

This contains a series of charts which show how the stars look in the African sky at any time of night and at any time of year.

Stars over Africa

Strangers in the Sky

Using the Sky



COMMON SUBSTANCES AROUND THE HOME

Description

This unit encourages children to learn more about materials commonly found around their homes, and to ask questions about the manner in which the materials behave. Suggestions are made for mixing and heating substances such as flour and starch with various liquids. Pupils have an opportunity to make observations and do their own testing which will enable them to identify mystery mixtures. Ideas for making paints from different flowers and liquids are included in this unit.

Materials

Powders such as cassava starch or flour, salt, sugar, wood ash, chalk dust, and liquids such as vinegar, lemon juice, water, etc., bottle tops, hollow reeds or straws, jars and bottles, iodine. Heating torches will be useful; directions for making these can be found in the unit *Changing Solids.*

Estimated time

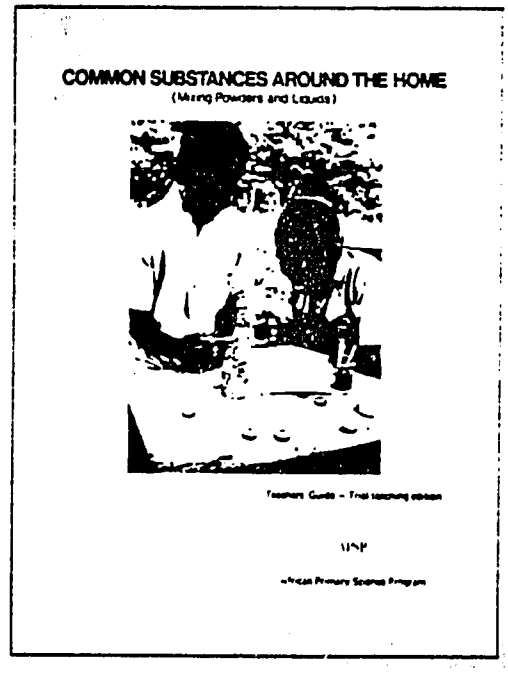
Ten to twelve lessons

Suggested class levels

6 and 7

Related units

Powders, Making Paints


COMMON SUBSTANCES AROUND THE HOME
(Mixing Powders and Liquids)

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MEASURING TIME: PART II

Description

In *Measuring Time: Part I*, children make simple clocks. In this unit, Part II, pupils try to make clocks that measure hours. They can make a burning clock, a water clock, a sun clock and a more advanced weight-driven pendulum clock.

Materials

Large paraffin tins, oil tins, large bamboo sections, small pieces of wood or bamboo larger pieces of wood and pieces of metal, small stones and sand, small nails, string hammer or large stone

Estimated time

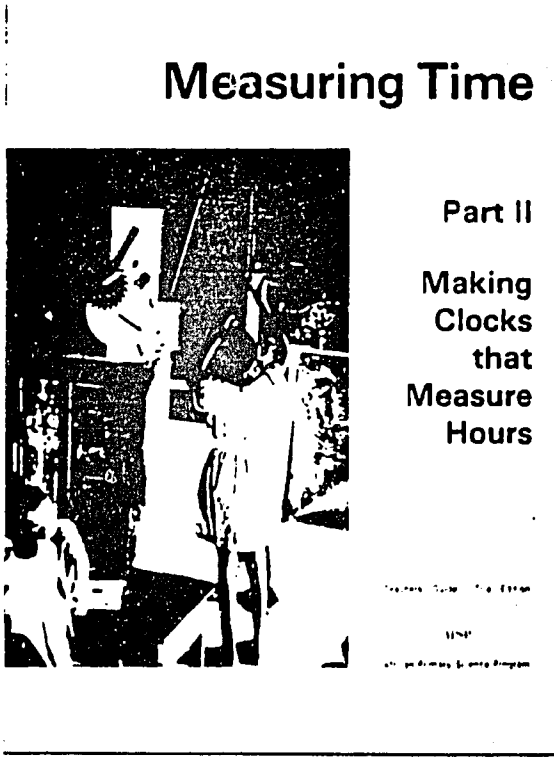
Ten to twelve lessons

Suggested class levels

6 and 7

Related units

Measuring Time: Part I;
Chima Makes a Clock;
Pendulums



PENDULUMS

Description

This introductory study of pendulum motion allows pupils to look at the surprising motion of two pendulums coupled together with a stick. Pupils try to trace the cause of the motion and duplicate it for themselves. To understand the motion, they must simplify the system and look at a single pendulum in detail. By varying the length of string, the weight and the swing, children will be able to predict the behaviour of swinging objects.

Materials

Pieces of string, weights, stones, sticks and rope

Estimated time

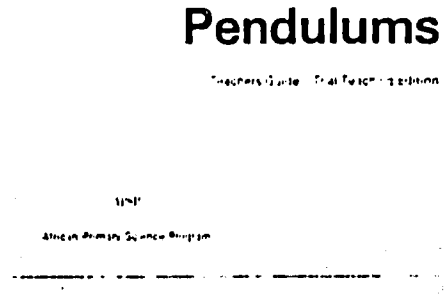
Eight to ten lessons

Suggested class levels

6 and 7

Related units

Measuring Time: Part I and Part II; Chima Makes a Clock



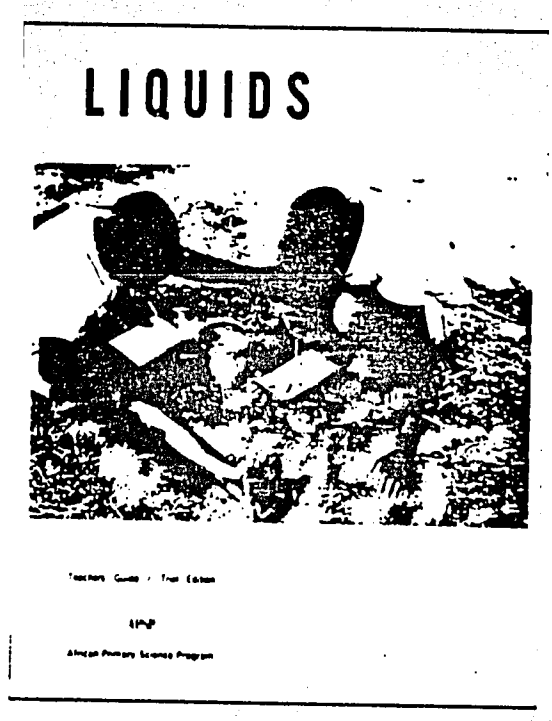
A BOOK ABOUT PENDULUMS

Description

A Book About Pendulums provides background information for teachers using the units on "Pendulums" and "Measuring Time." The book is a resource for teachers and may also provide ideas for further study of pendulums and time, beyond what is suggested in the units themselves.

Related units

Pendulums; Measuring Time: Part I and Part II



Description

Children see a variety of liquids every day: oil used in cooking, kerosene for lamps, water in a river or stream, steam over a hot road after a rain, bead-like raindrops on leaves, oil or water absorption on paper. The activities in this unit allow pupils to observe the characteristics of different liquids and to make comparisons on the basis of colour, shapes and weights of drops, evaporation, cohesion and absorption.

Materials

Water, paraffin, cooking oil, sand, clay, newspaper, blotting paper, other papers, bottle tops, thin sticks, reeds or Bic pens, sisal or string, tins and jars

Estimated time

Eight to ten lessons

Suggested class levels

7

Related units

Inks and Papers

WORKING PAPERS

Working Papers contain a series of suggestions which could be developed into future units. There is a substantial body of information in each, but the materials have had limited trial use in classrooms. It is hoped that these working papers will have further trial by interested teachers and that comments and suggestions toward organising the papers into units will be forwarded to Science Centres.

Activities with Metals

Pupils explore the interaction of solids and liquids, primarily the interaction of copper and liquid ammonia. Suggestions are made so that a teacher can help children keep records and charts of their work, identify problems, and ask questions which lead to further explorations of various metals.

The ideas in this paper have been used with pupils in the fourth and fifth years of Primary School but also could be tried with sixth-year classes. Materials needed are a variety of metal objects (coins, nails, bottle tops, wire, pins, aluminium foil), other solids such as sticks, pebbles and sand, containers, ammonia, and blue stone (copper sulphate).

Bubbles

Presented in this paper are suggestions for activities with bubbles, splashes and drops. Pupils examine bubbles of different sizes and shapes and in various groupings. Also explored are the surfaces of liquids and the tendency of some to form curved surfaces.

These activities have been tried with a few classes in the fifth year of Primary School. Materials used are tins and tin lids, pins, paper clips, sewing needles, hollow straws and reeds, Bic pens, and water, soapy water, coloured solutions, paraffin, spirit, cooking oil.

Building Houses in Other Countries

Activities connected with building houses are described at both Upper Primary and Lower Primary levels. Materials used were large reeds and sticks, grasses, clay, sisal, twine and wire.

Class six pupils in a Primary School in Kenya studied the houses of the Chagga people of Tanzania. In their exploration and building of a conical Chagga house, they did work in science and mathematics and also learned much about the Chagga people and their way of life. The class then went on to discuss the North American Indians and the type of conical house once used by those people.

The Lower Primary activity shows children making a large house of branches and grasses after they had visited houses being built in their community.

Printing

For children just beginning school, printing is a way of getting acquainted with the letters of the alphabet. Older children find the activity an interesting way of learning spelling. Printing provides a manner of expression in terms of both writing and design. This booklet also deals with the principles of printing methods. Suggestions are made to help teacher and pupils build their own printing equipment. How to make inks, large and small rubber letters and a drum printer are included.

Some of the ideas have been tried with Lower Primary children and other ideas with classes in the fourth and fifth years of Primary School. Materials used are rubber strips, a tool for cutting letters from the rubber, a large oil tin and lid for the drum printer, coloured liquids, cardboard, elastic bands, string, paste (starch), clays, and paper. The booklet contains patterns for large and small letters and for numerals.

Tools in the Village

These activities help children enrich their experience by learning about village technology, exploring local materials and appreciating the use to which their ancestors put these materials. The paper describes indigenous tools, many still in use in villages, on farms, and in fishing. Sections on tools in Sierra Leone, Kenya, Malawi, Uganda, and Ghana are included. There are also suggestions for examining the science inherent in the ways the tools are made and for what purposes. A great many drawings and descriptions illustrate the sections.

This paper presents ideas which have yet to be tested in classrooms. The writers suggest trial of the material with pupils in the sixth and seventh years of Primary School. Materials should include available local tools, and materials for making tools: woods of various kinds, bamboo, nails, pieces of metal, fibres such as sisal, hard stones, charcoal, and a heat source for firing metals.

SCIENCE IN YOUR CLASSROOM

It is hoped that the descriptions in this Guide will encourage you to use some of the APSP units in your classroom. Or, they may stimulate you to venture into new areas of exploration and study with your class.

An example of this is *Juba Beach* which is the written and pictorial record of children in a Class 6 in a Primary School in Sierra Leone. Samples of *Juba Beach* are available at science centres in all APSP countries.

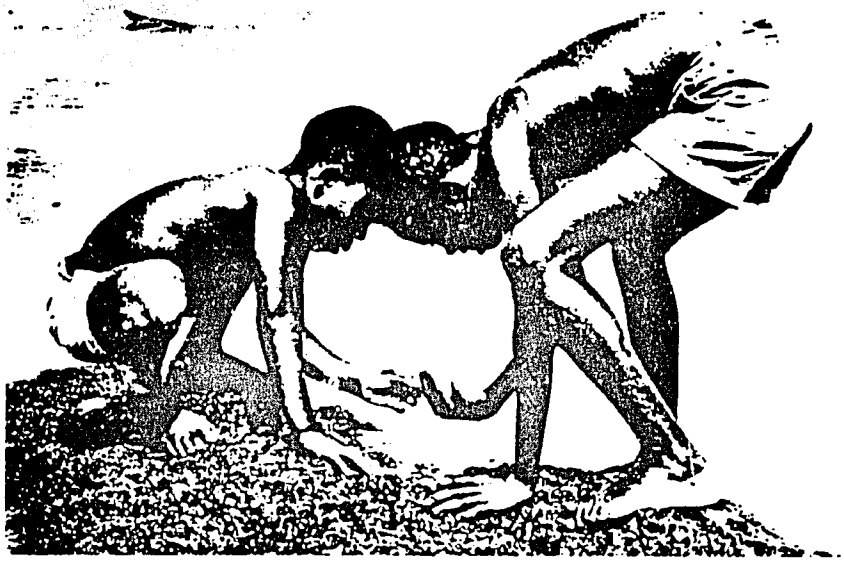
Juba Beach records a way that a class could explore a part of the local environment, not necessarily the sea shore as was done in Sierra Leone. The activities in this book include outdoor exploration and classroom work, and present a unique example of the relationships between living organisms and their different environments. Also included in the book are children's writings and drawings, and a teacher's systematic evaluation of what was being done.

In the words of the teacher:

"After a week of working with the children a spirit of zeal and happiness came over me. By this time I saw that the children, when left to themselves, can learn many things. They no longer waited for me to give them instructions. Instead each group of four chose a leader and the children kept daily records of what they did.

"At this stage the children started making investigations even after school hours. They often reported their findings in class the next day.

"Daily the children became more curious about the environment of the beach. And daily my interest became greater as I saw how the children were progressing. Soon the children started looking more closely at tides and waves, water and sand, the river and many other things."

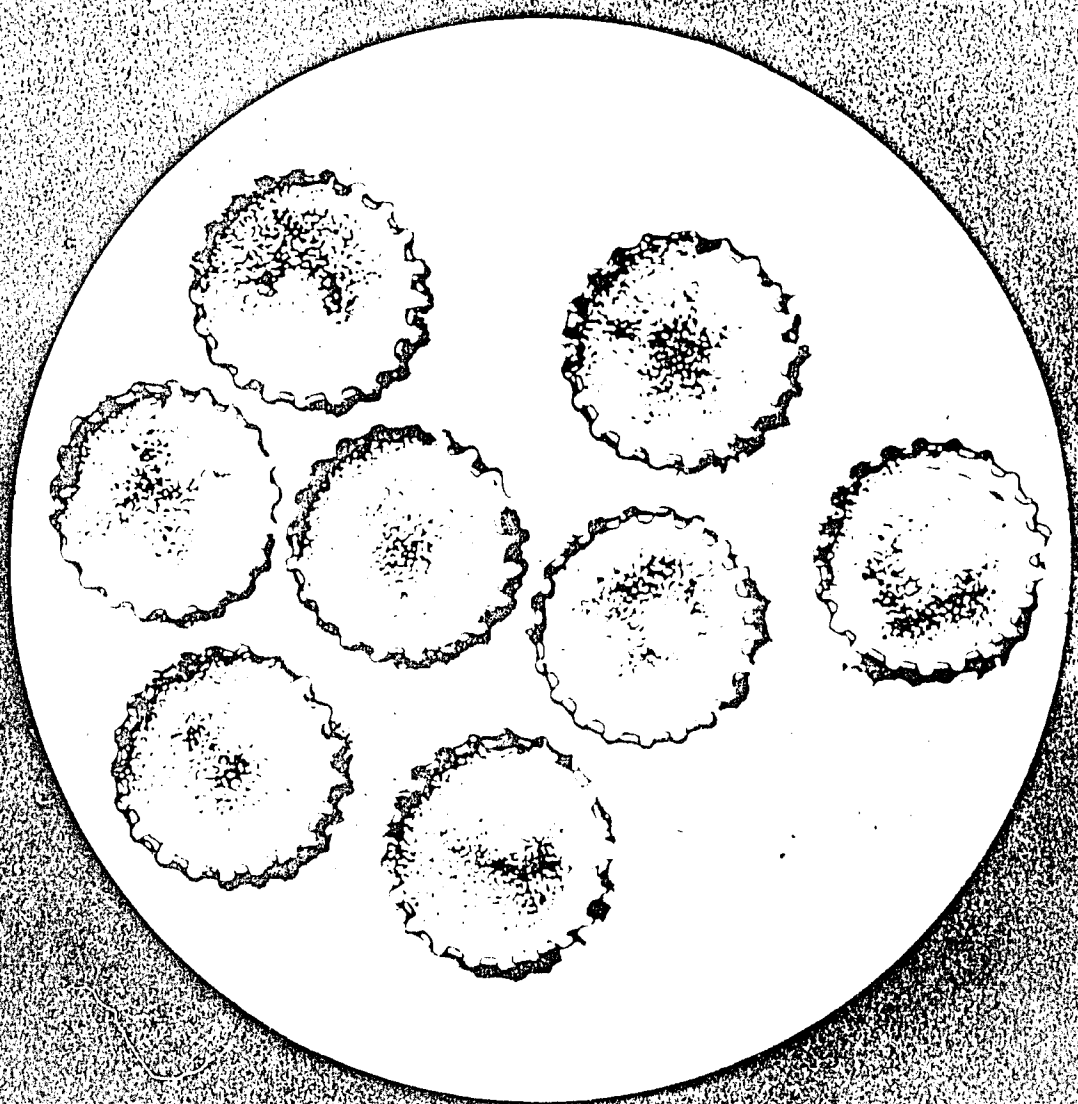


The colour of the rocks is brown and dark. Some of the rocks are on top of others. I can see so many holes in the rocks, and in the holes I can see small crabs and cockles and I can see the rocks shining.

POWDERS

An early look at chemical substances

Teachers' Guide - Preliminary version
to be used for trial teaching
in African Primary Schools



APSP

African Primary Science Program

This preliminary teaching unit *Powders* was developed in Africa at two Primary Science Workshops conducted in 1965 and 1966, and is based on actual classroom experience in Africa over several previous years.

This unit needs further extensive trial in African classrooms. In order to better assess the usefulness of the unit, comments of teachers using these materials are most important. Comments should be sent to your local Primary Science Centre, or to

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POWDERS

An early look at chemical substances

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PART I

Introduction

This science unit for primary schools is designed to encourage young children to take a close look at some of the common substances found in their surroundings. The pupils work to identify the contents of packets containing starch, salt, baking soda, sugar and, eventually, mixtures of these. They distinguish substances by appearance, feel and sometimes taste. Later, other tests will be needed to help identify the substances. As the children proceed with their work, they will learn to keep records of their experiments and will also become skillful in managing small quantities of chemical substances.

It is important that the teacher remember: *Correct answers and facts are often less important than asking the right questions.* The children's own curiosity is of primary concern. The teacher should serve as both guide and partner in discovery while the class is making initial inquiries about the natural world. It is important that children become excited about asking questions, discussing their results with one another, and finding answers for themselves. We hope that you, too, catch this excitement and do the experiments with the children.

Try not to be too impatient with progress, nor set too high standards immediately. It will take children at least three or four lessons before they become accustomed to working with materials in the way suggested in this unit. While some of the things the pupils will do may look easy to adults, these same things can be difficult problems for children. Do not try to rush the children by asking them to generalize or answer questions before they are ready to do so. One teacher thought she had failed when, at the end of one lesson, only a few of the pupils in her class had discovered that powder number 5 is a mixture of starch and soda. It sometimes takes three or four lessons for a class to realize this fact.

This teacher's guide is written in some detail to help you prepare the lessons and carry on the classwork with your pupils. Before each lesson it might be well for you to perform the experiments by yourself and thus be acquainted with the results. Once you know the purposes of this unit, and have a feeling for working with it, your experience will help you to adapt and add to the ideas presented here.

Class Management

YOUR CLASSROOM: THE ACTIVITY ROOM

This unit is planned for team-work; two children will be working together as a group.

As your pupils are using *Powders*, they will not be working in the same way as they do in History or Geography classes. Children will be talking to each other or walking about the room; some may even wish to go outside to work.

It is often of great help if you can simply rearrange the furniture in the room. If your classroom has separate desks for each child, group them in twos and fours. This arrangement will make it easier for you and the children to move about the room without disturbing one another. If you have long bench-like desks, arrange them around the sides of the room.

The cleaning of containers is often a problem. A bucket or basin of water, in which children can wash their equipment, can be kept just outside the classroom door.

The ideal way to hand out the powders is by putting them in envelopes as suggested in this guide. Twists of paper can be substituted. (See Figure I, page 5.)

Many teachers keep large containers of the powders on their desks so that the pupils can go to the desk for more as needed.

LENGTH OF CLASS PERIOD

In Part II of this guide, the times given for each lesson are meant simply as suggestions. They include time for handing out materials, the pupils' work, class discussion and collecting materials. It is most important for the children to have fairly long undisturbed periods (perhaps 30 minutes or more) when they are free to work with the materials and talk to each other. However, do not hesitate to interrupt or shorten a lesson if you feel that the children are becoming bored or frustrated.

Often there is no need for the class as a whole to stop working. Not everyone will become tired at once. There is no reason why those who have reached a stopping point should not be asked to finish their arithmetic problems, draw their maps, or do other work assigned that day.

RECORDING INFORMATION

Learning to record information is one of the important aspects of this unit. (However, in some of the trial classes, records were not kept.) Because children often forget what they have previously done, the need for taking notes will become apparent in this unit on powders. When a question to the class

brings answers of " I can't remember," suggest that they begin to write things down but do not force them to do so. Let them use the blackboard to record their observations if they wish. One pupil's recording will often serve as a model for the rest of the class. You can also add pupils' observations to the blackboard as they talk with you.

To introduce the idea of recording information, write on the blackboard other things you want to remember. Reminders to yourself that you have to post a letter or go to the market after school or bring something to class the next day are examples of keeping notes. Once your pupils grasp the idea of taking records, these reminders to yourself can be discontinued.

Background Information

Several of the tests that the children will make, while trying to identify powders, are tests used by scientists in their laboratories. When chemists are analysing chemicals before they begin sensitive tests, they handle the substances very much in the same way as your pupils will when guessing what a substance might be. Chemists look at, feel, smell and even taste the substance, though perhaps only in minute quantity.

Some substances the children will be handling in this unit are:

Vinegar: a liquid which is a weak acid and is sometimes used on vegetables to make them taste better.

Baking soda: a powder often used to make cakes as they are baked. (Note: " Baking Powder " is similar, but in addition contains starch and a powder which is an acid-producing substance.)

Iodine: most people know iodine as a substance for putting on cuts to kill germs. Iodine is also used in chemical tests.

A substance that changes colour under specific conditions is called an *indicator.* Iodine is such a substance since a dark colour results when it reacts chemically with starch. Thus, starch is also an *indicator* and can in turn be used to detect the presence of iodine. This test is extremely sensitive. Finding out how little starch is needed to give a blue colour when mixed with iodine will be interesting and fun for the children. As suggested in this unit, iodine can be used to find out which substances contain starch.

Another test your pupils will be using is the *vinegar test.* Vinegar contains acetic acid. When acids react chemically with certain other classes of chemicals called carbonates and bicarbonates, they effervesce and give off a colourless gas called carbon dioxide. This is the reason bubbles appear when vinegar is added to baking soda which is a bicarbonate.

Using the vinegar test, your class can try to find out how many things contain carbonates. Does chalk, or marble, for example, bubble when vinegar is added to each?

However, powders like Baking Powder and Andrews'* already contain acids which dissolve when put in water. Thus an acid such as vinegar need not be added to these to produce a bubbling reaction.

More detailed information on preparation of substances, as well as using them in tests, will be found in following sections of this guide.

Materials

The aim of this unit is to involve your pupils in the process of *doing science,* not just *learning about science.* Have sufficient materials available so that the children are not concerned about wasting or spoiling them.

Following are three lists of materials. List A consists of items provided in the kit. List B is a list of additional items you must supply. The third list suggests how to obtain the items if the kit is not available.

LIST A — ITEMS IN THE KIT

- 2 boxes of laundry starch (This often comes in lumps and should be crushed into a powder before using.)
- 2 packages of table salt
- 4 boxes of baking soda (sodium bicarbonate)
- 2 packages of sugar
- 1 bottle of solid iodine; to make the solution put 2 teaspoonsful of iodine in a large jam jar, add water and mix. The iodine solution will go bad in sunlight and should be kept in a dark place. (All containers of iodine should be marked POISON.)
- 2 bottles of white vinegar
- 1 box of drinking straws or hollow grass reeds, to be used as medicine droppers
- 200 bottle caps (Bottle caps should be washed after each use.)
- Pieces of newspaper to make packets for distribution of powders

*Andrews' Liver Salts is a medicine that many people take for their bowels. It is put in water and a "bubbling" drink results.

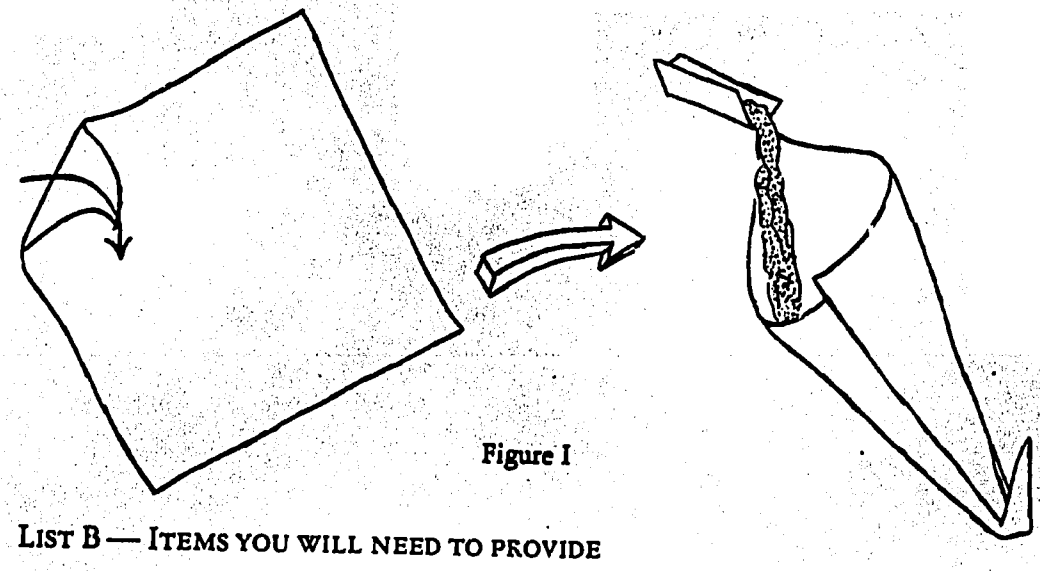


Figure I

LIST B — ITEMS YOU WILL NEED TO PROVIDE

Newspapers to keep desks clean
Clear, large jam jars for use in demonstration
18 or 20 small tin cans or jars to contain water, iodine and vinegar
A good supply of water (A bucket or large bowlful will do adequately.)

LIST C — WHERE MATERIALS CAN BE PURCHASED IF THE KIT IS NOT AVAILABLE

Bottle caps, hollow grass reeds, white vinegar, laundry starch, salt, baking soda and sugar are readily available in most grocery shops or general stores.
Solid iodine can be bought at most good chemists' shops.
Envelopes can be used for packets, or powders can be handed out in twists of paper. (Figure I)

PART II

Lesson Plans

Lesson 1: 35-45 minutes

MATERIALS

Each group of two children will need:
one packet of each of the powders 1, 2, 3, and 4 which are starch, salt, baking soda and sugar
containers for experimenting; e.g. bottle caps
straws, medicine droppers or hollow grass reeds
newspapers for tops of desks
Scattered around the room you will need 5 or 6 small tin cans or glass jars filled with water.

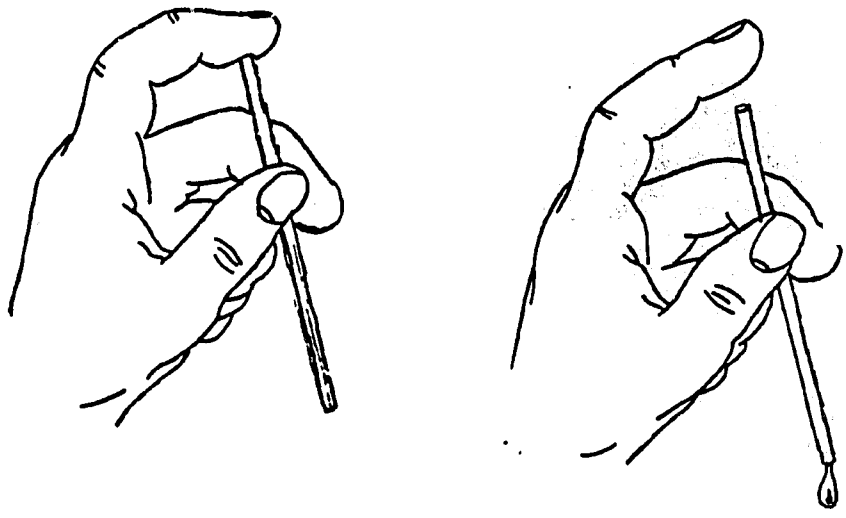
PREPARATION

Prepare the packets of powders before the lesson begins. If you have 40 children in your class, use 20 envelopes or twists of paper for each powder. Label 20 packets with a "1" and put about two teaspoons of starch in each. Mark another 20 packets "2" and put two teaspoons of salt in each of them. Mark 20 packets "3" and put baking soda in these. Do the same with sugar, marking the packets "4".

Have a supply of water in the classroom.

Show your class the four packets and tell them that today you want them to identify the powder in each one. Hold up the bottle caps and explain that a cap can be used as a container for a small quantity of each powder.

Show the children how a straw or hollow grass reed can be used as a medicine dropper. Dip one end of the straw (or reed) in liquid. Place a finger on the other end of the straw as you take it from the liquid. A small amount of liquid (a drop or two) can be released by quickly removing and replacing the finger at the top of the straw.



Hand out the materials. As soon as each group has its powders, encourage the children to start finding out what they are.

This may be the first time that your class has worked with materials in this way. While you are waiting for them to begin to experiment you might walk around the room and talk to a pair of children. Ask them such questions as: "Have you looked at any of the powders?" or "Do you know what powder is?" Ask if they know what it looks like and what it tastes like. Soon most of the children in your class will be working with the powders. Encourage their questions, but do not give them answers. Let them find their own answers.

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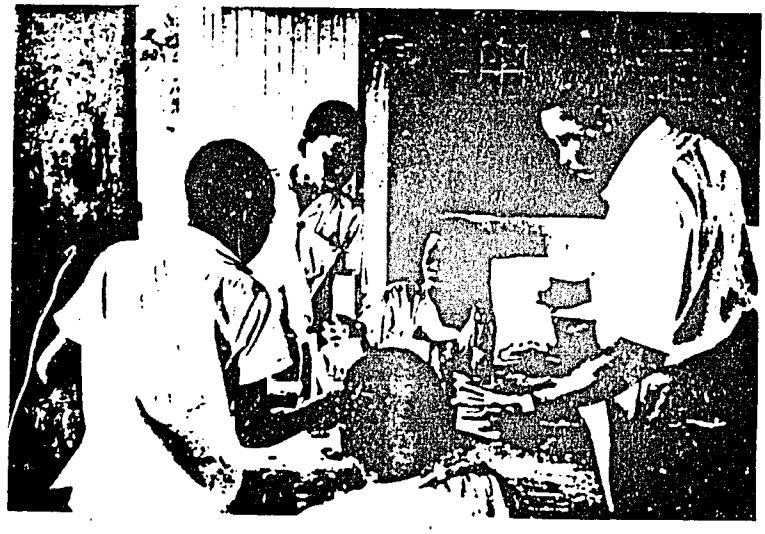
A good way to stimulate the children to begin work is to sit down with a group. Don't talk to them at all. Pour the powders out on their desks; taste the powders, feel them, put water on them. Children need to know that the teacher really means it when he says they can experiment freely with the materials and without close supervision.

As you move from group to group, many children will soon tell you that number 4 is sugar. They will probably have eaten it or made it into sugar water and drunk it. Ask if they have tasted any of the other powders. Suggest that they try to find out what happens when they put water on the powders.



" What does powder number 4 taste like? "

Many children say, "It is a powder," in response to the question, "What do you think it is? "

The teacher, by asking questions, can stimulate the child to explore further. For example:

" What does number 4 taste like? "

" Is it chalk powder? "

" Or sugar powder? "

" Does it smell like dusting powder? "

" Could you use this powder to make Garri? " etc.

Your main aim during this lesson should be to encourage the children to experiment with the powders. Let them feel, taste, look at the powders, and put water on them. Indeed, let your pupils feel free to experiment as they wish.

After 35 minutes or so of working with the powders you will know whether or not the children are getting tired. If they are, stop the work and collect the materials. If the children have school boxes or satchels, let them take their equipment home.

On several occasions teachers have been surprised by discoveries made by children in the trial classes. One group noticed the difference in grain size of the powders, and continued to use this as a method to identify powders throughout the unit. Another group decided to test powders with water (without suggestion from the teacher) and made their own discoveries:

" This one disappears."

" Starch gums."

" Sometimes it sinks and is like milk."

Not all classes notice everything and you must not expect them to. Each group will follow its own way of working with the powders.

Lesson 2: 30-40 minutes

MATERIALS

same as for lesson 1

also, samples of other common materials such as Andrews', tobacco salt, cassava (see discussion on page 9)

As soon as possible it is a good idea for your pupils to feel responsible for the materials. Have them take charge of handing out, cleaning and putting away the equipment. Since you will want your class to refer back to the powders during the course of this second lesson, make sure that each group has its materials before you begin. Ask the children what they found out in the first lesson, and put their ideas on the blackboard. Put down all their ideas, not only the ones you think are good.

These are the kinds of answers they may give:

" Number 4 is sugar."

" I made sugar-water with number 4."

" Number 2 is salt."

" Number 1 looks like milk when I put it in water."

" Number 3 is tobacco salt."

Sometimes children need encouragement before they will speak freely. The teacher often has to show patience while waiting for a reply. Such direct questions as these often help to start a discussion:

" Birangi, do you think number 2 is salt? "

" Who agrees with her? Do you, Patience? How about you, Boniface? "

" What does powder number 2 feel like? "

" John, does powder 2 taste like pepper? What does it taste like? "

After several minutes of allowing the children to tell you anything they know about the powders, ask more specific questions. For example:

Teacher: How do you know number 4 is sugar?

Child: It is sweet.

"We put it on our porridge", "It is white pebbles," are other answers you might get. "We wash with it", "It feels slippery," are the sorts of answers trial classes gave to the question: "How do you know number 1 is starch?"

"Because it is," is a common answer to the question: "How do you know powder 4 is sugar?" Children are immediately comparing the unknown powder with a substance, sugar, which they know very well and they are deciding that the two substances are the same. The teacher should try to stimulate pupils to have a closer look at any powder even if they know it well.

"Sugar is pebbles," the children might say.

The teacher can point out that salt is also like pebbles.

"But they are smaller," the children might say.

The teacher could ask if the pebbles of salt are the same shape as the pebbles of sugar.

At this stage you will probably find that many of the answers are conflicting. Some children will have forgotten things they have previously discovered, some may have worked carelessly, and others may simply be repeating what they hear their friends say. This disagreement is desirable. The main purpose of this unit is not that the teacher identify the powders but that the children are given the opportunity to learn for themselves.

In the trial classes, it was found helpful to have the children whisper answers to the teacher. Then they did not give an answer that they had heard from another child. When you have heard a few answers whispered to you, and if the answers differ, you can tell the whole class that some pupils think (for example) number 3 is salt, some think it is baking soda and some that it is starch.

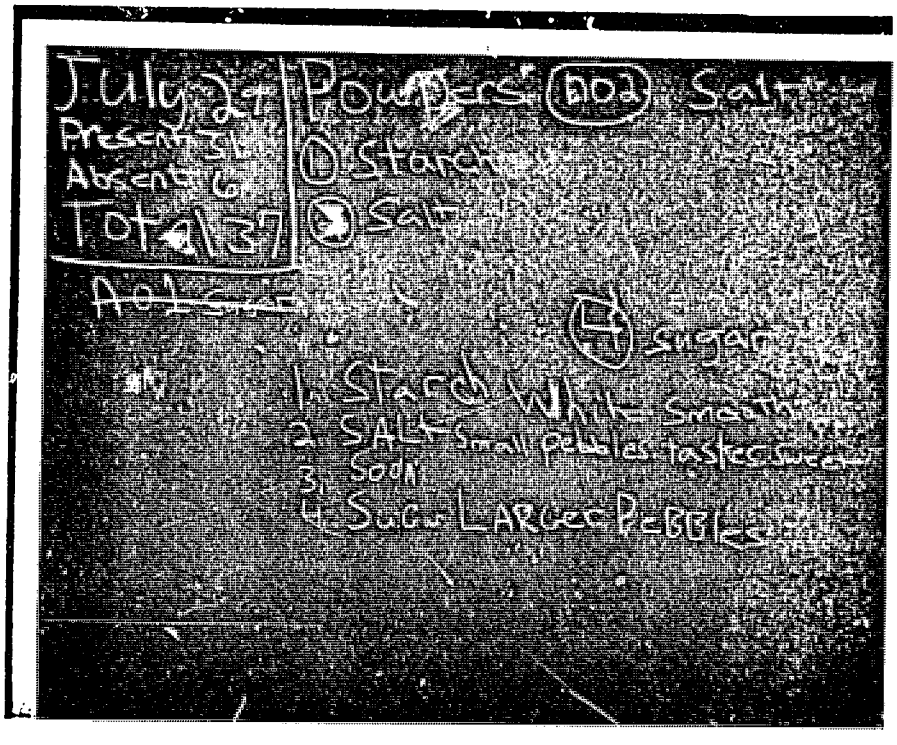
You might then ask your pupils to experiment with their powders again, and urge the children to remember what they do. Perhaps there can be agreement this time.

During this lesson it is a good idea to have packets of the four powders on your desk and labelled with their names. Also try to have samples of the substances your pupils think the powders might be. (Andrews', Akwam, tobacco salt, mistalba, chalk, cassava, are just some of the guesses that have been made by children; there will be differences in each part of the continent.) When you hear a child make such a claim as: "Number 3 is tobacco salt," ask him to compare his powder with the tobacco salt on your desk and find out if they are the same.

Again, when you feel that the children have had enough work for one session, stop and collect the materials.

Sometimes it is helpful to end the lesson with the teacher pulling together the information. Ask the children what they think each powder is and why they think so.

During the discussion they can write their conclusions on the blackboard.
Starch — feels like it; turns water milky; gums.
Salt — taste. Disappears in water.
Soda — tastes bad.
Akwam
Andrews'
Sugar — sweet; pebbles.



A first attempt by children to record on blackboard.

Lesson 3: 45-60 minutes

MATERIALS

Each group of children will need:
bottle caps
packets of powders 1, 2, 3 and 4
straws (to be used as medicine droppers)
packets with powder number 5 — a mixture of starch and baking soda
6 tin cans or jars filled with water
2 clean, empty dry jars

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PREPARATION

To prepare powder number 5, take equal quantities of starch and baking soda and mix them together thoroughly.

Begin this lesson by telling the children that you have brought in a new powder. Ask them to try to identify it. Frequently children will immediately start guessing before they have even seen the powder. As well as powder number 5, each group will need the packets containing the first four powders. Have the children help you pass out the materials.

Let the groups of children begin experimenting as soon as each has its powders. By this lesson your class will probably need no encouragement to begin work. Soon, some groups will be busy tasting and feeling the powders. Others might be trying to discover what happens when number 5 is put in water. They will be talking to one another and this should be encouraged. By listening carefully to what his pupils are saying to one another, the teacher can better judge what particular question to ask an individual child.

During the class period, walk around the room and talk to each child. There may still be some children in the class who have not identified the four original powders. A child might say that number 3 is Andrews'. Give him some Andrews' and ask him if it is the same as number 3. Show him the packets which are on your desk and labelled with the powders' names. Ask him to try to find out if one of those powders is the same as number 3.

If the children tell you that number 5 is starch, ask them why they think so. Many will say, "Because it feels like it." Feel some yourself and then feel some of powder number 1, which they may know is starch.

Ask them if number 5 tastes like starch or, when put in water, does it turn the water milky as starch does. Taste it yourself; taste the other powders and encourage your pupils to do the same.

Many of the children may decide that number 5 is baking soda. Ask if it feels the same as baking soda and, when put in water, does it disappear in the same way as baking soda.

Any interesting comments or experiments that the children do can be written on the blackboard. It is a good idea to have the children write their own comments or observations on the blackboard.

After your class has worked with the powder for 25 to 30 minutes you may wish to stop the activity.

Ask your pupils what they think number 5 is and have them whisper their answers to you. Many may think it is baking soda, others that the substance is starch. When asked why they think it is baking soda you will probably get such answers as:

" It tastes bitter."

" We make cakes with it."

Then ask your class to tell you how number 5 feels. Many pupils will probably reply that it slips, as starch slips or that it gums as starch does in water. Several children in the trial classes even claimed that it felt like salt or sugar. Ask what happens when they put number 5 in water.

At the end of one trial class most children said that number 5 was baking soda, even when they knew it had a different feel and reacted differently in water. If you get similar answers from your class, don't let such conclusions discourage you; remember there are many more lessons to come. Only a few children in all the trial classes could say, " Number 5 looks the same. But it's different. It tastes like baking soda, it feels like starch, and goes like milk with water."

You can point out to the children that some of them have nearly guessed correctly. Tell them that for the next lesson you will bring something that will help them identify powder number 5.

" Look, number 5 turns blue, like number 1."

Lesson 4: 45-55 minutes

MATERIALS

same as in previous lesson but, in addition, 5 or 6 small tins or jars filled with iodine solution

new straws or hollow grass reeds for each pair of children

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PREPARATION

Make up the iodine solution before the lesson begins. A few teaspoonsful of solid iodine in a quart of water gives a good test solution. The solution will keep best if stored in a dark place or in a dark bottle.

Begin by telling the class, "Today I have brought something that may help you find out more about your powders."

Hold up a bottle of iodine solution and again demonstrate how to use a straw as a dropper. *Explain the dangers of working with such substances as iodine.* (You can tell the children that although they may taste their powders, tasting the iodine could make them very sick.) As they begin working with iodine they will be surprised and delighted to see the deep blue colour which appears when it is put on some of their powders. You may need to encourage pupils to try iodine on all their powders by asking if the same colour reaction appears when they test numbers 1, 2, 3, 4 and 5.

As discussed in the section *Background Information* the reaction of starch and iodine results in a dark colour. Thus, some children will detect the presence of starch when testing powder number 5 and comparing the result with an iodine test on powder number 1. Do not point this out to them; let the children make the discovery for themselves.

For 30 minutes or so walk around the room and watch the class at work. Encourage pupils with a remark here and a question there, such as:

"Ngozi's did that too?"

"What did you do to make that colour?"

"Does soda change colour?"

"Do any of the other powders go blue like that?"

"Go and see the funny colours Chiawa has."

When it is time to stop the work, ask the class, "What happens when iodine is put on number 5?" Have each child whisper his answer and write it on the board. (Most of the children in the trial classes said pink, or purple, or blue, or black, all of which happens.)

Then ask what happens when they put iodine on the other powders. Again have the class whisper answers to you and finally write these quickly on the blackboard. Here are samples of replies children have given:

"Baking soda is pink."

"Sugar is white."

"Sugar goes brown."

"It goes purple with starch."

"It is white with salt."

"Nothing happens with sugar."

"Baking soda goes purple."

Perhaps you could complete the class work by saying that there seems to be a lot of disagreement. Take one of the powders which has caused disagreement, e.g. baking soda, and put some into one of the clear glass jars. When you have had the children guess what will happen when iodine is added, do the experiment as they watch. You might do the same with another powder that will give a colour change, for example, number 5.

End the lesson by collecting the materials.

" Look, number 1 turns blue."

Lesson 5: 45-60 minutes

MATERIALS

new bags of powders 1, 2, 3, 4 and 5 for each group of children
3 new straws per group
15 or 16 tin cans or jars; 5 or 6 filled with water, 5 or 6 with iodine solution, and 5 or 6 with vinegar
sheets of note paper for each child

PREPARATION

You will need to make up fresh packets of the powders. Fill some tins or jars with vinegar and make sure that there are also jars of water and iodine solution.

Ask the children to tell you what powder number 1 looks like. Have them whisper their answers. They may also tell you things they discovered in the previous lesson. Do not start recording until you have answers from several children, and then write all answers on the board at the same time.

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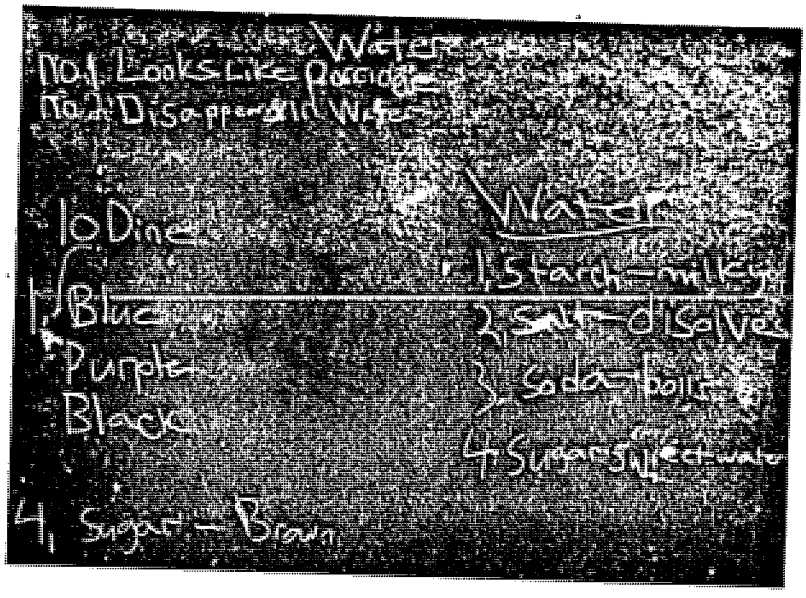


Second attempt by children to record on blackboard

Ask how powder number 1 feels and again have the class whisper answers. You may discover that the children have forgotten what they learned from previous tests (or they have not been careful enough).

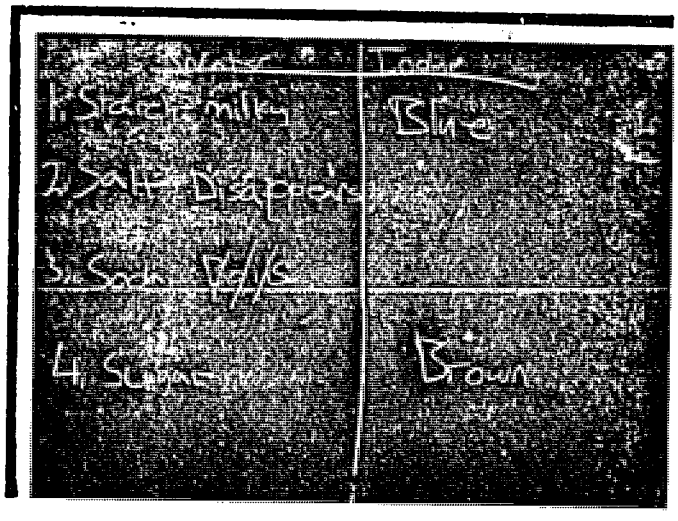
As soon as there is disagreement about a particular point, suggest to the pupils that they may be confused or have, perhaps, forgotten what happened during the previous lesson. Suggest that they do their experiments again, this time carefully, and with clean powders. Give them a piece of paper in case they wish to write things down themselves so that they will not forget what they have done. You and your class can also use the blackboard as another place to record information.

Show them the new liquid, vinegar, and suggest that the liquid might help them to find out more about the powders.

Hand out the new powders, caps and straws, and distribute the bottles of iodine and vinegar around the room. Your pupils will be eager to start working and by this time they will probably have a more careful technique.

Walk around the classroom as you put questions to the children: "What happens?", "Does number 1 also go blue with iodine?", "Have you tried using vinegar?", "See, what made that foam?", "Does it foam the same way in iodine?"

Whenever a group of children tells you something, put the comments on the board; encourage each child to write his own comment on the blackboard. After about 15 minutes of work in one of the trial classes the board was as shown on the following page.



Soon many children will be writing down their own results as well as experimenting with the powders.

Tell your class that each group should write down only what happens with its own powders. (Many of the pupils in the trial classes tried to copy what was written on the blackboard. To prevent pupils copying, the teacher had to clean the board.)

Continue walking around the room; talk to the children and encourage them to do more experiments. You may need to help a few children with their written notes.

It is impossible to anticipate what phrase pupils will use to describe what happens when vinegar is dropped on powder number 3. The children in the trial class in Entebbe either said it was "like Andrews'," or used a Luganda word *Okubi ba,* which means something like "foaming." In Nigeria, pupils said, " It boils "; "It's like palm wine," was also a common response. Whatever the children's response, it is better to use words they give and not try to impose your own description.

After the class has been working for 30-40 minutes you will probably feel that it is time to stop. Ask what happens with a mixture of powder number 1 and iodine. Suggest that the answers be written down; walk around the room and have each pupil whisper his answer. Write what they say on your record on the board. Then ask about the reaction of powder number 1 with vinegar. Again have them write it down and whisper their answers to you. Write their comments on the blackboard.

Have them test the other four powders in a similar way, asking them to tell you what happens when iodine or vinegar is put on each one. Some children may wish to do more experiments to find out the answers to your questions. You should encourage them to do so.

Lesson 6: 45 minutes

MATERIALS

same as for previous lesson (Keep a good supply of all powders on hand.)

While some of the children are handing out the materials, start writing on the blackboard information learned in the previous lessons. Have the class look at their own records to help you. Again have the children whisper their answers to you. By now your pupils will probably agree about what happens when iodine is put on the powders. (In the trial classes there was still disagreement about what happens when vinegar is added to each powder.) Write down the answers that your pupils give and then let them begin work and try to resolve any disagreement.

At this stage draw lines around your information on the board so that it begins to look more like a chart. Next put headings at the top of each column. Your pupils can suggest what headings to use.

After the class has been working for 25-30 minutes, stop the work and ask the children to tell you what happens when vinegar is put on each powder. There may still be disagreement. You could perhaps demonstrate to the class as a whole what happens when vinegar is put on any one of the powders about which there is a question.

You could end the lesson by telling the children that during the coming week they can experiment with iodine and vinegar to find out as many things as they can that turn blue with iodine and fizz the same way powder number 3 does in vinegar. Make these liquids available for children to experiment with at times of the school day when they are not doing other work. Some of them might even take the liquids home with them.

Lesson 7: 35-40 minutes

MATERIALS

same as for Lessons 5 and 6

packets with powder number 6 — a mixture of starch and salt

Also have available such things as bread, cassava, ash, chalk, paper, etc. to demonstrate to the class what happens when you test them with iodine and vinegar.

PREPARATION

To prepare powder number 6, use a sufficient quantity of starch. Add just enough salt to make the powder taste salty. Crush and mix thoroughly. It is a good idea to check the iodine solution to be sure it still reacts with starch.

First ask the children if they have tested any substances with iodine and vinegar as you suggested in the previous lesson. Many may have tried testing substances which they already know about. Write on the blackboard what your pupils did, and encourage them to talk about what happened. You could show them some of the things you have tried yourself. (Children in the trial classes have been surprised and delighted in seeing what happens when iodine is put on bread and cassava, or discovering that cigarette ash fizzes in vinegar.) Again encourage your class to try the vinegar and iodine tests on as many things as they can think of.

Hand out powder number 6 to your pupils. Explain that the new substance could be either starch, salt, baking soda, sugar, or a mixture of powders.

In one trial class several children did not understand the meaning of "mixture" when an explanation was given in English. It was necessary to show the children by mixing two powders as a demonstration while their teacher explained in the vernacular.

Ask your class to try to discover what is in powder number 6. Many children will find out quickly that it is a mixture of starch and salt. Encourage them to talk about why they think there is starch in it, and why they are so certain that it does not contain baking soda. When you feel that groups of children really understand the contents of powder number 6, ask them to go back to powder number 5 and discover if they can now tell what it contains.

End the class by asking what the pupils think powders 5 and 6 are. If you have them whisper their answers you will probably, as happened in the trial classes, get many different answers. Children, like adults, quickly forget. This is again a good opportunity for pointing out that it is sometimes useful to write things down.

Lesson 8: 35-40 minutes

MATERIALS

In addition to the materials and equipment used in previous lessons, you will need packets of powder number 7 — a mixture of baking soda and sugar.

PREPARATION

Prepare powder number 7 by mixing quantities of baking soda and sugar.

Again begin the lesson with a discussion about any tests with iodine and vinegar which the children might have done in their spare time.

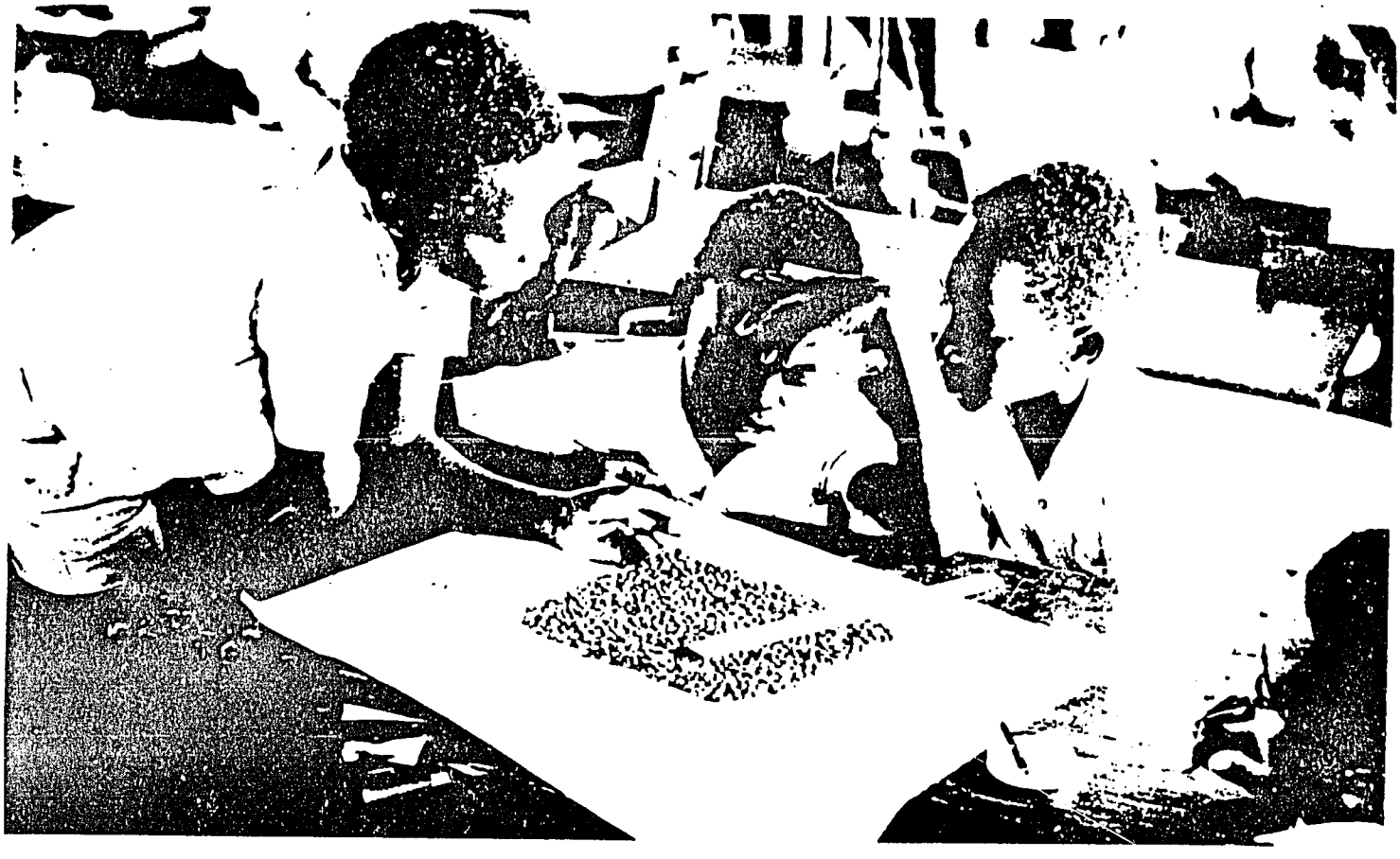
Tell them that you have another mixture, number 7. Ask them to try to discover what is in it, and let them begin work. Give them paper and again suggest that it might be a good idea to write down what happens.

By now the children in your class may be working at many different stages. Some may need to go back and re-test the original four powders. Others will still be unclear about powders numbers 5 and 6, and will need more work on them. Some, of course, will not need your help at all and will rapidly discover the contents of powder number 7. Remember that this variety is to be expected; help each group to work at its own speed. This is much more satisfactory than trying to rush everybody along so that each child is doing the same thing at the same time.

Teachers in a trial class found this a good way to keep the faster children occupied and interested: Have them make up their own mixtures of powders and then ask their friends to identify a mixture.

There are other powders which can be given to the children who finish quickly. We found that many children will work eagerly and well trying to find out what Baking *Powder* is made of. Eventually, they will probably say it is a mixture of soda and starch. You might ask some of the faster children to make a mixture of soda and starch to see if it does the same things as Baking Powder. (It doesn't quite, as it bubbles in iodine and water as well as in vinegar.)

"Look, 7 turns purple with iodine!"



Estimating Numbers

Teachers' Guide / Trial Edition

APSP

African Primary Science Program

A86

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This preliminary teaching unit, *Estimating Numbers*, was begun at the 1967 Workshop in Akosombo and was based on the Elementary Science Study unit, *Peas and Particles.* Modified by actual classroom experience in African countries, *Estimating Numbers* was rewritten at the Nairobi Writing Workshop in April of 1969 by Dr. D. M. Lapp and D. Kiyimba, Uganda and F. M. K'Opiyo, Kenya. Other contributors include Dr. H. Dyasi, R. Francis and R. King, Sierra Leone. Comments from teachers using these materials will be appreciated. Correspondence should be addressed to your nearest Science Centre:

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August 1969

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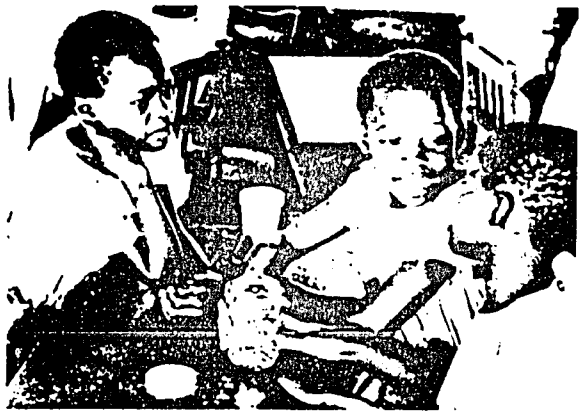
ESTIMATING NUMBERS



How many maize plants grow in a field? How many people live in your village? How many children are there in your school? Every day there are questions which must be answered by large numbers. Does it mean anything to answer them exactly? Usually not. For example, must we say there are 55,921,716 people in Nigeria or is 56 million close enough? Often in science we are satisfied with only an approximate number. This unit contains some activities, designed for upper primary, which give children a feeling for large numbers: hundreds, thousands and millions. They will learn to guess numbers more and more accurately; in other words they will learn to make good *estimates.* Even more important, your pupils will have many opportunities for thinking in a scientific way.

You, the teacher, should plan to spend some eight to twelve lessons (double periods) depending on your pupils' interest. Double periods are better than single periods because children need enough time to find answers to estimation problems.

This unit has been used very successfully with children in the fifth year of primary school. However, these activities may be used in any of the upper primary classes from the fourth year through the seventh year.

MATERIALS FOR A CLASS OF 40 PUPILS

This list includes the materials necessary to do all of the activities in this unit. The particular things that are suggested for the children to count are not important. Although choices of materials are suggested, in many cases you will probably wish to make other substitutions for items which are not easily found in your area.

The list has been made for a class which will be divided into ten groups of four pupils each. Try to collect all of the materials before you begin to teach this unit.

Containers

(Plan to collect these long before you begin this unit with the class. You may be able to have your pupils collect these. The more containers you can get, the better, especially if you can find many that are the same size.)

One small basket or bag or small cardboard carton

One large glass jar

Ten small glass jars; wide-mouthed jam jars or screw-top jars are ideal
(Small tins might be substituted but cannot be used for estimating by layers.)

40-50 paper cups (Small tins, jars, tumblers, or bamboo sections can be substituted, but you will need at least four containers of exactly the same size for each group of children.)

10-20 large spoons, jar lids, or small plastic cups

10-20 bottle tops, ball-point pen tops, or other small containers

Things to Count

(The greater the number of kinds of things to count that you can collect, the better.)

One basket of large objects such as oranges, lemons, potatoes, bananas, kola nuts, palm kernels, or other large nuts or seeds from trees

Medium-size seeds such as beans, peas, maize or groundnuts – enough of each kind to fill the ten small jars

Small seeds such as rice or millet – enough to fill the ten small jars

Salt or sugar – enough to fill one or two small jars (optional)

Other Materials

10 large sheets of paper (large newsprint sheets are suitable)

10-20 rulers

10 balances (See Lesson 8 for construction details.)

LESSON ONE: COUNTING LARGE THINGS AND ESTIMATION OF A HANDFUL

Materials Required

A small basket of oranges, lemons, potatoes, bananas or large seeds

10 small jars of beans, peas or maize

10 large sheets of paper (newsprint)

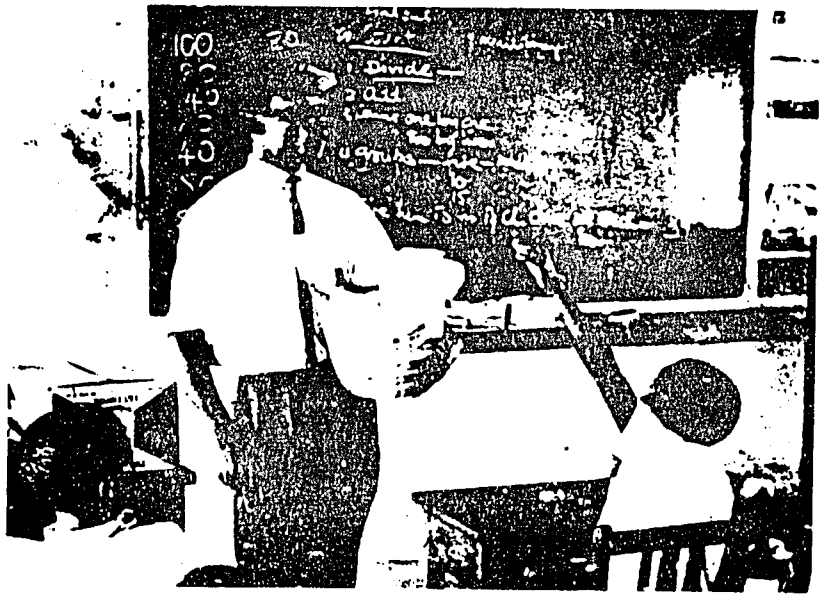
The Lesson

Have ready a basket or large bag full of one type of large objects such as oranges, potatoes, kola nuts or palm kernels.

Cover the basket so the children cannot see what is inside.

Ask the children, "What do you think I have in the basket?" Listen to their answers:
"Things from market"
"Fruit"
"Books"
"Stones"

Then remove one object (one lemon or potato or whatever you have) and show it to the class. Walk round the room showing the children that the basket is full of the same kind of object. Ask the children, "How many do you think I have in the basket?" "Can you guess?" The children can write their guesses on their own papers, but they should keep them secret. After everyone has guessed, call on each child to read his guess to the class. As the numbers are read, write the numbers on the blackboard.



Ask the children, "How can we find out how many are in the basket?" Perhaps they will suggest that you count them. They may say, "Hand one to each of us. We know how many children there are and we can see how far they go round." It is important that the children themselves suggest *how* the objects should be counted. Follow whatever idea they have. How does the count compare with the guesses? Whose guess was nearest? How can we learn to make better guesses? Tell your class that you will now give them a chance to practise making better guesses.

Take a small number of beans (or peas) in one hand and ask, "About how many do I have?" Ask the children to write down their guesses.

Then place one of the large sheets of paper on the floor. Throw the beans onto the paper. Let the children look at them briefly, then quickly cover the beans with another piece of paper so that the children do not have a chance to count each one. Ask, "How many beans were on the cloth?" Explain that you do not want an exact answer, but only a good *estimate*. If the children in your class do not know this word, explain that a *good estimate* is a careful guess. Again have the children write down their answers.

Now you or one of the children can count the beans. Was anyone exactly right? Who was the closest? Be sure to start with very few beans so that the estimates are quite easy to make. Then try using more beans. Move slowly to a handful, each time leaving the beans on the paper for only a short time.

When the children have understood the idea, let them divide into groups of four and continue guessing on their own. Each group can meet round one large sheet of paper. One child in each group can throw the seeds for the others to estimate. He should write down the estimates of the other children and then count the actual number of seeds. Another child can then be leader.

Make sure that everyone has a turn both to be leader and to estimate. Walk round the room to see that everyone understands the game. After the children have worked with beans for awhile you may wish to give them some smaller seeds such as maize or peas to try.

After about half an hour, collect the materials and bring the children together to discuss what they have been doing. Ask if any child has a method which he used to make good estimates. If the children find it difficult to tell you their methods, you may be able to encourage them to give their ideas by asking some of the following questions:

"How did you decide what number of beans to say?"

"Why did you say that particular number? There must be some reason why you said 40 and not 80."

"Which were the easiest to guess, beans or peas?" "Why?"

Carry on until all of the children have had a chance to give their ideas. Tell the children that during the next lesson you will give them a chance to discover new ways of making good estimates.

LESSON TWO: JAR EXAMINATIONS

Materials

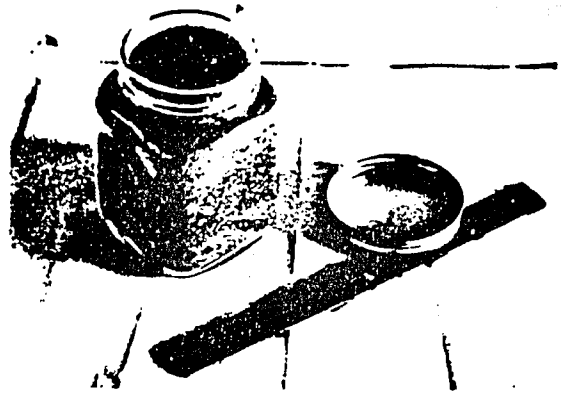
1 large jar of very small seeds (millet or rice)

5 small jars of beans

5 small jars of peas

10-20 large spoons or jar lids

10-20 bottle tops or ball-point pen tops



Getting Started

Hold up the large jar of seeds. Try to obtain small seeds, such as rice or millet, that are difficult to count one by one. Ask your class, "How many seeds do you think there are in this jar?" You will get answers such as:

"One thousand"
"Ten thousand"
"One million"
"A billion"

The children in your class will probably find it very difficult to think about numbers as large as these, and they are sure to give widely different answers. Write these on the board and then ask, "Can you think of any way by which we can tell *about* how many seeds there are in this jar?"

The children in one class responded with the following:
"We can count them one by one."
"No, we cannot do this with millet."
"They are too small; it is impossible to count them!"

When all of the children have had a chance to give their ideas, tell your class that during the coming weeks they will be given a chance to find some new ways of estimating the number of small seeds in the large jar, without counting them one by one.

The Lesson

During this lesson, you will be giving the children in your class a chance to discover by themselves some ways to estimate the number of seeds in a jar. Although their first efforts may not succeed, it is important that you give them a chance to try their own ideas. You can be sure that your pupils will learn from their mistakes as well as their successes.

Have each child make a chart like this one in his exercise book:

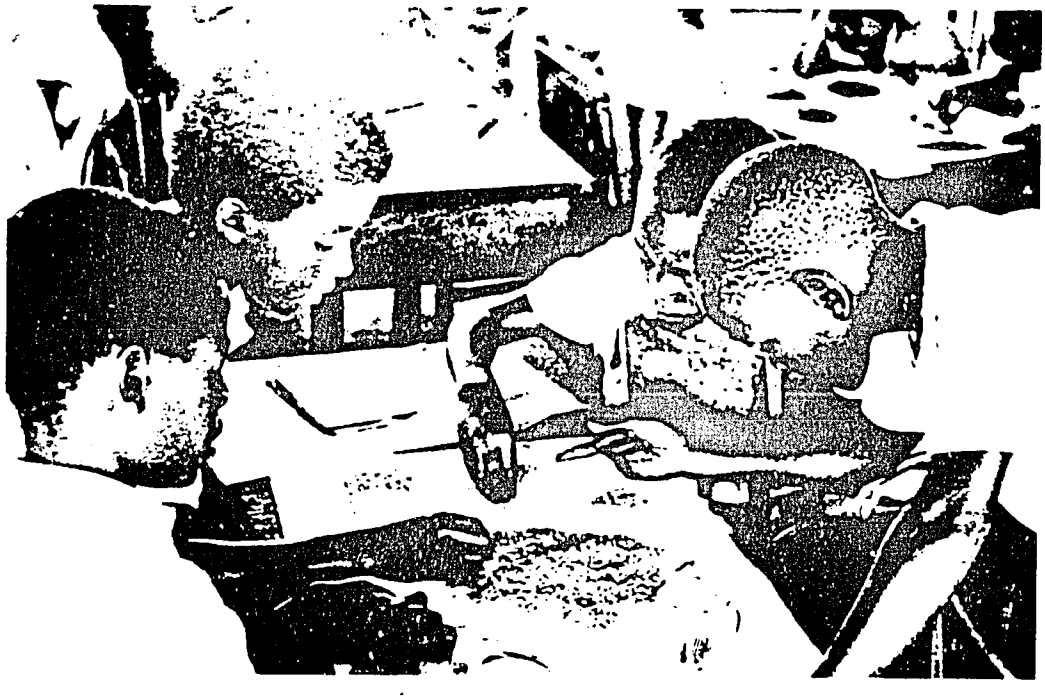
Kind of Object	Number Estimated	What I did
jar of beans		

Give each group of four children one of the small jars of beans or peas (or other seeds of similar size). Tell the children that each group is to try to find ways to estimate how many seeds are in their jar. Explain to your class that *exact* numbers are not necessary, but that you would like them to try to find out quickly *about* how many seeds there are.

Show your class the spoons, jar lids, or other measures which you have collected. Tell the children that they may be able to find ways to use these things to help them estimate the number of seeds in the jars.

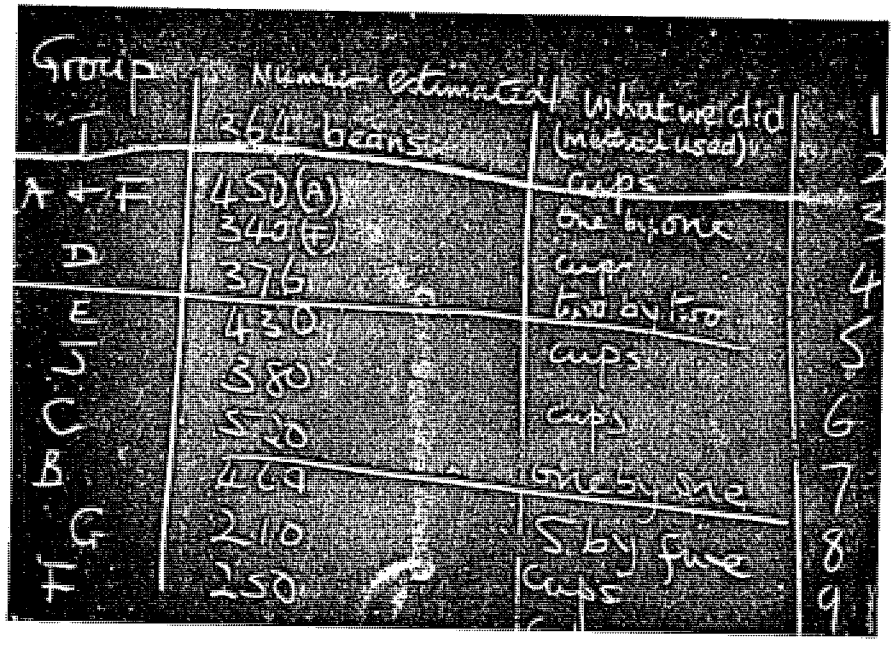
Each child should record his answer and describe briefly the method which he used in his exercise book. When a group of children who were given beans have finished making their estimates, you can suggest that they trade with a group that has been using peas. If some groups finish working with both beans and peas, you may wish to fill their jars with some of the millet (or other very small seeds) used at the beginning of the lesson.

You will probably find that almost all of the children in your class will try to count the seeds one by one. However, if any of your groups attempt to count the number of millet seeds in a jar, they will soon find that they cannot use this method, for it takes much too long. Even with beans and peas, children often lose count. They have to start over again, and become tired. This is useful because it shows them the need for quicker methods.



Often the first improvement which the children discover is to arrange the counted objects into little groups of 10 or 20 seeds. At this point they may begin to see the advantages of first grouping the objects and then counting the number of groups. Grouping can then lead them to the sampling method described in the next lesson.

About fifteen minutes before your lesson time is finished, collect the materials and ask one child in each group to give you his estimate and the method which he used. Write these estimates on the blackboard. For each kind of seed, you will then have a list of numbers like those in the photograph below.



Many children will now want you to tell them which number is "right," but you should avoid answering this question. (If one answer occurs twice, it does *not* mean that it is the "best" answer.) Instead, remind the children that they were not trying to find the *exact* number of beans in their jar, but only an approximate number. Although some of the jars might have contained a few more beans and others a few less, if one makes a good *estimate* he then knows *about* how many beans there are in each of the jars.

One useful way to discuss a list of the children's estimates such as the one above is to ask your class the following kinds of questions:

"Which is the smallest estimate?" (210, in the photograph above)

"Which is the largest?" (520, in the example above)

"How could an answer be written that would include all of the answers?"

If none of the children in the class can think of a way to answer the last question, the teacher can suggest that there are probably *at least* 210 and *not more than* 520 beans in the jar. The children will then begin tc see that although each of them may have arrived at a different answer for the number of beans in a jar, all of them can agree (in the example) that there are probably between 210 and 520 beans in the jar.

Another way to combine their estimates is for the children to take an average of all the estimates. It is not necessary to take an average, so do not do the following unless you feel your pupils are ready for it. An average is made by adding all the estimates together and then dividing by the total number of estimates.

In the example above, the sum of the ten estimates is

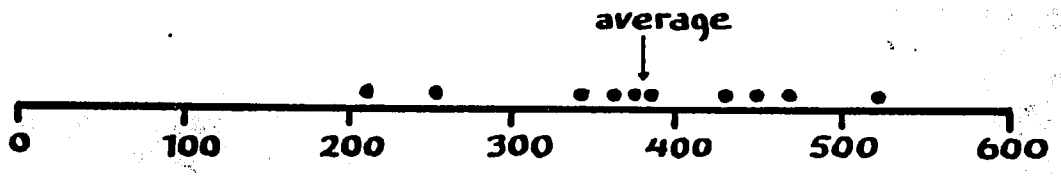
364 + 450 +340 + 376 + 430 + 380 + 520 + 469 + 210 + 250 = 3789

The average is then taken by dividing this sum by 10, which is the number of estimates.

3789 ÷ 10 = 378.9 or 379 to the nearest whole bean

Thus, the average estimate is 379 beans. There are not necessarily 379 beans in the jar, of course, but if you do not know the true number, this is the best guess or estimate the class can make at this point.

To see how good an estimate the average is likely to be, the class can make a line chart of their separate estimates.



You can see from such a chart that there is a very large spread to the estimates. From this you know that the average is not likely to be very close either. You can see that one-half of the 10 estimates lie between about 320 and 440. The best you can say about your estimate is that you have about a 50 – 50 chance of the true number being between 320 and 440 or within 60 beans more or less than 380.

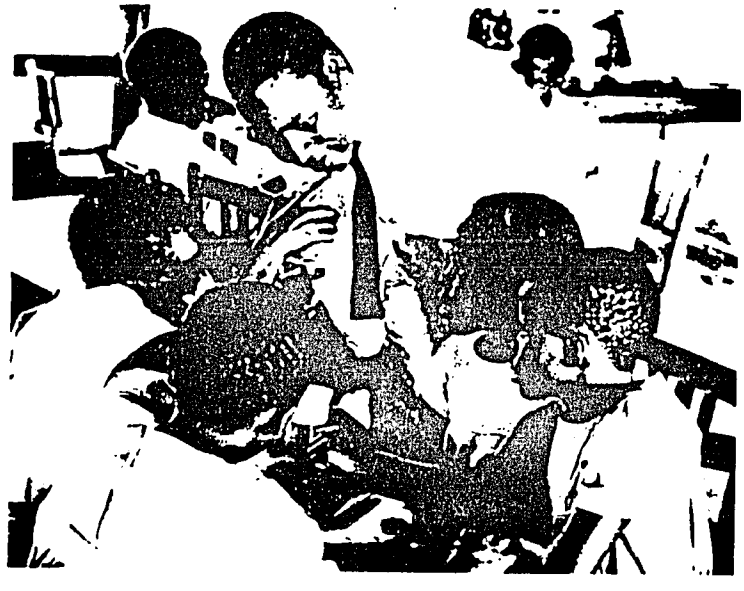
LESSON THREE: TAKING A SAMPLE

In the following seven lessons, a number of methods are described which can be used to estimate the number of seeds in a container. Your pupils may discover some of these methods by themselves. The teacher should be careful to allow the children plenty of time to work out their own ideas before suggesting new things for them to try.

It is not necessary to do Lessons Three through Eleven in the order they are presented in this booklet. You should try to do these lessons in the order which seems most natural for the children in your class. For example, if one of your pupils, during Lesson Two, discovers a way of estimating by counting the layers of seeds in his jar, you would be wise to have him describe his method to the class and go on to Lesson Five before doing Lesson Four.

In some classes, however, the children have been unable to discover some of the following estimating methods entirely on their own. It was sometimes necessary for the teacher to get the children started. He did this by questioning individual groups of children about what they were doing and by making small suggestions here and there. In the following lessons, some questions are suggested. The teacher can use questions like these to help children get started thinking about the various methods of estimation.

This does not mean that a teacher should give lectures to the class on the different estimating methods. Nor should he ever go to a working group of children and say, "No, you are not doing it right, do it this way." Instead, the teacher must be skillful enough to get the children started without telling them exactly what to do.



You will have already observed that children gain much more by solving a problem by themselves than they do when they are told exactly what to do. You will need to encourage children to find their own answers, and this may be difficult at first. However, you will be rewarded when you see the excitement in your classroom when the children are working by themselves to solve a difficult estimation problem.

Materials

10 small glass jars, tumblers, tins, or paper cups

Beans, peas and maize (or other seeds of similar size)

10-20 large spoons or jar lids

10-20 bottle tops or ball-point pen tops

The Lesson

To use the sampling method, a small sample of a large group of objects is counted. This number is then used to show how many objects are in the whole group.

For example, a child may start with a jar of peas to count. If he fills a jar lid with the peas, he can easily count this small number of peas.

He can then continue filling and emptying the jar lid until the jar of peas is empty. If he counts as he does this, he can find the number of lids it takes to fill the jar. He can multiply that number by the number of peas in one lid. He will then have a very good idea of the number of peas in the jar.

You can encourage the children to try this idea by giving each group of children a jar of beans and a number of small measures such as spoons, jar lids, and bottle tops. You can then suggest that the children try to use these measures to help them estimate the number of seeds in the jar.

However, at first you will probably find that although the children will immediately begin using measures such as spoons, they will continue to count all of the seeds one by one. Many children spend a long time doing this before they realise that they do not have to count the seeds every time they scoop them out with a spoon.

If some groups of children continue counting seeds such as beans one by one, you may find it helpful to give them smaller seeds such as peas or maize which take a longer

time to count one by one. If some groups still continue counting the seeds in every spoonful, you may wish to try asking the following questions:

"How many spoonfuls of peas does it take to fill your jar?"

"How many peas are there in a spoonful?"

"Can you find a way to use these numbers to estimate the number of peas in the jar?"

Near the end of the period, collect the materials, and record the answers of one child in each group on the blackboard. You can discuss these results with the children by using the method described at the end of Lesson Two. You might also ask the children if their answers agree more closely than they did at the end of Lesson Two.

LESSON FOUR: ESTIMATING BY LAYERS

Children sometimes discover that they can estimate how many seeds are in a jar by counting the number of seeds on the top layer of the jar (or the bottom if they can see through it) and then counting the number of rows up the side of the jar. Multiplying the number of seeds in a row times the number of layers then gives an estimate of the number of seeds in the jar.

Materials

10 small jars

(Water glasses or plastic tumblers can also be used, but they must be transparent.)

Groundnuts, peas or beans — enough to fill the jars

The Lesson

Give each group a jar of groundnuts. (Peas or beans can be used, but the children will be more interested if you introduce something new like groundnuts.) Explain to the children that they are to try to estimate the number of groundnuts in the jar without pouring them out. However, encourage the children to open the jars in order to see the groundnuts on top more closely. Also encourage them to look closely at the groundnuts on the sides and bottom of the jar.

Walk round the classroom to visit the groups of working children. If some groups cannot seem to get started, suggest that they count all the groundnuts they can see on the top or bottom layer. You can suggest to other groups that they may find it helpful to count the number of layers of groundnuts that are in the jar. But do not tell any group exactly how to go about getting an answer. In this way you will give the children as many chances as possible to think for themselves. If some groups quickly succeed in getting an answer, give them another kind of seed to try, such as beans or peas. When several groups of children have discovered how to use layers to make estimates, have one group describe its method to the rest of the class.

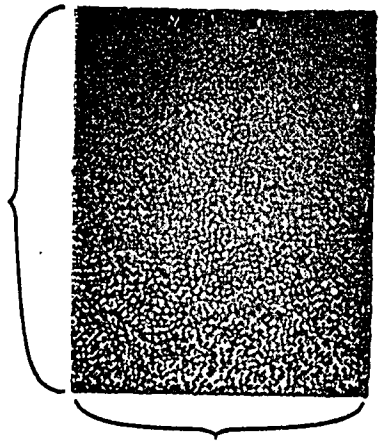
The children in one class had an argument at this point, because they said that the line of groundnuts that one boy had counted up the side of the jar was not a straight line. The boy answered, "It does not really matter much because we only need an estimate."

LESSON FIVE: ESTIMATING BY ROWS

Another way to estimate the number of seeds is to pour them out on a flat surface and use a ruler to push them closely together into the shape of a square or rectangle. The number of seeds in a 'row' along one edge can then be counted. If the number of 'rows' are then counted, the two numbers can then be multiplied to get an estimate of the total number of seeds.

Example:

There are about 82 seeds in the 'row' along this edge.



There are about 65 'rows' of seeds that can be counted along this edge.

Therefore, there are about 82 x 65 = 5330 seeds in the rectangle.

Materials

One piece of heavy wire mesh
(If necessary, you can use a piece of mesh that is installed in a window or fence. A brick wall also could be used.)

One full box of chalk, packed so that only the ends of the pieces of chalk can be seen

10 small jars of beans, peas, or groundnuts
(Other containers can be used, but it is best if all of them are the same size so that the results of different groups can be compared.)

10 large sheets of newspaper (optional)

The Lesson

At about this point in the unit, the children in your class may have tired of working only with seeds. It is therefore wise at the beginning of this lesson to take your class

outside the classroom so that they can try some different kinds of estimating activities.

There are many possibilities. One teacher found a tree which had almost the same number of leaves on each small branch. He pointed to a large branch and asked his pupils to quickly estimate how many leaves there were on the branch. Since there were about eight leaves on each small branch, and five small branches, the children were quick to see that there were about 5 x 8 = 40 leaves on the large branch.

Another teacher suggested that the chidren try to estimate the number of ridges in the corrugated iron roof of the school. By counting the number of ridges in each iron sheet, and counting the number of sheets along the edge of the roof, the children were able to estimate the total number of ridges. You and the children will get other ideas of things to estimate by looking at the surroundings of your school.

When the children have spent about one-half hour doing these kinds of estimations, bring them together and call their attention to a piece of heavy wire mesh on a window or fence, or to a brick wall. (Anything made of regular rows of things will do.) Give the children a short time to look at the wire mesh or wall and then ask them, "About how many holes are there in this wire mesh?" or "About how many bricks are there in this wall?"

When the children have made their estimates, ask some of the children to describe what they did to get their answers. Many will have counted the holes or bricks in one row, and then multiplied by the number of rows to get their answers.

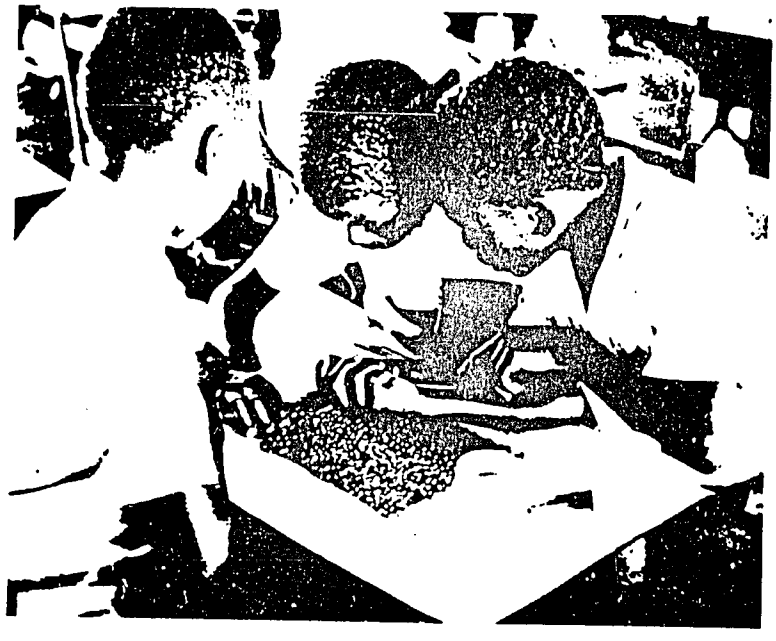
Then take the children to an open place on the school compound and tell them to stand as close together as they can in lines of about the same length. Ask your class,

"What is the quickest way to tell about how many pupils you are altogether?" In one class, the children answered, "There are six lines and about seven children in each line, so there are about 6 x 7 = 42 children." One boy disagreed, because he said there were only six children in one of the lines. However, the class decided that this did not matter since they only wanted to make an *estimate.*

When your class has finished this activity, take the children back into the classroom, and give a jar of seeds to each group. If possible, give each group a large sheet of paper such as newsprint. Let the children pour their seeds on the paper and encourage them to try the methods which they used outside to estimate the number of seeds. Provide the children with rulers or other straight sticks which they can use to push the seeds into a rectangular shape.

Children may discover more than one way to use the method of counting rows to make estimates. Some children count rows that are one seed wide, while others prefer to divide their seeds into lines one inch wide. Be sure to encourage groups with new methods to explain their method to the rest of the class.

Again, at the end of the period have a child from each group report his answer, and record these estimates on the blackboard.

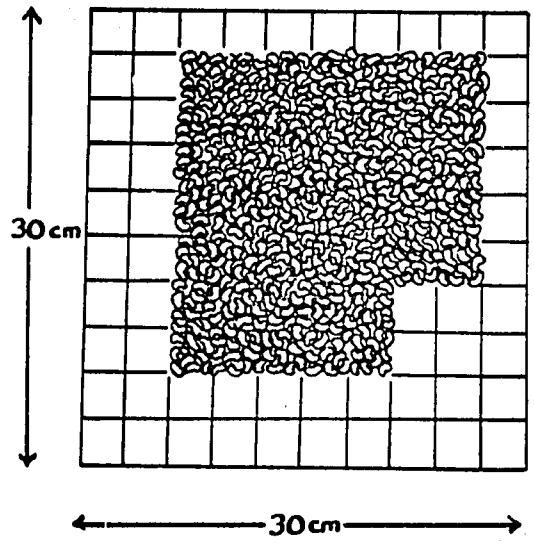


LESSON SIX: ESTIMATING BY AREA

Imagine that you have drawn a big square, 30 centimetres on a side, on a piece of paper and have divided the big square into small squares, 3 centimetres on a side. A jar of beans is now poured on the squares, and the beans are pushed together so that no spaces are left between them.

30

Since the squares are all the same size, the number of beans may now be estimated by counting the beans which are contained in one small square and multiplying by the number of squares that are covered with beans. In the example, there are 45 small squares covered. If it is found that there are 12 beans in one small square, then the total number of beans must be about 12 x 45 = 540 beans.



Materials

10 large sheets of paper

10-20 rulers

10 jars of beans, peas, or maize
(If possible, it is a good idea to introduce a new kind of seed for children to count in this lesson.)

The Lesson

On the blackboard, draw a set of squares like those described above. (If you wish to use inches, you can draw a big square 12 inches on a side, with small squares one inch on a side.) It does not matter what size you make the small squares as long as all of them are equal.

Ask the children:
"Are all of these little squares the same size?"
"How many little squares are there altogether?"
"What is the quickest way to find out?" (Most of the children will use the method of rows that they used in the previous lesson.)

Pass out the jars of seeds, sheets of paper, and rulers, and tell the children that you would like them to draw squares like the ones on the board and try to find a way to use the squares to estimate the number of seeds in the jar.

In one class, some groups of children used the squares to help them count the seeds by putting four seeds in each square until all the seeds had been used. Other groups

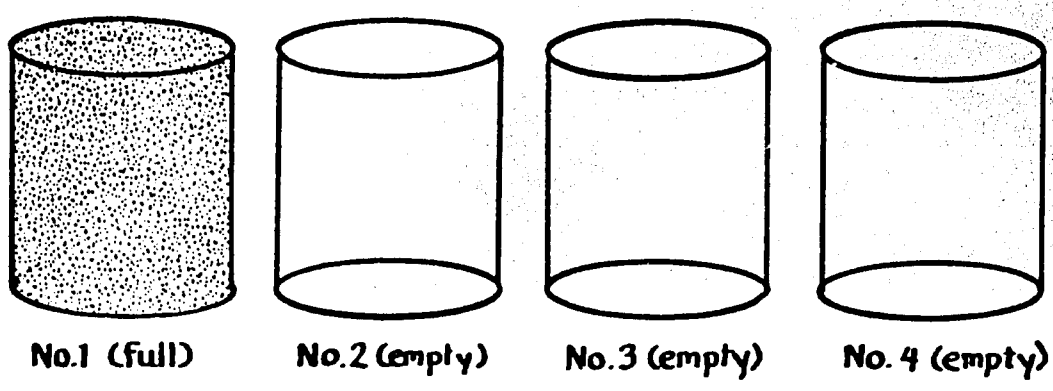
used the squares to help them estimate by rows. You should let such groups work on their own ideas; it is not necessary or desirable that all the children in the class use exactly the method outlined above.

If some groups of children seem to be having trouble getting started after they have drawn a set of squares, you may wish to suggest that they try counting the number of seeds in one square. Do not, however, explain the whole method to them.

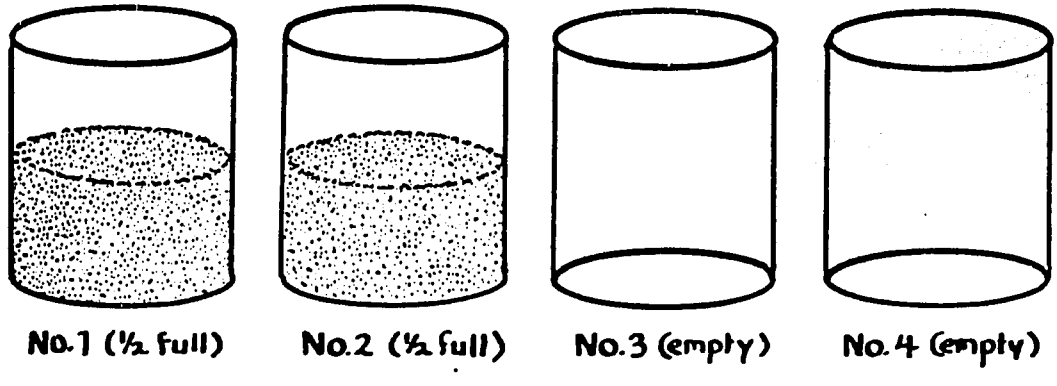
Children are often troubled when they are counting the number of squares because they do not know whether to count half-filled squares. If such problems arise in your class, you will want to be sure that the children have a chance to discuss them when they report their results at the end of the period.

LESSON SEVEN: ESTIMATING BY DIVIDING IN HALF

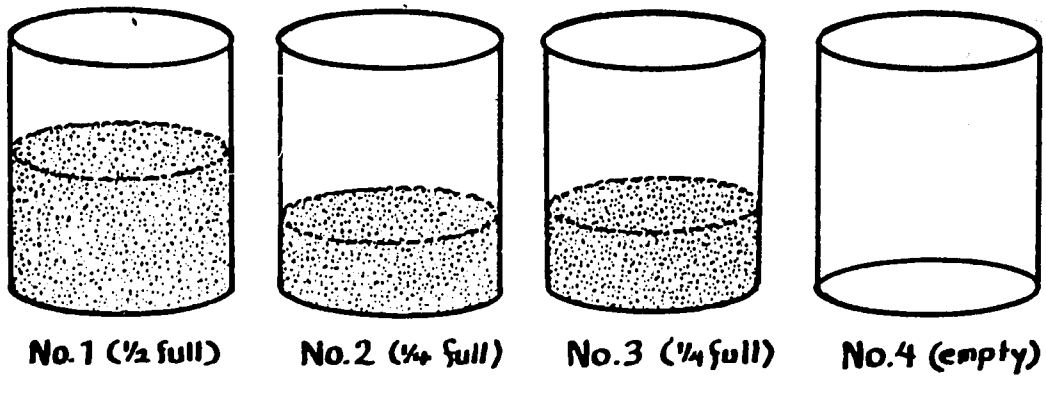
Imagine that you have four tins, all of the same size. One of them is full of peas, and you would like to estimate the number.



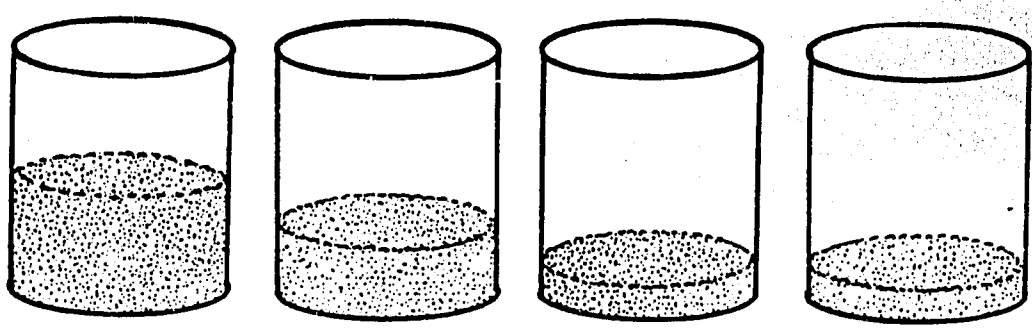
One way to estimate the number of peas in the first tin would be to use the following method of dividing in half. First, pour half the peas in the full tin into the second tin. The first and second tins will now both contain about one-half the original number of peas.



Next, pour half of the peas in the second tin into the third tin. The second and third tins will now both contain about one-fourth the original number of peas.



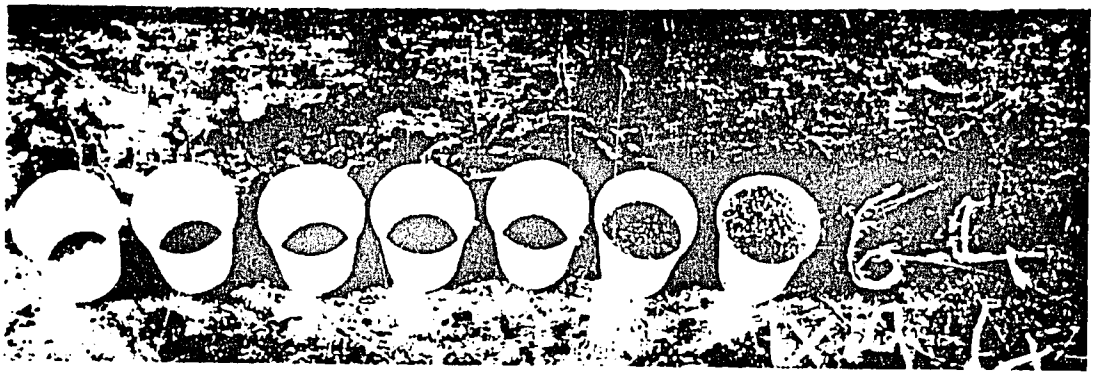
Pour half of the peas in the third tin into the fourth tin. The third and fourth tins will now both contain about one-eighth the original number of peas.



No. 1 (½ full) No. 2 (¼ full) No. 3 (⅛ full) No. 4 (⅛ full)

The peas in the fourth tin can now be counted. Since the fourth tin contains about one-eighth tin of peas, there must be about eight times as many peas in a full tin. Thus, for example, if there are 132 peas in the fourth tin, there must have been 8 x 132 = 1056 peas in the original full tin.

When very small seeds are being used, the process of halving can be continued even further until the last tin contains a number of seeds that is small enough to be counted easily. This method can then be used with objects as small as rice or grains of salt to get a quick estimate.



Materials

40-50 paper cups, tins, jars, tumblers, bamboo sections or other similar containers
(Each group of children will need at least four containers of the *same size.* Transparent containers, such as jars or clear glass tumblers, are preferable if enough of them can be collected.)

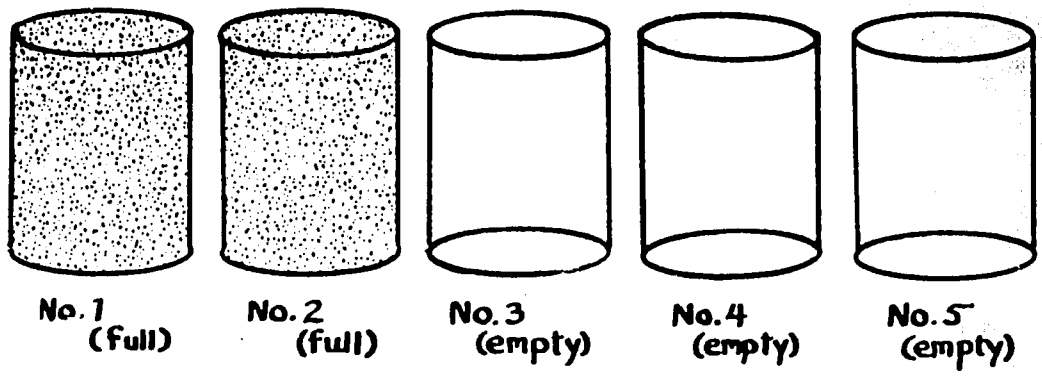
Beans, peas, or maize — enough to fill one container for each group

The Lesson

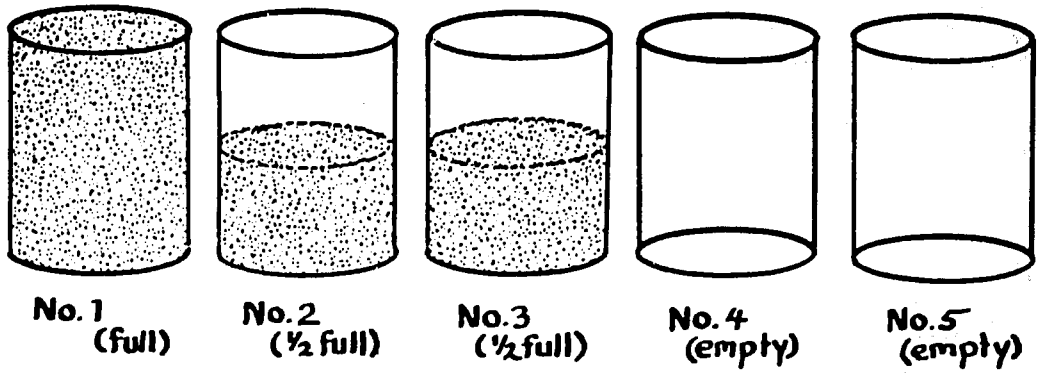
Give each group of children four or five containers, all of the same size. Fill one container with beans, peas or maize. Explain to the children that you would like them to try to find a way to estimate the number of seeds they have by using the empty containers.

Allow your class about one-half hour to experiment with the materials. Some groups may discover the method of halving by themselves. Other children may not be so successful. If your class has not had much experience working with fractions, they may become confused about what fraction of the original cup of seeds is in the last cup. If your pupils are having this kind of difficulty, you may wish to call the class together and have the following kind of class discussion:

Use five jars, water glasses, or plastic tumblers of the same size. Put them in a row in a place that everyone can see. Fill the first two of them with seeds.



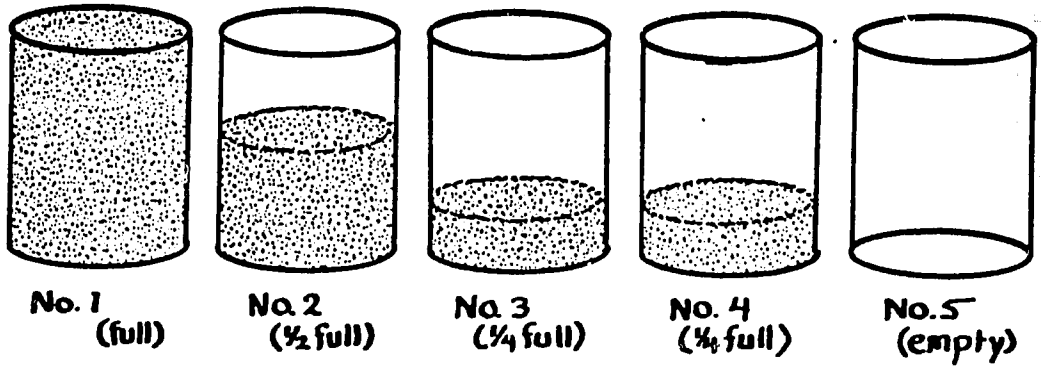
Then have the children watch carefully as you pour one-half of the seeds in the second jar into the third jar. They will now look like this:



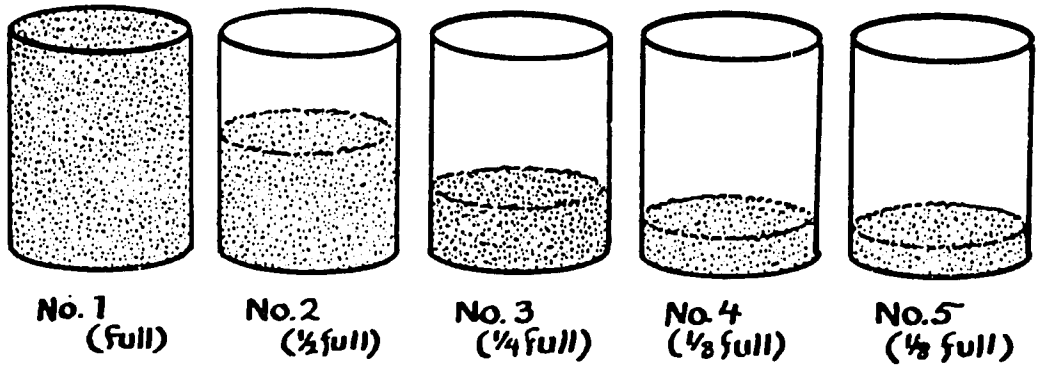
Ask the children, "Are jars No. 2 and No. 3 equally full?" (If they say, "No," adjust the seeds until everyone in the class agrees that the two jars are equally full.)

"How many jars with as many seeds as jar No. 2 would it take to equal jar No. 1?"

When the children have given their answers, pour half of jar No. 3 into jar No. 4. The jars will then look like this:



Ask the class, "Are the seeds in jar No. 3 equal to those in jar No. 4?"
"How many jars with as many seeds as jar No. 3 would it take to equal jar No. 2?"
"How many jars with as many seeds as jar No. 3 would it take to equal jar No. 1?"
Finally, pour half of jar No. 4 into jar No. 5. The jars will then look like this:



Ask the children, "Are the seeds in jar No. 4 equal to those in jar No. 5?"
"How many jars with as many seeds as jar No. 4 would it take to equal jar No. 3?"
"How many jars with as many seeds as jar No. 4 would it take to equal jar No. 2?"
"How many jars with as many seeds as jar No. 4 would it take to equal jar No. 1?"

Give the children plenty of time to discuss the answers to these questions. In one class, many children were convinced that there were six times as many seeds in jar No. 1 as there were in jar No. 4; other children believed that the correct number was

eight. If at all possible, let the children argue *amongst themselves* to solve such problems. You can help them to do this by encouraging them to give reasons for their answers.

When the children have finished discussing the above problem, let them go back to working in groups. Explain that they are to try to use what they have learned in the discussion to help them estimate the number of seeds in their containers.

At the end of the period, again record the children's estimates on the blackboard, and, if you have time, discuss them with the class.

LESSON EIGHT: ESTIMATING BY WEIGHT

If you can provide each group of children with a simple balance, they will enjoy trying weighing as a method of making estimates. A balance can be used in at least two ways to estimate the number of seeds in a jar:

1. A large number of seeds can be counted and placed on one pan of a balance. Seeds can be added to the opposite pan until the two pans are balanced. One of the pans can then be emptied and seeds from the jar can again be added until the pans balance once more. This can be repeated until all of the seeds in the jar have been used. The total number of seeds in the jar can then be estimated by multiplying the number of seeds counted in the first pan by the number of pans that have been weighed.

2. If, in addition to the balance, you can provide each group of children with about 100 washers or bottle tops, many children will want to try another method. They will find how many seeds are needed to balance one washer (or bottle top). They will then find how many washers are needed to balance all of the seeds. The total number of seeds can be estimated by multiplying the two numbers together.

Example:

If one washer balances 13 beans, and one jarful of beans (not including the jar) balances 27 washers, then the total number of beans in the jar is about 27 x 13 = 351 beans.

Materials

10 small jars or cups of beans, maize, or peas

Washers or bottle tops, for use as weights

(Enough weights are needed so that each group of children can balance a full cup or jar of seeds. Galvanized roofing washers are ideal.)

Small weights such as paper clips or drawing pins — about 10 for each group

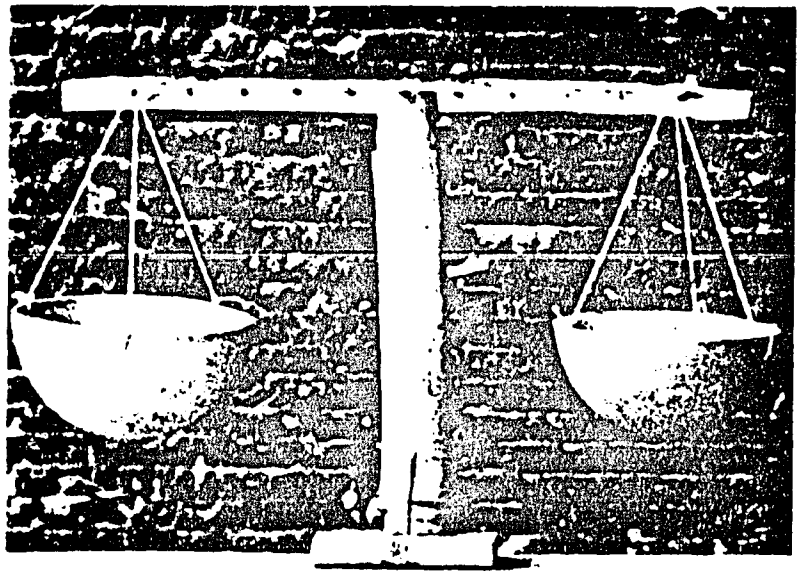
10 simple balances

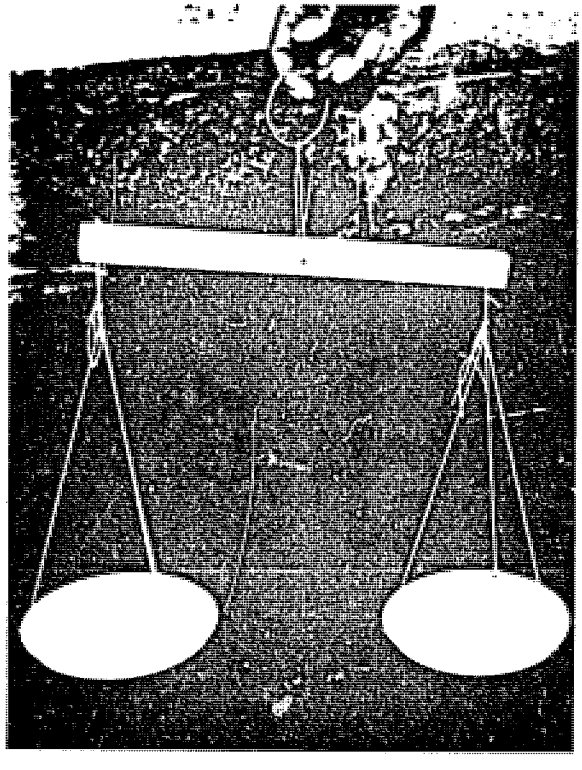
If your class has completed the unit, *Balancing and Weighing,* you may wish to use the balance described in that unit.

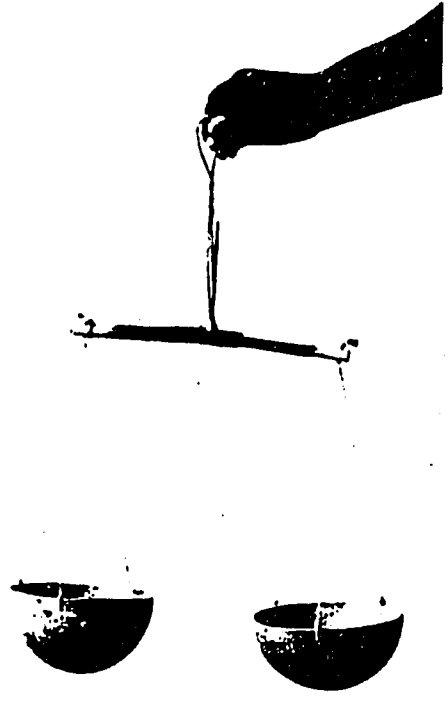
Two types of simple balances that can be easily constructed from bits of wood and string are shown in the photographs opposite. The teacher can either prepare these in advance, or have the children make them.

The arm of the balance can be made from a piece of wood about 30 centimetres long. The actual length used is not important, but it is very important that the distances from the centre point to each of the holes from which the pans are hung be exactly equal.

Small calabashes are press-on lids from tins can be used for the balance pans, or the pans can be made from cut-down oil tins. If the empty balance does not hang level when it is finished, nails can be pounded into the light end of the balance arm until it does hang level.







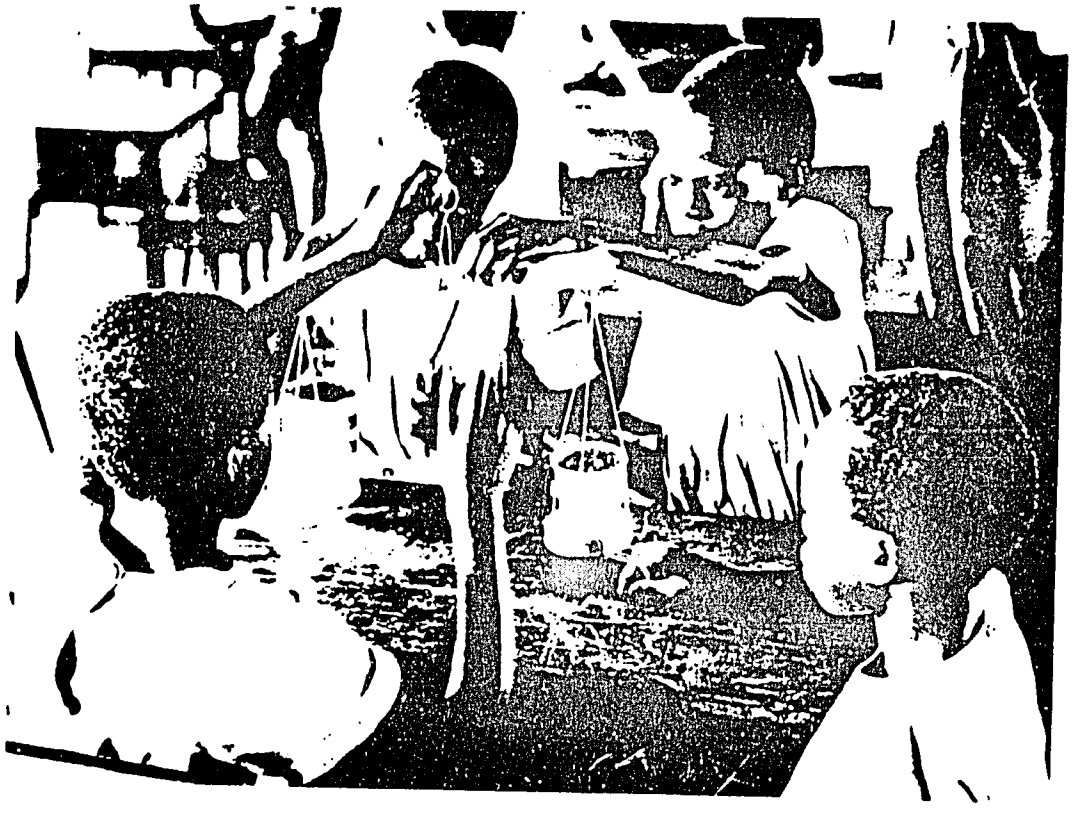
The Lesson

Give each group of children a balance, weights, and a jar of seeds. Encourage the children to use these materials to estimate the number of seeds in their jar.

Do not be surprised if there is a lot of noise and excitement while the children are working with the balances. If your class has not worked with balances before, there will be many things that your pupils will want to try. Children usually want to weigh many things before they begin working on the problem of estimating the number of seeds in the jar. Allow your pupils plenty of time to experiment in any way they like, as this will help them to become familiar with their balances.

Near the end of the period, collect the materials and bring the class together for a discussion. Many of the children may not have yet discovered a way to use their balances to estimate the number of seeds in their jar. Other children may have questions which they want to have answered, such as whether they should weigh the beans together with the jar, or the beans alone; or what to do if 11 beans are too many and 10 beans are too few to make the pans balance.

Encourage your pupils to describe what they have done, but do not answer all of their questions. Instead, tell them that they will have more time during the next lesson to work out their own answers to their questions.



LESSON NINE: ESTIMATING VERY LARGE NUMBERS

During this lesson your class will have a chance to solve the "impossible" problem introduced at the beginning of Lesson Two: "How many millet (or rice) seeds are in the big jar?"

Materials

A large jar of very small seeds (millet or rice)

10 small jars or cups of these same small seeds

2 jars of sugar or salt (optional)

All other materials used in Lessons Two through Eight, including large and small measures, large and small weights, paper cups or tins for halving, large sheets of paper, and rulers

The Lesson

Hold up the large jar of rice or millet, and ask your pupils if they now can think of some ways to estimate how many seeds are inside the jar. The children are certain to have many suggestions.

Pass out a small jar of millet or rice to each group. Tell the class that the first group of children that succeeds in estimating the number of seeds in their small jar will then have a chance to estimate the number in the large jar. Encourage the children to use any method they like to make the estimation, and help each group to get the materials that they need.

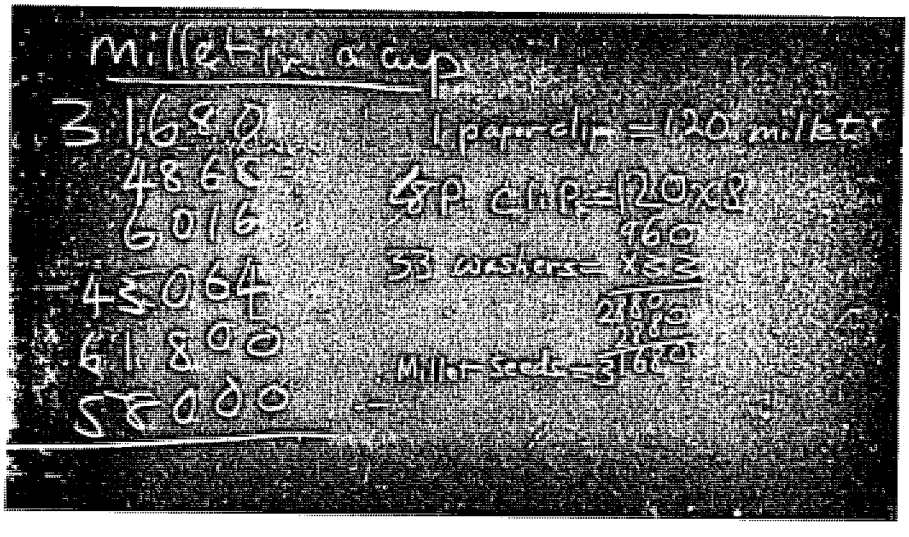
When a group of children succeeds in estimating the number of seeds in their small jar, give them the large jar to estimate. If some groups work very quickly and finish both problems, you may wish to provide them with a jar of salt or sugar, and suggest that they try to estimate how many grains the jar contains.

Children can estimate large numbers of objects such as grains of rice, millet, sugar, or salt in several different ways.

Some children use a method of *double sampling.* A boy in one class discovered that a bottle top would contain 85 grains of rice. He then found that he had to fill a bottle top with rice eight times to fill a jar lid. It took 16 jar lids of rice to fill the jar. The boy was then able to estimate the number of rice seeds in the jar by reasoning in the following way:

1 bottle top = 85 rice grains
1 jar lid = 8 bottle tops = 8 x 85 = 680 rice grains
1 jar of rice = 16 jar lids = 16 x 680 rice grains
1 jar of rice = 10,880 grains of rice

Another method involves double weighing. If the class used balances during the previous lesson, many children will probably want to try this method. If they are to do so, they will need both small weights (paper clips or drawing pins – about 12 for each group) and large weights (washers and bottle tops – enough to balance the jar of seeds).



Using the method of double weighing, one pupil found that one paper clip balanced 120 millet seeds. Nine paper clips balanced a washer, and 33 washers were needed to balance all of the millet that was in his cup. He then made the following calculation:

1 paper clip = 120 millet seeds
1 washer = 8 paper clips = 8 x 120 = 960 millet seeds
1 cup of millet = 33 washers = 33 x 960 millet seeds
1 cup of millet = 31,680 millet seeds

Some children have also used the method of estimating by area, using a large sheet of paper and very small squares. Others have used the method of dividing in half, repeating the process until only 1/64 of a jar of rice remained to be counted.

The pupils in your class may be able to think of some other ways to solve this estimation problem. For example, in one class one group first used a sampling method to find how many paper cups of rice were contained in their jar, and then repeatedly divided the cup in half until they had obtained an amount of rice small enough to count.

Near the end of the period, hold a discussion. Write the children's estimates on the blackboard. Why did the groups arrive at different answers? Some pupils may give answers like these:

"Our jar wasn't as full as theirs."
"They dropped some of their seeds."

"We multiplied wrong."
"We used a different method.'

This can lead into a discussion of the various ways of estimating which were used. Let one member of each group explain to the rest of the class the method which his group used. When all of the groups have described the method which they used, you may wish to ask some of the following questions:

Of all the ways of estimating you have tried, which method do you like best? Why?

Which of the methods are slowest? Which are the fastest?

Which of the methods are very similar? How are they alike?

Is there one correct answer to an estimation problem? How could it be found?

Is it often useful to know the *exact* number?

If time still remains, the class can discuss their answers to the problem of how many millet or rice seeds are contained in the large jar. However, you may wish to wait to have this discussion as it will be a good way to begin the discussion of large numbers in the next lesson.

LESSON TEN: MAKING A MILLION

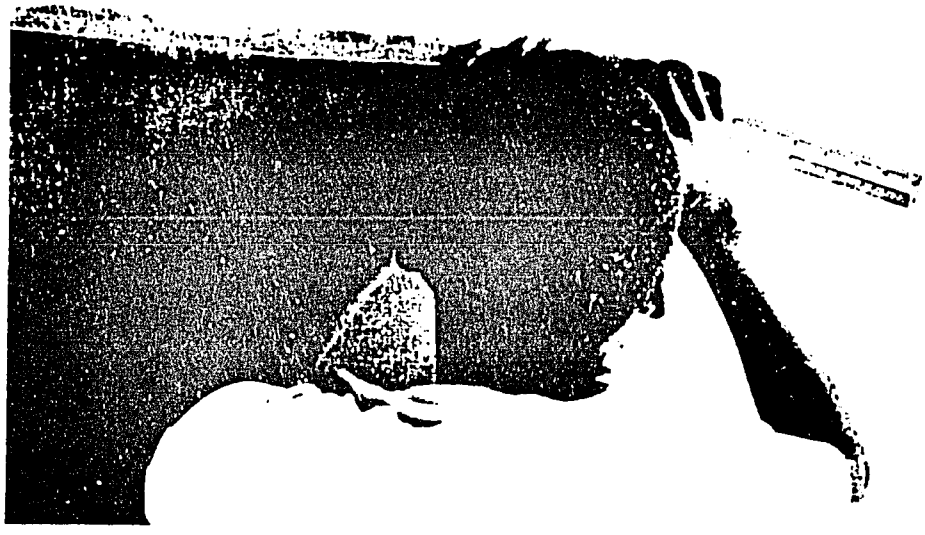
What is a million? It seems that everyone has a limit to his understanding of big numbers. Many people have difficulty in knowing the difference between 10,000 and 100,000 things. People working in government need to have a good idea of how much money a million pounds is. The following activities may help children to gain a better understanding of large numbers.

First, challenge your pupils to describe the quantity of a million. Some may say that it is a thousand thousand. Does this help them to understand a million?

Are there a million objects in any of the jars? How many jars of peas would be needed to make a million peas? If you have not already done so, this is a good time to discuss the children's estimates for the number of rice or millet grains in the large jar. How many large jars of millet or rice would be needed to make a million grains?

You may wish to ask your pupils, "Can you collect a million objects? Can you bring a million things to school to show the class?"

One pupil may set out to make a million ink dots. Other children may try to find out how many holes there are in a large piece of fine wire mesh. Some pupils (or the teacher) may be able to bring to school a piece of mosquito netting or cloth about one metre (three feet) square. If such a piece has about one thousand holes on an edge, it has a million holes in total.



"How many holes are there in a piece of wire mesh one metre square?"

If some children have already counted jars of sugar or salt, they may claim that there are a million grains in a jar. If not, you can take this opportunity to help the class to estimate about how many grains there are in a small jar filled with salt or sugar.

You may then wish to tell the class a story that can be used to encourage children to think about large numbers.

"A Tale of Rice"

Once long ago there was a famous and wealthy chief who was very tired. He was tired of talking with the village elders; he was tired of listening to his musicians; he was tired of watching his dancers.

Finally, one of the chief's advisors thought of a way to solve the chief's problem. The chief would offer a large sum of money or other reward to anyone who could provide a new kind of entertainment for the chief.

No one was able to claim the reward for a long time. Many months passed. Then one day, a trader from far away came to the village. He brought a draught board with him.

The trader taught the chief to play draughts. The chief liked the new game very much. He did not tire of playing it day after day.

When it came time for the trader to continue his travels, the chief asked him what he would like for his reward. Did he want ivory, or gold? Whatever the trader wanted would be his.

The trader said that he had simple needs and liked his travelling life. He would only ask a small reward, since it was pleasure enough to see the chief happy. If the chief would give him as much rice as would go on the draught board in a certain order, the trader would be quite content. First, one grain would be put on the first square, then two grains on the second, then four on the third, eight on the fourth square and so on, doubling the amount each time.

The chief protested; surely this was not a big enough reward.

"You promised to give me what I asked," said the trader. "I have your word."

The chief finally agreed and ordered the keeper of the granaries to bring a sack of rice.

You might stop here if you are reading this story to the class, and ask the children some questions. "What do you think happened next?" You might ask your class, "How many grains of rice were there in all?"

Since your class has been working with jars of rice or millet, they may be able to discuss the trader's reward in terms of jars of rice. It will help if you have a draught board and a supply of rice available. If not, some pupils can draw a draught board with 100 squares on a sheet of paper.

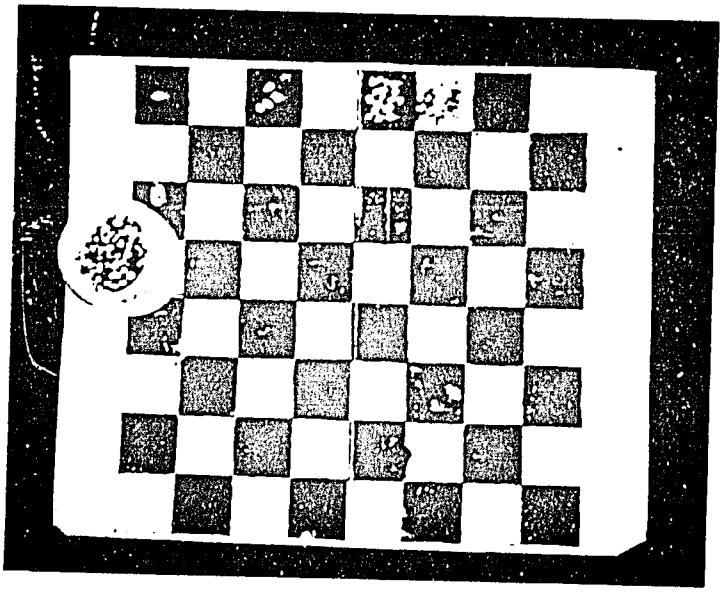
The children can then begin putting grains of rice on the squares, doubling the amounts for each square in succession. At some point they may have to shift to tins and then to big jars. This should make the problem very clear to them.

Does the class see that the trader wanted more rice than there was in the entire country? If one multiplies 2 x 2 x 2 x 2 . . . one hundred times, the resulting number is unbelievably large. Some of the children in your class may wish to calculate the number of rice grains that this would be.

You may wish to introduce some other questions into the discussion. For example, "What would happen if the trader had asked for two *additional* grains of rice for each square instead of twice as many?"

"What if he had begun with five grains in the first square, and added five for each square? Would he then have had more when the last square was reached?"

Perhaps your class will be able to think of other bargains which the trader might have made with the chief. Was the trader clever in his choice of a reward?



LESSON ELEVEN: IN AND AROUND THE SCHOOL

By now your class will have become familiar with many methods of estimation. It is time for them to start using what they have learned.

What can be found around the school to count? You and your class may have already started to think about such problems in Lesson Five. Suggest some new problems to your class, and encourage your pupils to think of others. They may think of such questions as:

How many bricks are in a wall?

How many bricks were used to build the school?

How many corrugated iron sheets were used to make the roof?

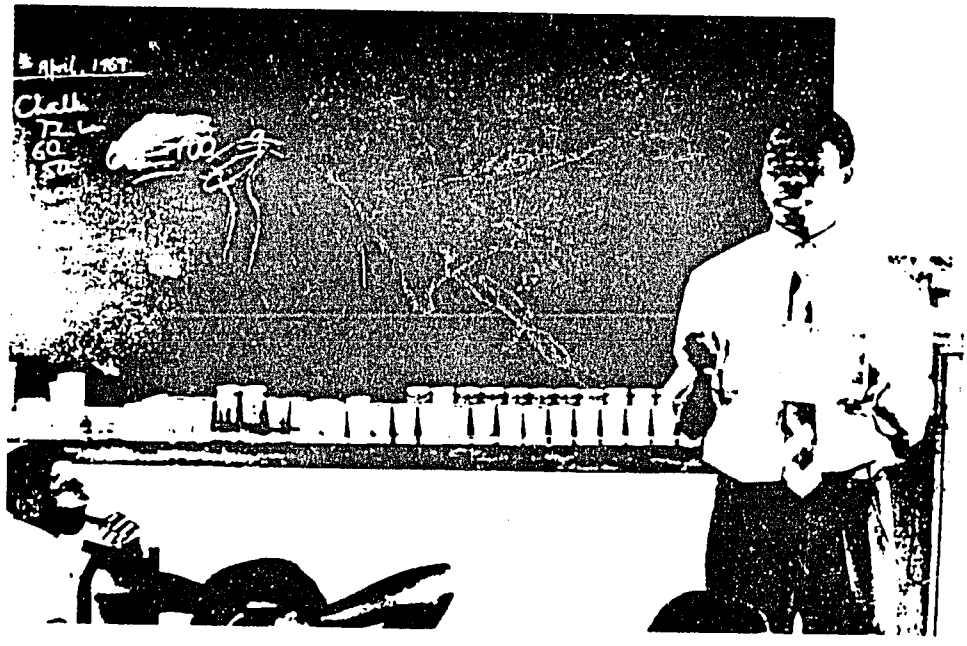
How many pieces of chalk are in the chalk box?

How many books are in the classroom?

How many words are on the page of a book?

How many words are in a book?

How many blades of grass are in the school compound?



"How many pieces of chalk are in the chalk box?"

You then can encourage your class to think about the answers to other estimation problems outside the school, such as:

How many leaves are on a tree?

How many pods are on a pod tree?

How many seeds are in a melon or other fruit?

How many ants are in a trail of safari or driver ants?

How many drops of water are in a bottle of water?

How many hairs are on a person's head?

How would one go about answering these questions? Which would be easiest to check? Discuss with your class what a reasonable answer would be. For example, the number of books in the room is likely to be less than 100, but the number of hairs on a person's head is likely to be much more than 100. Some children may wish to find answers for some of these problems.

Estimation is an everyday tool for many people. Ask your class to think of some other things that people might need to estimate. Here is a list of things that some children have named:

The number of children in a given grade of school in a district or a country

The number of school books in the country

The number of trees in a forest

The number of people in a crowd or at a football game

The number of stalks of rice or maize in a farm

The number of bags of rice or maize to plant a field

The number of potato hills in a garden

The number of potatoes that will be harvested from a garden

The number of coffee trees in a farm

The number of coffee beans in a farm

The number of bags of coffee that will come from a farm

The number of ears of maize that will come from a farm

The number of bushels of rice or groundnuts that will come from a farm

The eggs that will be produced by a flock of chickens in a month

The sacks of maize or fish that will fit into a lorry.

The pupils in your class are certain to have many other suggestions. Encourage your pupils both to create their own problems and to solve them.

You may wish to have your pupils do estimation projects. Each pupil could solve an estimation problem which he finds interesting outside the school. If the class finishes this unit just before the end of the school term, you may wish to have your pupils do such projects during their school holiday.

KENYA PRIMARY SCHOOL LEARNING EXAMINATION

GENERAL SCIENCE SECTION

1979

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CPE 1979 GENERAL PAPER

Time 2 hours 30 minutes

READ THESE INSTRUCTIONS CAREFULLY

1. You have been given this question book and a separate answer sheet.
2. First read the question in this book. Do any necessary rough work also in this book
3. When you have chosen your answer, mark it on the ANSWER SHEET, not in this question book.

USING THE ANSWER SHEET.

4. Use only an ordinary pencil.
5. Make sure that you have written on the sheet

   YOUR FULL INDEX NUMBER
   YOUR NAME
   THE NAME OF YOUR SCHOOL.

6. Write your School Code Number and your three figure Index Number in the blank boxes below the words 'School Code No.' and 'Index Number'. By shading the correct numbered ellipses (small oval shapes) mark your full Index Number (i.e. School Code Number and three-figure Index Number) in the grid near the top of the answer sheet.
7. Do not make any marks outside the ellipses (small oval shapes).
8. Keep the sheet as clean as possible and do not fold it.
9. For each of the questions, numbered 1, 2, 3 . . . , four answers are given. The answers are lettered A, B, C, D. In each case only ONE of the four answers is correct. Choose the correct answer.
10. On the answer sheet the correct answer is to be shown by shading the ellipse in which the letter chosen is written.

Example

In the Question Book:

2. Kamau was burning pieces of paper in his room. He noticed that as he dropped th onto the fire one by one, they floated upwards. The main reason why this happened was that
   - A. paper is lighter than air
   - B. the wind blew the papers upwards
   - C. hot air moved upwards and carried the papers
   - D. when papers become hot they move upwards

The correct answer to this question is 'C'.

On the Answer Sheet:

In the second set the ellipse with C printed inside it is shaded.

11. Your shading MUST be within the ellipse. Make your shading as DARK as possible.
12. For each question ONLY ONE ellipse is to be shaded in each set of four ellipses.

GENERAL SCIENCE

51. Plants that grow in dry areas have special ways to help them grow there. Which one of the following does not help plants grow in dry areas?

    A. Small, narrow leaves.
    B. Deep roots.
    C. Water storage in stems.
    D. Long thin branches.

52. In Kenya, wood from trees is the main fuel used for cooking. Which one of the following will not help to save trees?

    A. More people should use charcoal instead of wood for cooking.
    B. Clay, which loses heat slowly, should be packed around charcoal stoves.
    C. Where possible, people should use sawdust and carpenter's waste for cooking.
    D. Fires should be put out as soon as the food is cooked.

53. Which one of the following cannot be made from plants?

    A. Sugar.
    B. Charcoal.
    C. Butter.
    D. Bread.

54. Three of the following are reasons for carrying a clean handkerchief. Which one is not?

    A. It can be used to stop bleeding from a cut.
    B. It can be used to stop germs entering your body.
    C. It can be used to cover your mouth when you cough.
    D. It can be used for blowing your nose.

55. Three of the following help cross-pollination in plants. Which one do not?

    A. Water.
    B. Bees.
    C. Wind.
    D. Butterflies.

56. Cut dry grass is often placed between rows of coffee trees. Three of the following are reasons for doing this. Which one is not a reason?

    A. The grass reduces the speed with which the rain strikes the soil.
    B. Water evaporates from the soil more slowly.
    C. The grass protects the coffee beans from pests.
    D. The grass helps to prevent weeds from growing around the coffee trees.

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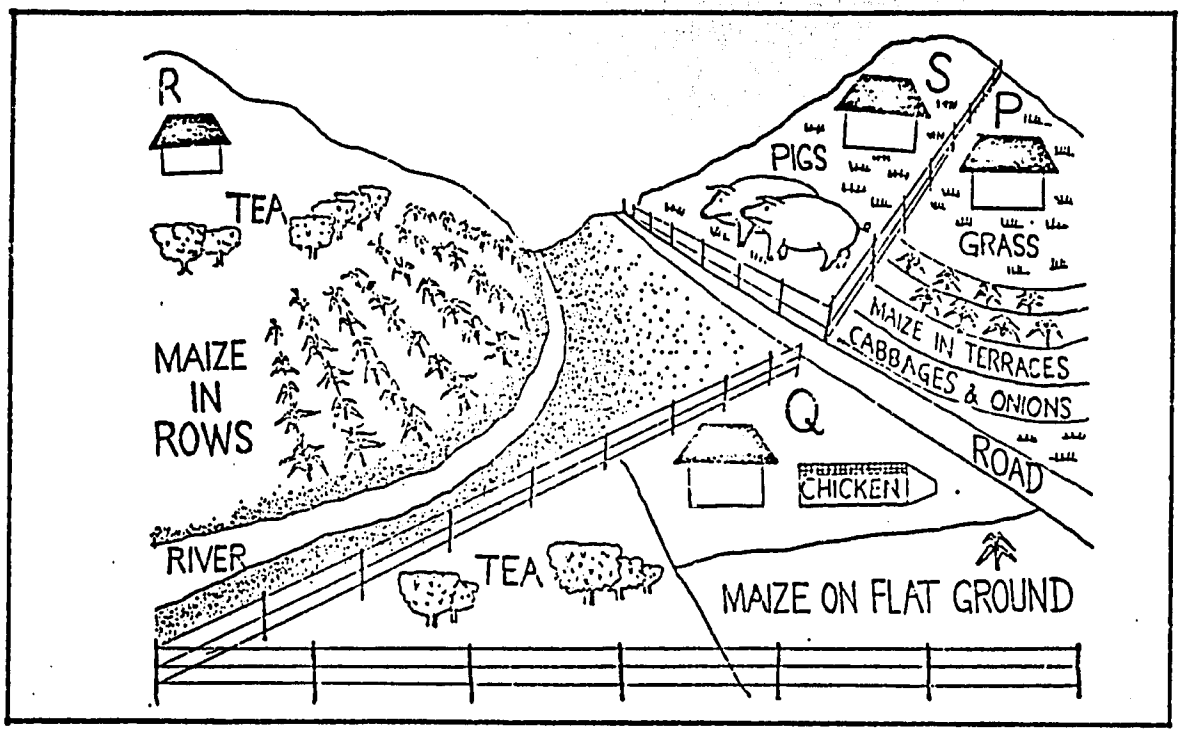
Use the diagram to answer Questions 57, 58 and 59.

The diagram shows farming activities in four farms, P, Q, R and S.



57. You cannot get food for a balanced diet from any one of the farms P, Q, R and S. From which one of the following pairs of farms can you get enough vitamins, carbohydrates and protein for a balanced diet?

A. Q and R.
B. P and R.
C. R and S.
D. P and Q.

58. From which one of the farms is most soil likely to be lost during heavy rains?

A. Farm P.
B. Farm Q.
C. Farm R.
D. Farm S.

59. Look carefully at the diagram. At about what height above sea level are these farms most likely to be?

A. 100 metres (325 feet).
B. 1 000 metres (3 250 feet).
C. 2 000 metres (6 500 feet).
D. 4 000 metres (13 000 feet).

60. Njeri set off to the market just after sunrise. Her shadow was stretched out to her left. Towards which direction was Njeri walking?

A. South.
B. North.
C. East.
D. West.

61. Substances which turn the juice from red hibiscus flowers green are called bases. Substances which turn the hibiscus juice pink are called acids. Ali tested different substances with the hibiscus juice and recorded his results in the following chart:

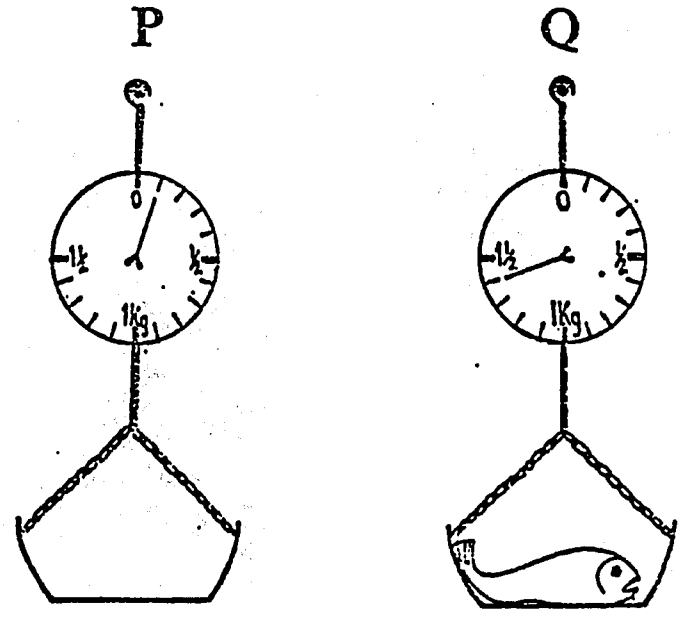
	lemon juice	solution of ashes	vinegar	milk	solution of soap
turns pink	yes	no	yes	no	no
turns green	no	yes	no	no	yes

Using the chart, which one of the following conclusions is correct?

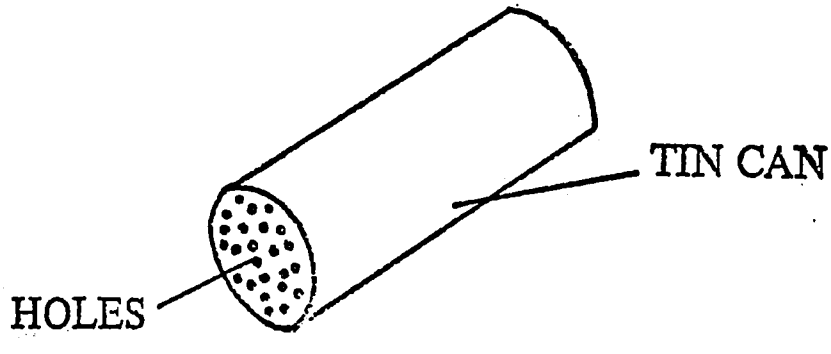
A. Milk and soap solution are both acids.
B. Soap solution is a base and lemon juice is an acid.
C. Ashes solution and vinegar are both bases.
D. Vinegar is an acid and lemon juice is a base.

62. Said goes to the market to buy a fish. He notices that the pointer of the balance is set as shown in Diagram P. When the fish is placed in the pan, the pointer is as shown in Diagram Q. Which one of the following is the most likely weight of the fish?

A. 1 kg. 100 g.
B. 1 kg. 200 g
C. 1 kg. 300 g.
D. 1 kg. 400 g.



63. Kiprotich has a dry tin can with holes in it as shown in the diagram. Each hole has a diameter of 1 mm. Which one of the following mixtures can Kiprotich separate using his tin can?



A. Wheat flour mixed with powdered salt.
B. Beans mixed with peas.
C. Beans mixed with rice.
D. Wheat flour mixed with peas.

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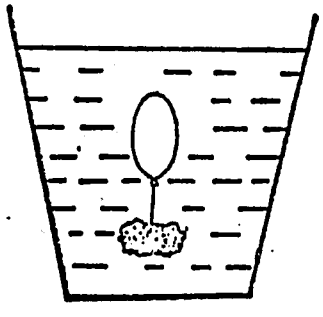
64. Three objects which repeat their movement regularly are

1. A tall tree swaying in the wind.
2. A stretched wire producing a musical note
3. Your heart beating.

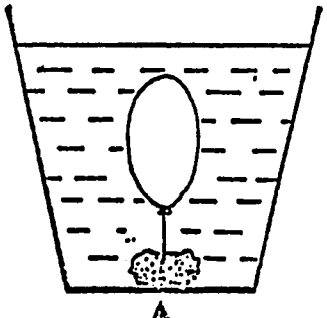
Juma wrote down in order how quickly the movements repeat themselves. Starting with the fastest and ending with the slowest, which one of the following gives the correct order?

A. 1, 2, 3.
B. 1, 3, 2.
C. 2, 1, 3.
D. 2, 3, 1.

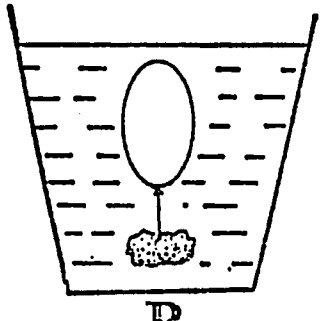
65. Chege took an empty balloon and blew some air into it. The diagram shows what happened when a stone was tied to it and it was placed in a large bucket of water.



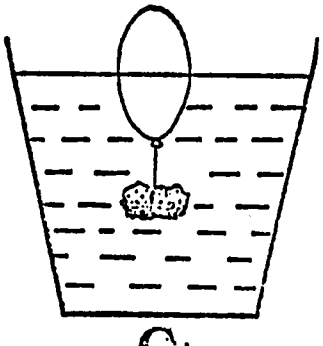
Chege then took the balloon out of the water and blew some more air into it. Which one of the following diagrams correctly shows what happened to the balloon and the stone when they were again placed in the bucket of water?



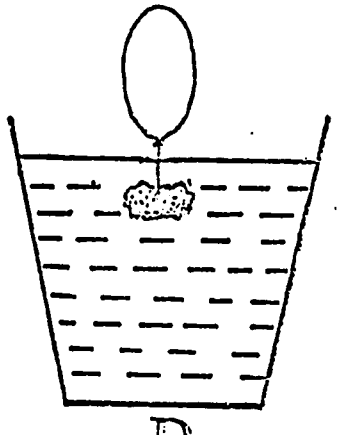
A



B



C



D

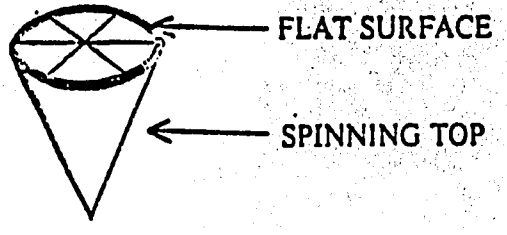
66. On four different days, Akoth washed her dress and left it out to dry. She recorded the weather and how long it took the dress to dry. Her results were as follows:

	Weather	*Time for dress to dry*
Day 1	warm and windy	4 hours
Day 2	warm with no wind	6 hours
Day 3	hot and windy	2 hours
Day 4	hot with no wind	5 hours

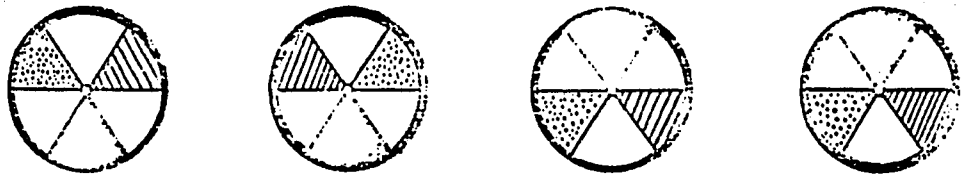
Using the information given in the chart, which one of the following statements is correct?

A. Clothes dry faster when it is warm with no wind than when it is warm and windy.
B. Clothes take longer to dry when it is hot with no wind than when it is warm and windy.
C. Clothes take longer to dry when it is hot and windy than when it is warm and windy.
D. Clothes dry faster when it is warm with no wind than when it is hot with no wind.

67. Four boys made spinning tops as shown.



The following diagrams show how each boy painted the flat surface of his top.



KAMAU JAMES KARANJA MICHAEL

Which boy painted his top in a different way from the others?

A. KAMAU.
B. JAMES.
C. KARANJA.
D. MICHAEL.

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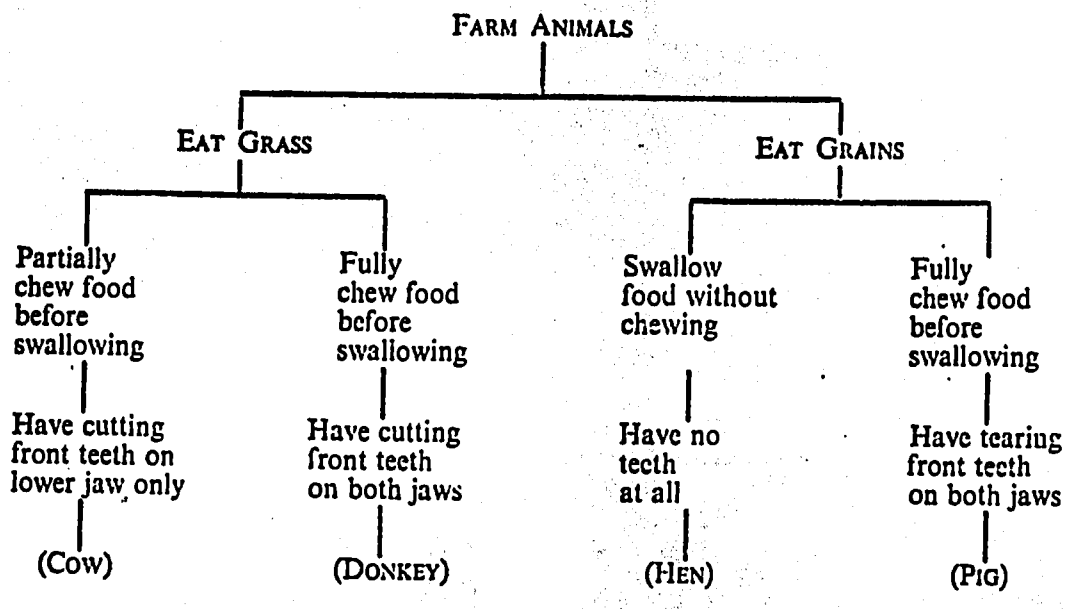
Use the following chart to answer Questions 68 and 69.



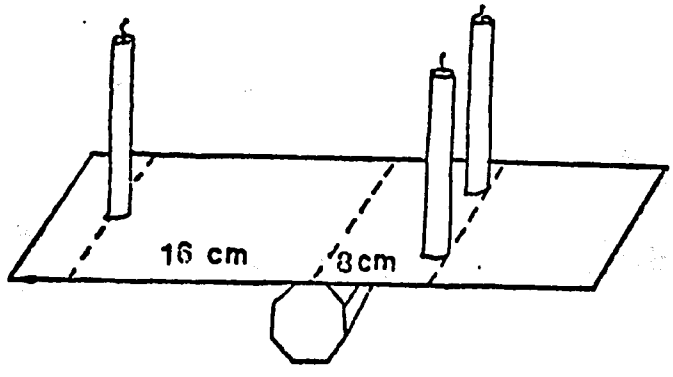
68. A farm animal eats grass. It fully chews its food before swallowing. The animal could be a

A. pig
B. cow
C. donkey
D. hen

69. Which one of the following statements about farm animals is correct?

A. Only farm animals that fully chew their food before swallowing can feed on grass.
B. Animal feeds made from grain should only be given to animals without teeth.
C. Only animals with cutting teeth on the upper jaw can feed on grass.
D. Grain can be fed to animals which have teeth and also to animals without teeth.

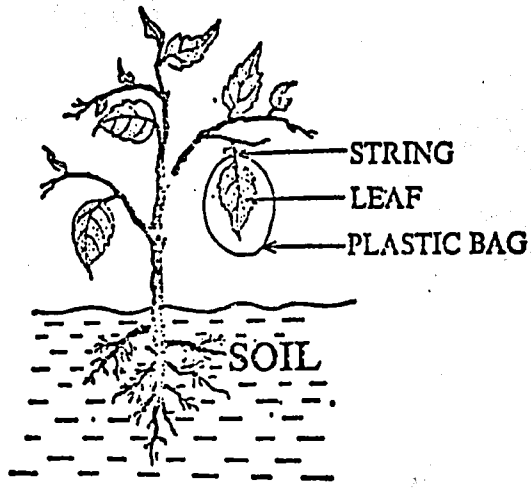
70. Three identical candles are balanced on a piece of wood as shown.



The candles are lit at the same time and they continue to burn in exactly the same way. As the candles burn, what happens?

A. The piece of wood remains balanced.
B. The side with two candles goes down.
C. The side with one candle goes up.
D. The side with two candles goes up.

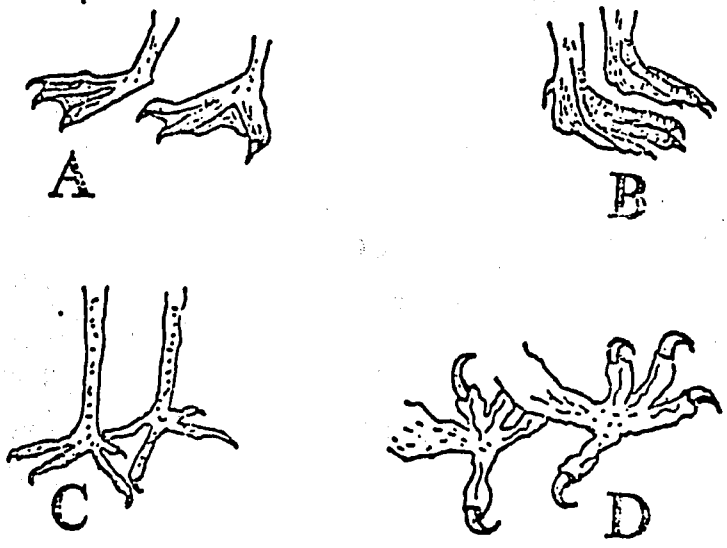
71. During the day, Maweu tied a transparent plastic bag around a leaf on a plant as shown. The plastic bag contained air.



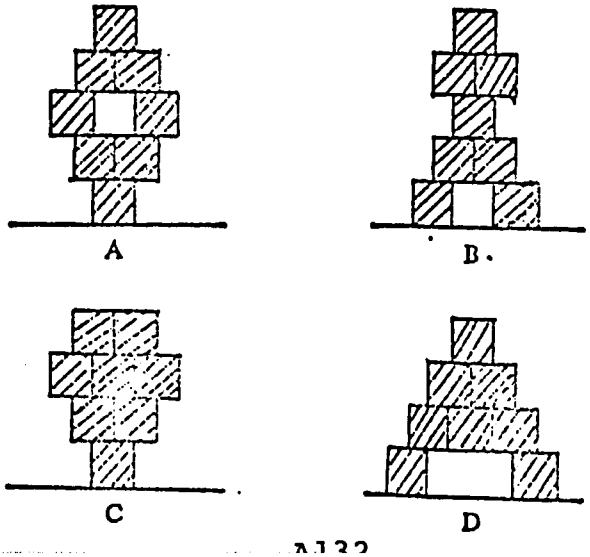
Which one of the following is most likely to have happened after **four hours**?

A. The leaf in the plastic bag turned yellow.
B. All the air in the plastic bag was used up.
C. Water droplets formed inside the plastic bag.
D. The other leaves on the same branch turned yellow.

72. Nziok saw a bird carrying away a rabbit. Which one of the following correctly shows the shape of the bird's feet?



73. Using wooden cubes of the same size, which one of the following is **impossible** to make?



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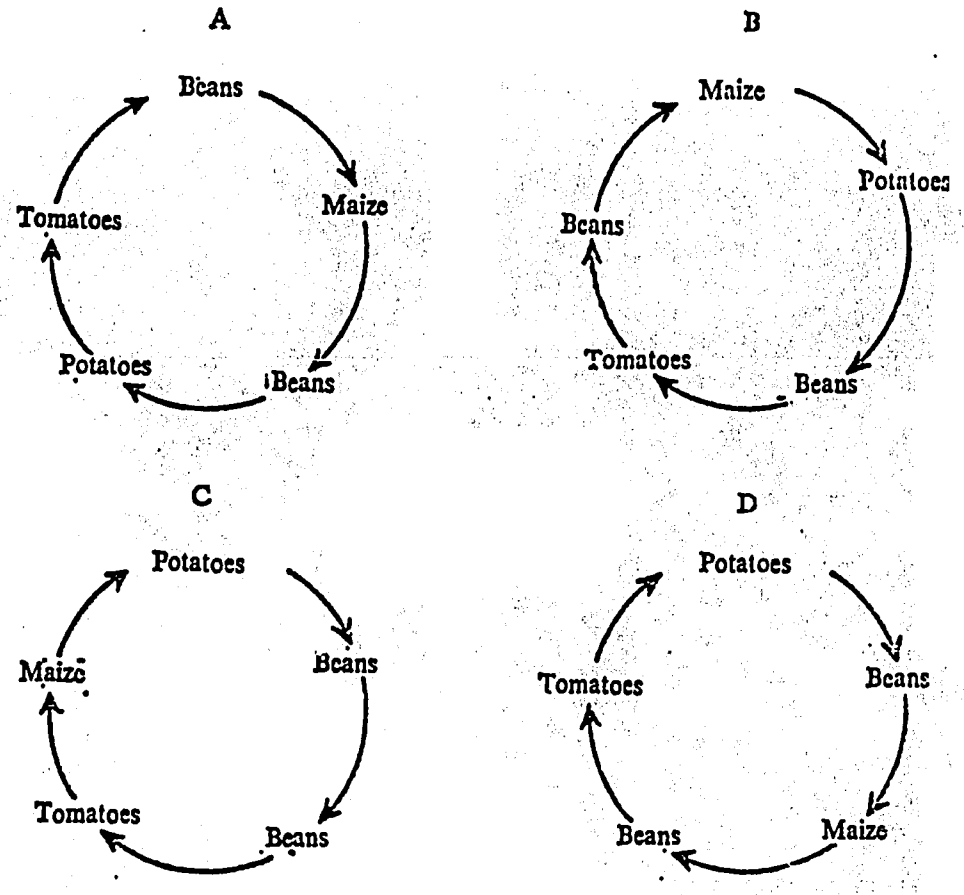
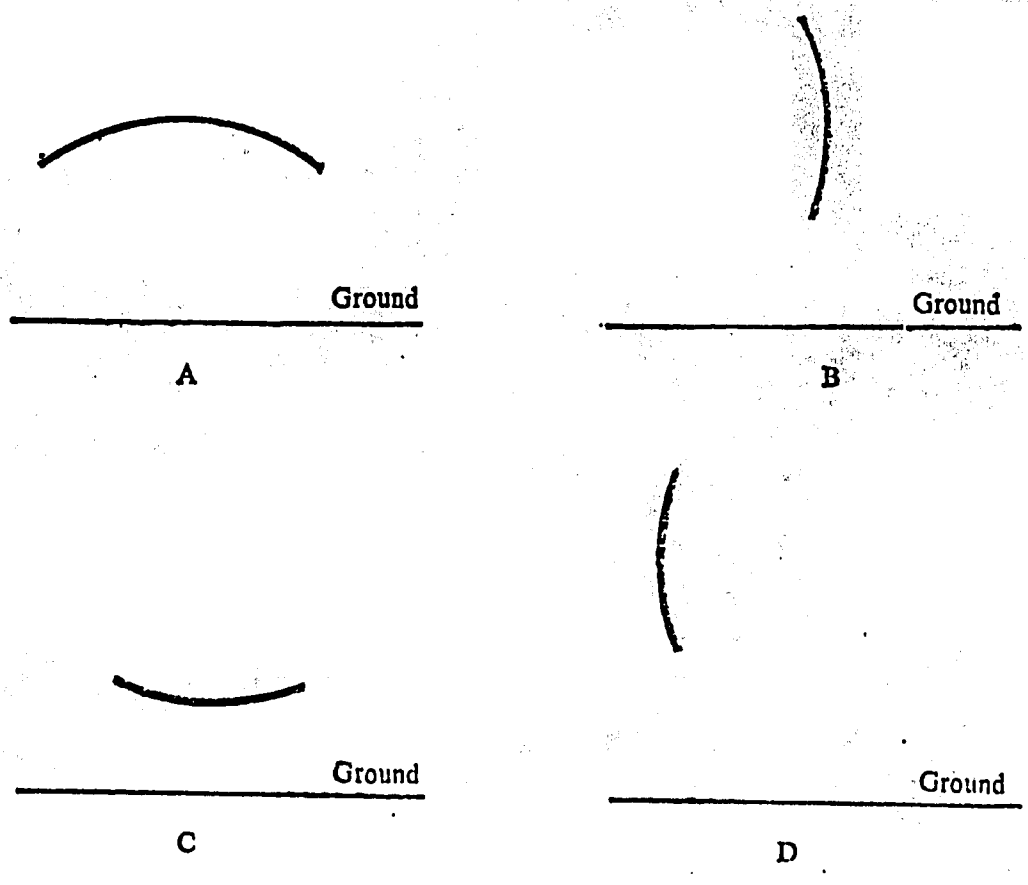
74. Beans add nitrogen to the soil which is needed by tomatoes, maize and potatoes. Tomatoes and potatoes are attacked by the same diseases which can live in the soil from one year to the next. Kamau planned to rotate the crops growing in his *shamba*. Which one of the following would be the best plan to use?



75. Omolo was standing on flat ground and saw part of a rainbow in the sky. Which one of the following correctly represents what Omolo saw?



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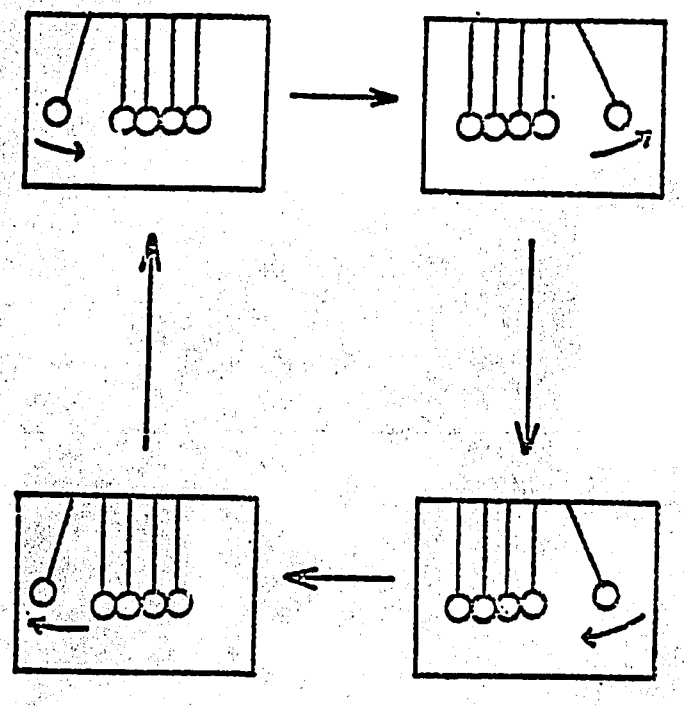
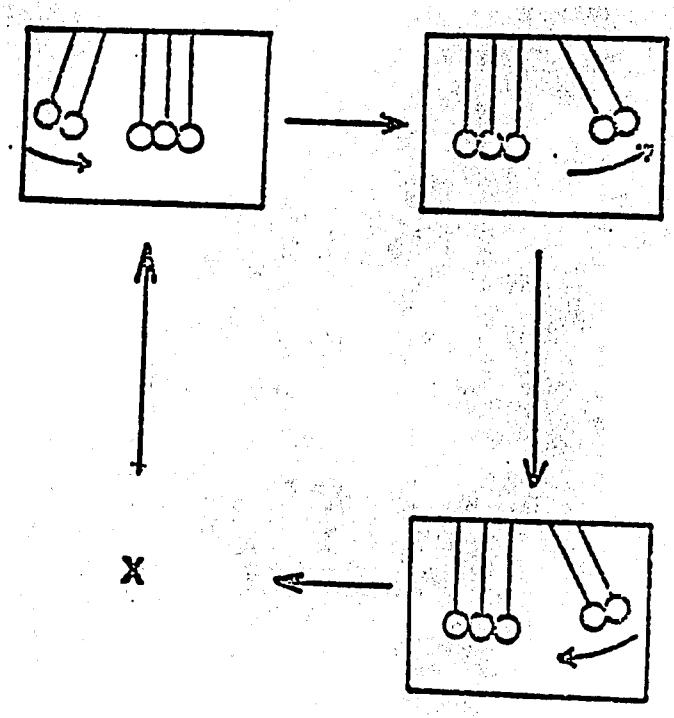
76. Study Diagram (i) below.

(i)

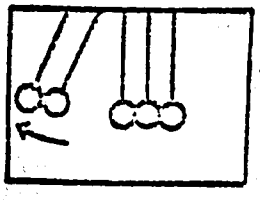


Now study Diagram (ii) which is incomplete.

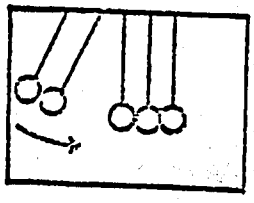
(ii)



Which one of the following should be placed in the space marked X to correctly complete Diagram (ii)?



A



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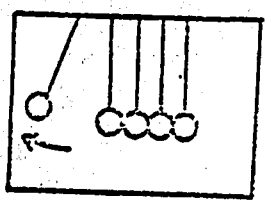
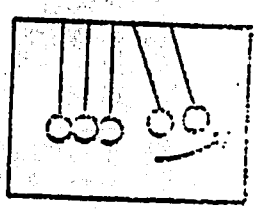


C



D

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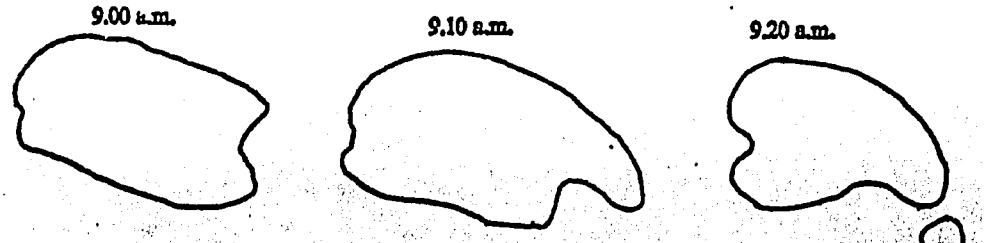
77. One morning, Patel observed a cloud. He drew the cloud at different times. The diagram shows three of his drawings and the times he drew them.



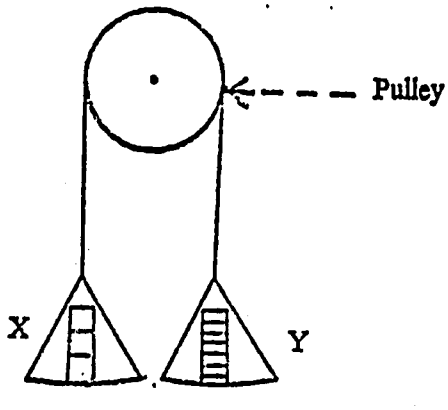
At which one of the following times did Patel make this drawing?

A. 8.50 a.m.
B. 9.05 a.m.
C. 9.15 a.m.
D 9.30 a.m.

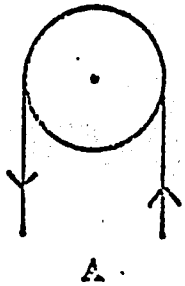
78. Diarrhoea is a disease that kills many babies in Kenya. When babies have diarrhoea they lose a lot of water and foods. One correct way to treat babies with diarrhoea is to

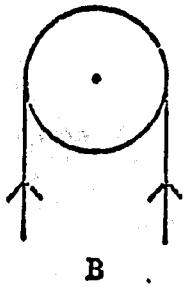
A. keep them wrapped up and warm so that they sweat out the sickness
B. give them drinks of boiled cold water containing some sugar and a little salt
C. give them solid foods containing plenty of carbohydrates
D. give them very little food or water until the diarrhoea stops

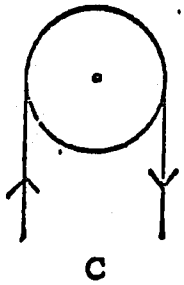
79. Three large identical blocks are placed in pan X on a pulley. Seven small identical blocks are placed in pan Y so that the two pans balance as shown in the diagram.

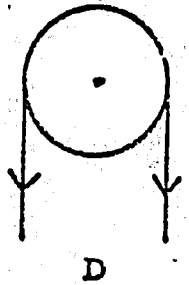


If one block is removed from pan X and two from pan Y, which diagram correctly shows how the pans would move?


A


B


C


D

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80. The substances below are listed in order of hardness.

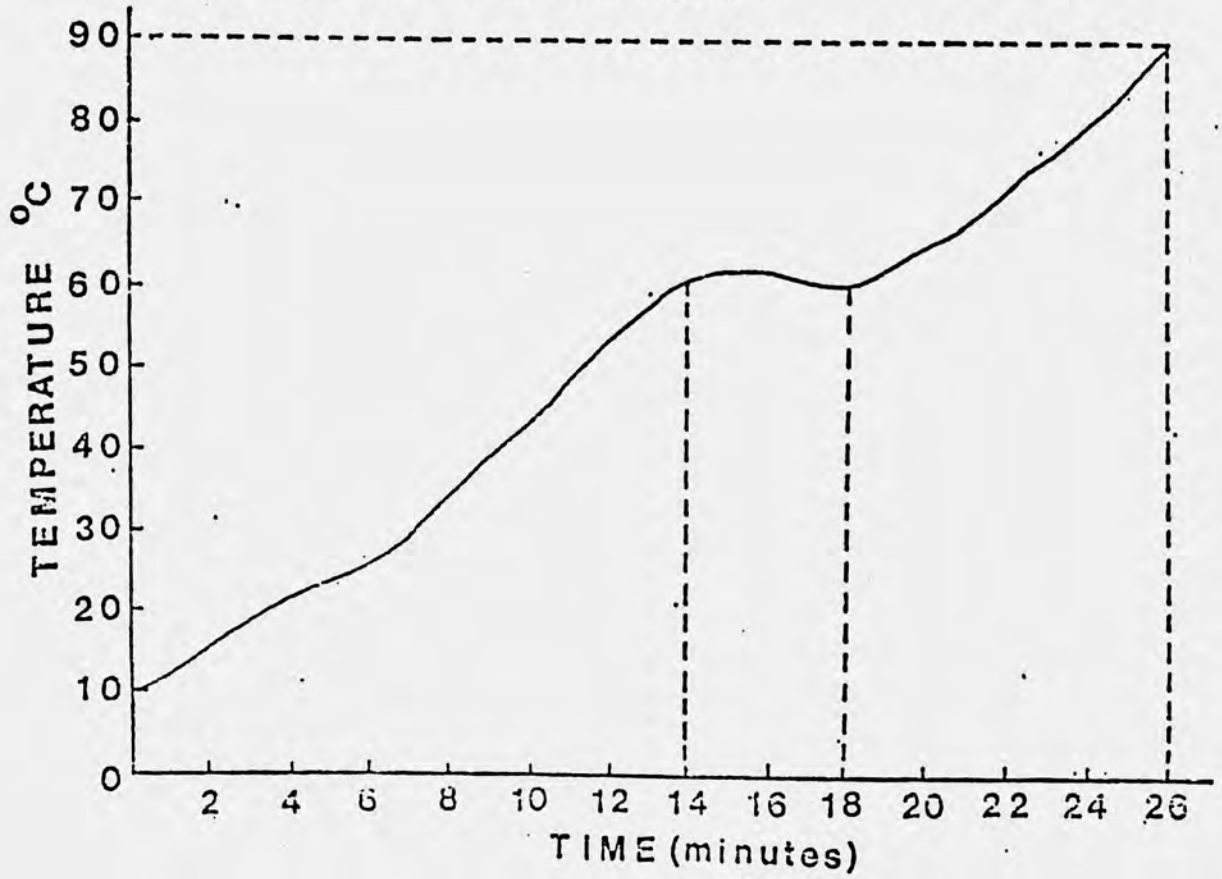
SOFT	Pencil lead
↓	Finger nail
	10 cent piece
	Glass
	Steel
	Quartz
	Ruby
HARD	Diamond

Which one of the following statements is correct?

A. Quartz is less hard than either a finger nail or glass.
B. Quartz is harder than a 10 cent piece but less hard than steel.
C. Steel is less hard than either glass or ruby.
D. Glass is harder than a finger nail but less hard than ruby.

Use the following information to answer Questions 81 and 82.

Standard 7 pupils heated water in a container and recorded the temperature after every two minutes. From their readings they drew the following graph:



81. What was the temperature of the water when the heating started?

A. 0 C.
B. 10 C.
C. 26 C.
D. 90 C.

82. Which one of the following [illegible] explanation for what happened between the fourteenth and the eighteenth minute?

A. The water was [illegible]
B. Heating stopped.
C. The water evaporated.
D. Some water was [illegible]

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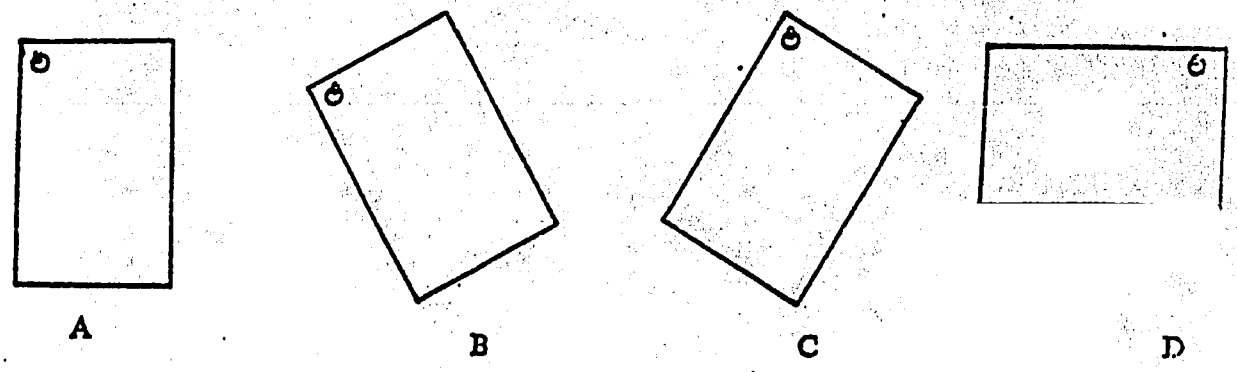
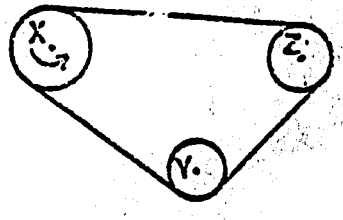
83. All things can be grouped into *living things, things that were once alive* and *never alive things*. Which one of the following belongs to the *never alive things?*

A. Ivory.
B. Charcoal.
C. Paper.
D. Water.

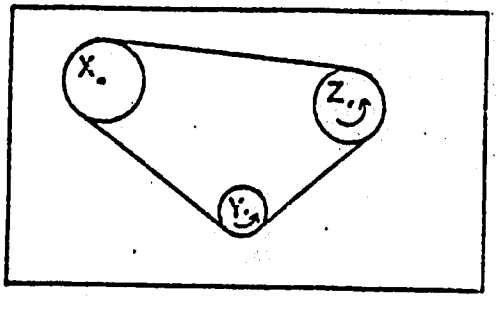
84. Peter has a card with a hole in it. He hangs it on a nail fixed on to a pole so that it swings freely. Which one of the following shows the correct position of the card when it is at rest?

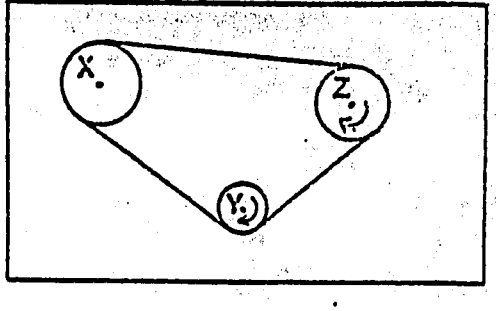


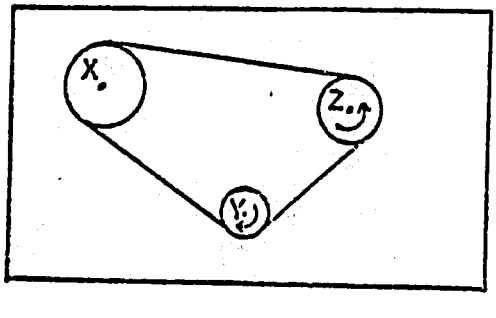
85. Three pulleys fixed on a board are connected by an elastic band as shown.

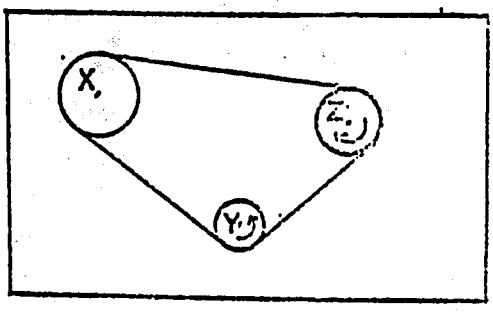


Pulley X is turned in the direction of the arrow. Which one of the following correctly shows the directions in which the other two pulleys turn?

A


B


C


D


86. It is true that:

All butterflies are insects AND
all insects are arthropods BUT
not all arthropods are insects.

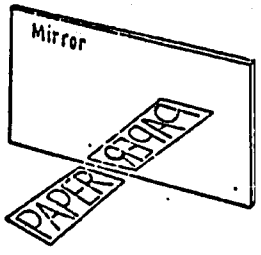
Therefore it is true that:

A. No butterflies are arthropods.
B. All butterflies are arthropods.
C. All arthropods are insects.
D. Some butterflies are not insects.

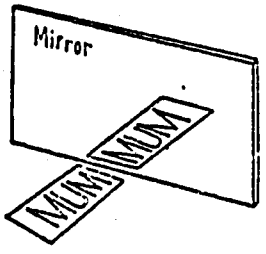
87. At which stage of its life cycle is the housefly most dangerous to human health?

A. Egg.
B. Larva.
C. Pupa.
D. Adult.

88. Most words look different when seen in a flat mirror.



But some words look the same when seen in a flat mirror.



Which one of the following words would look the same when seen in a flat mirror held as shown in the diagrams above?

A. NOON.
B. REDDER.
C. TOOT.
D. DEED.

89. Wangari lives in a village with many people. From which one of the following sources can Wangari collect the best drinking water?

A. A big river nearby.
B. The rain from her *mabati* roof.
C. The dam near the village.
D. A swamp on her farm.

90. John, Mary, Peter and Jane were asked to collect three pests that cause sickness in farm animals.

John collected a tse-tse fly, a tick and a weevil.
Mary collected a bee, a mosquito and a caterpillar.
Peter collected a tick, a flea and a tse-tse fly.
Jane collected a grasshopper, a louse and a flea.

Which one of the pupils correctly did what had been asked?

A. John.
B. Mary.
C. Jane
D. Peter.

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APPENDIX B

Materials Related to Science Education in Sierra Leone

Suggested Primary Science Syllabus, 1981 ... B 2

Suggested Science Syllabus for Use in Primary Teacher Training Colleges ... B 47

Bunumbu Teacher Training College, Syllabus for Basic and Applied Science ... B 55

Science in Our Daily Lives, Pupils Pamphlet for 1973 Sierra Leone Schools Broadcasting Science Program ... B 62

Schools Broadcasting Time Table, 1981-82 ... B 85

PRIMARY SCHOOL CURRICULUM DEVELOPMENT

SUGGESTED PRIMARY SCIENCE SYLLABUS INTEGRATIN

SCIENCE AGRICULTURE AND HONE ECONOMICS

Presented by the SCIENCE REVIEW PANEL:

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Mrs. F. Dahniya	-	Home Economics, NUC.
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March 1981.

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I - OBJECTIVES FOR SCIENCE TEACHING

A. GOALS OF PRIMARY SCIENCE

1. The Science Programme in Primary Schools is designed to enhance the child's natural sense of inquiry by providing activities and experiences for the development of:
   a) Basic processes or skills in scientific inquiry;
   b) The thoughtful manipulations of materials;
   c) The scientific methods of gathering, organizing, communicating concepts and principles of science and, skills in problem solving.
2. The programme attempts to develop in the child, not only an understanding of himself and his relationship to his natural environment, but also a sympathetic appreciation of the value of plant and animal life to the community and the nation. The learnings should forster in the child, attitudes for effective participation in the community and the motivation to apply scientific habits of thought in problem solving activities towards the improvement of the conditions of his life in his community as well as his country.

B. AIMS OF PRIMARY SCIENCE

At the end of primary education, the child should have developed:

1. an understanding of his physical environment beginning with the home environment and widening into his community and national environment;
2. basic skills of making observations, collecting data and applying simple processing of data to make generalisations regarding the environment;

3. the tendency to base judgement on observations and willingness to alter one's opinion in the fac of new evidence;
4. the ability to communicate with others regarding new and exciting information gained about the environment;
5. willingness to be involved in community development activities and to use scientific knowledge and skills in solving problems related to improviding conditions of life;
6. knowledge and skills in science and technology relevant to make agriculture a profitable and development-related pursuit.

C. OBJECTIVES OF PRIMARY SCIENCE

1. Block I (Classes I & II - Integrated in Environmental Studies)

After two years of environmental study mainly concerned with the home and the immediate environment the child should be able to:

i. relate facts about the natural environment of the home such as demonstrating knowledge about common items found in the house, himself, pets in the home, and animal pests that affect the home;
ii. identify relationships between certain common illnesses and one's feeding and living habits;
iii. infer cause - effect relationships within certain phenomena in the home;
iv. communicate and share ideas, observations and results of investigations that promote understanding of the child's immediate environment;
v. identify and group basic foods stuffs that are necessary for life;

vi. observe and relate soil types that can support plant growth;

vii. identify simple farm tools;

viii. demonstrate positive attitudes towards utilization and conservation of resources of the environment.

2. Block II (Classes III & IV - Science)

At the end of Class IV, the child should be able to:

i. demonstrate knowledge about plants, animals and processes in the community environment where he lives;

ii. organize simple observations into natural occurrences in the community.

iii. make simple measurements of scientific phenomena, using improvised and more accurate measuring instruments where available;

iv. predict cause-effect relationship by asking questions, making guesses and trying to relate observation to causes;

v. work with others in the cause of pulling their thinking resources together to solve mutual problems;

vi. recognize the use of science and technology in improving and enriching life in the community.

3. Block III (Classes V & VI - Science)

At the end of upper primary, the child should be able to:

i. identify common plants and animals of the home community, and the nation;

ii. classify animals and plants into categories relevant to their uses, benefits to, and effect on man;

iii. carry out simple scientific procedures of measuring and testing to find out information about the environment;

iv. make operational definitions of terms based upon what is observed and how these are measured;

v. maintain crops and livestock for profitable marketing;

vi. participate in group action projects related to agriculture.

II - SCOPE AND SEQUENCE OF INSTRUCTION

Class 1 - 2 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
a) Where water can be found. Coming to the river; collecting water from wells, and streams.	Pupils discuss activities children and adults carry out in the community in going to the river to collect water.	Pictures depicting sites of water and people carrying water.	Pupils questioned on how water is carried; where it is found; and why we need water.
b) Importance of Water. Children play with water; rain water can make wheels turn; children make small rivers; things live in river water.	i. Children collect water and allow it to run on improvised wheel ii. Pupils allow water to flow through sandy patch to make rivers. iii. Pupils examine stagnant water, stream and river water to locate things that live in the water.	Water, bucket, sandy area, hand lenses.	Pupils to exercise manual dexterity in using water; should show cause for furrows in the soil caused by water erosion.
c) Water can make people ill When people swim in rivers and work in swamps they get ill; tiny animals e.g. bilharzia bore into their skin.	Children discuss how adults complain of getting ill while working in rivers and swamps.	Charts of small animals that live in the water and their effect in making people ill.	Pupils communicate ideas of how people get well working or swimming in water.

Class 1 - 2 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
d) Doing things with Water Sand can be mixed with water similar to children's experiences mixing mud with water.	Pupils add varying amounts of water to sand and examine consistency. i. Pupils add varying amounts of water to sand and examine consistency. ii. Pupils mix sand and water to make structures that would stand on their own. iii. Pupils strengthen structures by adding twigs, leaves and stones. Pupils make other shapes.	Water, sand receptacles, stone, branches, twigs.	Pupils talk about effect of water on sand; need for other materials to strengthen structures. Pupil to identify relationship between materials required to strengthen soil blocks.
e) What water does to other Objects Colour adds new interest to children's work with water	i. Pupils drop water paint in varying quantities to water and mix these. ii. Pupils find out the following: do paints fall faster in water than inks or vegetable dyes do? Do different colours fall faster? Do some colours colour the water better than others? Does colour look like smoke?	Drinking straw or or pawpaw petiole Vegetable dyes, water colour	Do pupils recognize intensity of colours; how colours mix with each other; can communicate ideas on colours?

Class 1 - 2 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
II. Animals in the Home a) Kinds of animals and what animals do.	i. Pupils put small animals in a bottle and link that bottle with another by joining the mouths of the bottle; keep one bottle in the dark and the other in the light and observe reactions of animals. ii. Pupils discuss experiments indicating the different conditions small animals prefer. iii. Pupils collect stages of small animals e.g. caterpillars and larvae and keep these in cages. iv. Pupils breed insects such as houseflies, moths, butterflies, termites, safari or driver ants, millipedes. v. Pupils dig up damp soil and find animals in the soil such as earthworm. vi. Pupils collect fireflies and glowworms in the early hours of the night and observe their behaviours.	Bottles, cork, cellotape, dark polythene or brown paper. Larvae, caterpillars, leaves and potted plants. Larvae and pupae of houseflies, moths, butterflies, termites. Damp soil with humus to find earthworms, glow worms and fireflies.	Pupils to explain why animals reaction differ from one bottle to the other. Pupils to be able to identify conditions in which certain animals live and can be found. Pupils should identify how animals develop. Pupils make observation and record findings. Pupils communicate ideas of animals found in the soil. Pupils should recognize fireflies as small animals.

Class 1 - 2 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
	vii. Jiggers are collected from dusty floors that are not cleaned frequently. Pupils also look at each others feet for jiggers. Some may be found with bags of eggs.	Jiggers, pins, needles, alcohol	Pupils should recognize health hazards of jiggers infecting one's toes.
b) Care of animals in the Home	viii. Pupils examine stages of beetles. Pupils discuss their experiences in caring for domestic animals such as dogs, cats, chicken, goats and sheep.	Larvae and pupae of rhinoceros beetle and bed bugs, cats, dogs, sheep, chicken and other community animals to be used.	Pupils recognize beetle stages; pupils should be able to bathe, feed and generally take care of pets and other domestic animals.

Class 1 - 2 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
III. Cooking at Home a) Making a simple breakfast. Cooking of coffee and Cooking of pap.	Building of fireplace; collecting of equipment and materials needed to cook coffee and pap. Children will bring water; some children will add water, some the coffee; and in another pot, will pour the pap unto boilding water. Some will prepare the cups and bowls for serving coffee and pap. Pupils and teacher can talk about the coffee and pap. Few car watch the pots, others can do so occasionally. Serving and clearing up.	Pots for the coffee and pap. Sugar and milk in containers, egg shell, strainer, fire-wood, fireplace. Cups and bowls.	Teacher would observe pupils at work doing various tasks. Every child should have a job, and they would be evaluated on that job. Compare the cooking of coffee and pap at home with that in the classroom.
IV. Clothing and Textiles and related Arts	Pupils will take turns to wash and wipe their hands.	Water, soap, wash-basin or sink, handtowel	Teacher would watch each child wash his hands.

Class 1 - 2 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
a) Clean Habits; Regular washing of hands; care in bathing of fingernails, teeth, hair, feet. Use and care of handkerchief; wearing of clean clothes.	The pupils will study what each material collected for washing is used for. The pupils will see a demonstration done on either a doll or a small baby. Story-telling by children about how they wash themselves and also how their young ones bathe. They will all wash some clean clothes. They would observe both clean and dirty clothes.	Sapo or washcloth, soap, water, washroom scissors, nail cutter, nail file, toothpaste, powder, hair oil comb, hair and nail brushes, water and soap. Handkerchief, iron, clean clothes, dirty clothes.	Teacher would watch each child wash his hands. Then he would see them do it correctly. Storytelling compared to the action demonstration done in class. Pupils will compare and examine clean hands and clothes.
b) Line	Discovering of line, through observation of self measurements. Lines could be used to make shapes.	Sticks, strings.	
V. Soil			
a) Different types of Soil	Pupils collect soil from different locations. Soil are mixed with water to make wet and then smeared on white paper. Pupils mix soil with plenty of water and observe the soil settle into layers.	Soil, containers, water, white paper. Cut bottles or glass jars.	Pupils identify soil types by colour. Pupils communicate colour codes of soil.

Class 1 - 2 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
b) Plants in the soil around the school	i. Pupils identify different types of soil in the school compound and identify plants that grow in them.	Soil in the school compound.	Identify soil types related to plants that grow on them.
	i. Pupils plant seeds in pots containing different soil types and observe their growth and development	Plant seeds, potted plants.	Pupils record observations of plant growth and development.

Class 3 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
I. Antlion			
a) Where do antlions live?	i. Children search in the dust in the school compound to locate antlions. ii. Pupils could have antlions in boxfull of sand and small stones in the classroom for study.	Antlions, empty tins, stickers, powders, flour, salt, dust, sand, ants, black and red.	Close records are made stating children's participation; pupils handling of insects and materials; co-operation with other's opinion.
b) What do Antlions feed on?	i. The pupils will be requested to bring different types of food from home. ii. Let children try to feed the antlion by dropping the insects into the dust. iii. Pupils may discover that the antlion eats black dirt.	Dust, sand, ants, black and red.	Children are asked to give oral report on what they have investigated. Other group members listen and criticize them at least to have common agreement.
c) Life habit of Antlions	i. Let children find out what are the habits of antlion. ii. Children should be able to find out why antlion is not easily seen at day, but only at night. iii. Children could look around for a suitable place where they think antlion lays its eggs; instead of nest building.		

Class 3 Topic and Content	Learning Activities/Experience	Materials Required	Evaluation Techniques
II. Chicks in the Classroom			
a) How do Chicks look	i. Let pupils collect wide range of various chicks to classroom (size, colour, shapes, etc.) ii. Let pupils tell differences in size, colour, etc. although chicks are from the same hen. iii. Let pupils describe how the chick looks, in appearance regarding the body, feet, back etc. by handling them.	One-day old chicks, cages, heat source, water trays, feed trays, weighing materials, record sheets, storage.	Record of children handling chicks. Ability of those who are able to collect materials for class to be assessed.
b) What uses are Chicks to us?	Pupils should be able to make suggestion for further work on chicks in class.		
c) How does the Chick feed?	i. Pupils collect different types of food as listed and materials. ii. Pupils put small handfull of chicks to feed on each desk and let the children observe the chicks pecking for food. iii. Children to find out the result of poor feeding of chicks.	Maize, Cow peas, groundnut, minerals (salt and woodash), fish, meat.	

Class 3 Topic and Content	Learning Activities/Experience	Materials Required	Evaluation Techniques
III. Soil			
a) Particles in the Soil	Children could look around for grains from rocks, and for animal or vegetable matter.	Soil from variety of places, containers(sandy soil, clayey soil, mixture of many others). Tins, plastic or jars or anything transparent, plastic cups, plastic tubes, funnels, cards, or fitting caps to stopper tubes, hand lenses, sieve, water, variety of plants.	Pupils should be able to differentiate the sizes of particles in the different layers of soil.
b) Mixing Soil	i. Let pupils find out what happens when soil and water are mixed. ii. Children to identify what part of the soil falls to the bottom first. iii. The class can do sedimentation in different kinds of soil. iv. Pupils to find out whether the layers in three different soils are the same. v. Let children try to observe what happens when they experiment with soil and water. vi. Pupils should be able to find out that plants grow in soil and that they can grow only where the soil provides enough water.		Pupils make reports of their activities and defend observations made.

Class 3 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
c) Type of soil suitable for particular uses	i. Let pupils find out why loam soil is said to be good agricultural soil (mixture of sand, clay, dead vegetable matter). ii. Pupils plant seeds in different types of soil and observe their development.	Visit to agricultural land.	
IV. Sinking and Floating a) Which things sink	i. Children should be able to do experiment on things that sink. ii. Pupils should put different types of objects collected and put them in a bowl of water. iii. Pupils should be able to see which materials sink.	Reeds, nails, wood dry maize stalks, dry cassava stalks tins of various sizes, stones, paper boats, bowl of water, iron rods, wood	Children's involvement in the experimentation should be recorded, e.g., collection of science materials, handling and tolerance to other opinions.
b) Which things float	At this stage children should be able to see and examine floating materials.		

Class 3 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
c) What makes materials float?	i. Let children find out what makes things float. ii. If a cup or plastic container is full of mud can it float? iii. What happens if a dry maize stalk is dropped into water?		
d) What makes a material sink?	i. Let children suse some piece of iron rods. ii. Pupils should be able to determine that iron has more weight than a dry stalk of a maize of similar size.		
e) Why do launches and boats stay afloat and do not sink?	i. Pupils to make three piles of objects: those that float,sink, and those objects that both sink and float. ii. Let pupils find out how many passengers a boat carries. iii. Children to find out from a launch captain (or that of a boat) why it floats. iv. Children to determine that the water the ship floats on has a vital role to play.	Paper boats, visit to a stream to see a boat/launch.	Pupils to experiment and distinguish things that float or sink. Pupils to be able to make things that float sink, and those that sink float.

Class 3 Topic and Content	Learning Activities/Experience	Materials Required	Evaluation Techniques
V. Fish			
VI. Insects			
VII. Colour			
VIII. Clothing, Textile and related areas			
IX. Family Living			
X. Kitchen Utensils			
XI. Food and Water			

Class 4 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
I. Water and Paper			
a) What does water do to paper	(Materials to be developed.)	Dyes and inks, bottles Different kinds of papers, hollow straws, pawpaw petiole	Children's response to observation
b) Coloured water on paper	i. Children should mix different colours in different containers filled with water. ii. Let the children drop the different colours on different papers and observe the different patterns made. iii. Encourage the children to find out what water and paper can be used to separate.		
c) Water on newsprint: on grease-proof papers	(Materials to be developed.)		
II. Torch, Bulbs and Batteries			
a) How do torches light	i. Ask the pupils to bring used batteries, bulbs and copper wire. ii. Draw a battery and a bulb and ask if the bulb will light with such an arrangement.	Torches, pieces of copper wire. Batteries, battery holder.	Can the children do proper connections after discussions

Class 4 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
	. Let the children make the appropriate connections using wire. Teacher can tell the children that the wire has to touch certain parts.		
	iv. Discuss with children how a torch works.		
b) What are batteries made up of	i. Open up some used batteries step by step		
	ii. Discuss the various components making up the batteries and their functions.	Used Batteries	Pupils should identify components of battery.
c) Uses of torch light	(Materials to be developed later)		
d) Constructing torches	i. Discuss the important parts of a bulb and battery.	Bulbs, batteries, wire	Did the children succeed in making the torch light? were they able to give you a rule about when a bulb will light?
	ii. Let the children mount the battery and bulb on a holder and make the necessary connections.		
	iii. Let them reverse the connections if the bulb does not light.		
	iv. Discuss the flow of current from the battery to the bulb.		

Class 4 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
e) Things required to light a torch	i. Demonstrate the lighting of the bulb by joining them to a battery with wire. ii. Ask your pupils if current flows through other things in addition to the wire. iii. Let the children experiment with objects available in the classroom, e.g. metal roofing, keys, bolts, fence wire, knives, wood, etc. iv. Children should record their observation with objects in the classroom and at home.	Small pieces of metal papers, pieces of cloth glass, copper wire tins, chalk, rubber old batteries, lead steel and wood etc.	Were the children able to list the objects correctly?
f) Activities with batteries and bulbs	Plan activities using torch with paper and wire.	Foolscap paper, copper wire, bulb batteries.	
III. Balancing and Weighing			
a) Factors involved in balancing	(Materials to be developed/adapted.)		

Class 4 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
b) See-saw Activities	i. Construct a see-saw with the children if there is not one already in the playground. ii. Discuss ways to balance the see-saw using heavy and light weights.	A "Y"-shaped tree trunk A piece of strong rope A 3½ metre (12ft) pole about 10 cms (4in) in diameter A matchet/stick to dig a hole Pieces of bamboo some branches 120 cms long and 5cm in diameter Timber of the same size, sets of tins of the same size, small stones, sand, water, stoppers, nails.	Can pupils respond and interact with teacher and other pupils.
c) Using the balance to find unknown weights	i. Let the children carry out activities using a balancing board to find equivalent weights. ii. Teacher and children should use the balance constructed and the standardized weights to find unknown weights.		
IV. Plants and Vegetables	(Materials to be developed/adapted)		
V. Stitches	(Materials to be developed/adapted)		
VI. Common Substances	(Materials to be developed/adapted)		

Class 4 Topic and Content	arning Activities/Experiences	Materials Required	Evaluation Techniques
VII. Separating Things			
a) Mixtures of substances in nature	(Materials to be developed/adapted)		
b) Materials that make mixtures: solids and solids, solids and liquids and liquids Separating the above mixtures			
- Solids and solids	i. Ask children to list the possible ways of separating sand and salt. ii. Help the children set up an experiment following the procedure of dissolving, filtering and heating to dryness. iii. Children should record their observation at every stage.	Sand, salt, funnel cotton wool, jam jars, sources of	Were the pupils able to separate the salt and sand? Do children respond to questions?
- Solids and Liquid	i. Provide a salt solution and let the pupils taste it. ii. Encourage pupils to find ways of separating the dissolved salt from the water - there may be need to remind them about heating to dryness.	Salt, jam jars, water, heat source, tins.	Children's response to questions.

Class 4 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
- Liquids and Liquids	i. Ask pupils to drop some palm oil into a container half filled with water. ii. Discuss ways the liquids can be separated in a home situation. iii. Set up the experiment of separating palm oil from water by dripping.	Palm oil, jam jars, glass tubing, plastic straw, corked conical bottle, water.	
VIII. Stitches			

Class 5 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
I. Changing Solids			
a) Mixing substances with water: which disappear and which do not	i. Pupils to carry out simple experiment to show which solids (common powders and substances) that can dissolve in water and which do not.	Common powders and materials in the home: starch, chalk dust, salt, sugar, wood ash.	Be able to classify substances which can dissolve in water.
b) Requiring heat to change solids	ii. Using heating torches or forms of heating equipment, pupils heat various solids they have collected in bottle tops and classify solids which can melt and those which cannot.	A variety of solids such as small pieces of stones, sugar, maize stalk nails, bits of metal, plastic, wax, butter, jar.	Be able to classify solids which melt on heating.
	iii. Using the result and observations, pupils use appropriate materials to do some soldering.	Soldering wire and heating torches.	Observe the ability of pupils to solder some metals.
c) Some solids disappear on heating and exposed to air	iv. Pupil take some pieces of camphor (naphthalene) and air freshener and leave in the sun or apply some gantle heat until all disappear without melting.	Camphor (moth balls), (naphthalene) or airfresher.	

Class 5 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
II. Light			
) Where light can be obtained	Pupils to show that electricity from batteries (cells) can produce light by appropriate arrangement of materials.	Copper wire, bulb, batteries (dry cells)	Observe the ability of pupils to light a bulb using a battery.
III. Making things look bigger			
a) Constructing a magnifier	i. Pupils piece number 1 and piece number 2 from heavy grey paper that comes with children's book to construct the magnifier. ii. If the paper is not available, the children will use a thin cloth of a small size.	Heavy grey paper of piece number 1 and piece number 2. Or a piece of this cloth.	Children are able to see that small objects are made bigger with their magnifier.
b) Constructing a microscope	Pupil use the black cut-out that folds to become the microscope attached at the end of the book, cigarette foil, cotton and an old match or stick to make the magnifier.	A black cut-out folder already provided 2. Cigarette foil, cotton, an old match or stick.	Understanding that certain things not observed with magnifiers are better seen with the microscopes.

Class 5 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
IV. How the sky looks			
) Examining the sky at night	Pupils use the star charts to examine the sky at night.	Star charts provided in how the sky looks. The natural sky.	Observing to know what the different heavenly bodies are.
) What are the Heavenly Bodies?	Pupils use the star chart to examine the sky at night to identify the various stars, at night (moons and planets).	Star charts and the night sky	Be able to state that the sun, moon and stars are all Heavenly Bodies.
) Are there Patterns in the sky?	Pupils study and understand the star charts to know whether there are patterns in the sky.	(a) The star chart (b) picture of how to use the star	Children should know that there are groups of stars at different times.
d) Using the stars to locate and directions	Using the star chart of two monthly preparations to find directions.	Star chart of well-known star and planets.	Children to be able to tell positions and direction when paths are not known.
V. Clouds			
VI. Cooking			
VII. Home and Family Living			

Class 6 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
I. Plants in the Compound			
a) Examining parts of plants more closely using the magnifier	i. Pupils collect variety of twigs from trees, shrubs, creepers etc. They pluck off the leaves. The twigs are then placed in bottles, tins, large bamboo canes, clay pots and jam jars with some water in them. The containers of twigs are placed at the window ledges for storage and observations, using magnifiers.	Recently collected twigs, bottles of various kinds, jam jars, bamboo canes empty tins, clay pots, water and magnifiers.	After some time pupils discover buds develop- into leaves and flowers, the flowers opening to show their parts. Pupils also find out that some twigs grow roots.
	ii. Pupils can also up-root various types of plants and take to class. They use magnifiers to observe them.	Natural whole plants and magnifiers.	Pupils see more parts of the plant. Leaves of different shapes and size flowers, thorns, fruits and seeds, roots, branches and stems.

Class 6 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
b) Plants classified according to their uses.	i. Children observes and collect various plants in the school garden, around the school compound and nearest farms or personal gardens. ii. Pupils do more of group discussions in their small groups.	i. More materials to be developed later. ii. Various types of whole up-rooted plants, and magnifiers.	Through discussions with teacher's help children can record group plants that are food, medicinal, clothing production dyes.
c) Life cycles of plants	i. Pupils collect different seeds - maize, beans, rice, garden-eggs, etc, ii. They prepare beds for planting their seeds. iii. They are encouraged in their groups to make serious records of the developments of their seeds until the time of harvest.	i. More materials be developed. ii. Seeds of various kinds and well prepared beds.	In their conclusion, the pupils are able to know that it is the same seed that grows into its kind of plant. And this process continues all along in the life of the plant.

Class 5 Topic and Content	Learning Activities/Experiences	Materials Required	Evaluation Techniques
d) Annuals, biennials and perennials	i. Pupils collect different seeds in their groups - beans, garden-eggs, mango and oranges. ii. Pupils visit beds in the school garden and also some orchards - (pineapple and orange plantations). iii. They prepare beds to plant their seeds. iv. Group discussion. v. Teacher's questions for which plants are harvested within a year? (b) Which plants take only two years? (c) Which plants take many years?	i. Visit plantations. ii. Seeds such as corn, beans. Garden-eggs, mango, orange, lemon. iii. Well-prepared beds for planting.	After the discussions, the pupils are ableto know that some plants can produce for only a year, some can do so for two years and others are permanent for years.

II. Our School Garden (Materials to be developed)

III. Laying out the Garden

IV. Sowing and Nursing Seeds

V. Caring for Crops

VI. Harvesting and Processing of Crops

VII. Livestock

VIII. Keeping Simple Farm Records (Materials to be developed)

III - FORMAT OF UNIT OF INSTRUCTION

Topic:

Scope of Topic:

Duration:

Objectives: Knowledge, psychomotor skills, attitudes.

Previous Knowledge: To have been acquired before lesson. If absent should provide opportunity for acquiring such knowledge, not by telling.

Learning Activities: Pupil activities, teaching activities, methods and approaches.

Safety Precautions: (Where necessary).

Materials Required: Tools, equipment, consumables, reading materials.

Evaluation: (Attainment of objectives of Teacher assessment of classroom - interaction)

Follow-up Activity: Testing of pupils. Discussion with pupils.

Relationship of topic: With other Science Areas. Other subject area.

FORMAT OF UNIT OF INSTRUCTION IN SCIENCE

Topic: Ant - Lion Class: 3

Lesson Title: Locating Ant-Lions.

Lesson Type: Explorative and Investigative

Scope of Topic: Ant-lions are found in dry sandy places. Ant-lions live in conical patches in dry sandy soils: Ant-lions are found near houses under the eaves.

Duration: 60 minutes.

Objectives: Children should:

- make observations of where ant-lions could be found.
- locate and identify ant-lion.
- observe ant-lions as they dig into the soil.
- observe and describe shape of ant-lion, relating name of animal to its shape.

Previous Knowledge: Pupils had observed water around the house. Their experience this time would be dry places.

Learning Activities: Children visit dry areas where thesoil is sandy and loose and look for conical holes in the soil. Children patiently observe any movement in the

base of the cone-shaped hole. When animal is identified, collection of sand including animal is placed on flat surface, e.g. the lid of a can, or paper. Pupils observe any movement and attempt to identify the ant-lion and its movements.

<u>Materials required</u>: Collecting tins, tin lids, strong sheets of paper to spread sand on. Paper scoop to collect sand and ant-lion for examination.

<u>Evaluation</u>: Pupils should be able to collect, and examine ant-lions. The shape and movement of the animal should have been described by the pupil.

FORMAT OF UNIT OF INSTRUCTION IN AGRICULTURE

Topic: Growing vegetables Class: 5.

Lesson Title: Nursing vegetable seeds.

Lesson Type: Informational and Operational.

Scope of the Topic: Some seeds are planted direct and some are nursed.
Seedlings are stronger, healthier and hardier than those that are planted directly in the field.
Seeds can be nursed in a seedbox, seedbed, cardbox, big tin etc.
Materials and equipment used for nursing seeds.

Duration: 60 minutes.

Objectives: At the end of the lesson, pupils should be able to:

- Explain the term "Nursing"
- Give reasons why some seeds are nursed can be nursed and few examples of seeds that are nursed.
- Demonstrate the processes in nursing vegetable seeds.

Previous Knowledge Ask the pupils to name the different areas in the vegetable garden.
What materials do we require in a nursery, etc.
How are crops taken care of?

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Vegetables sown direct and those that are nursed:

Ask pupils for names of vegetable seeds that are sown directly and those that are nursed.

Nursed	Seeds sown directly
Tomato	Krain-krain
Pepper	Cucumber
Lettuce	Carrot

etc.

Ask pupils to define nursing and give reasons why seeds are nursed.

Reasons:

to raise stronger, healthier and hardier seedlings.

to increase the chances of survival.

Pupils to name materials and equipment necessary for nursing seeds.

Nursing seeds in a seedbox:

Take the pupils out to the potting shed and emphasize the conditions necessary for a nursery viz shade, water, fertile soil.

Demonstrate and explain the steps involved in preparing a seedbox and nursing the seeds.

Allow one pupil to go over the steps for others to see and comment.

Evaluation:

Can the pupils define nursing?

Can they differentiate seeds sown direct and seeds that are nursed?

On examining the seedboxes prepared by the various groups, did pupils follow the correct procedure? Were the seeds sown at the right depth?

Follow-up Activity: Pupils to compile a list of seeds that are nursed and/or sown directly in your area or country.

Pupils to nurse seeds at home in a seedbox or cardbox.

A complete account of what pupils did in nursing the seeds should be written by pupils in simple English.

Relationship of Topic: With other Science Area.

IV - APPROACHES AND METHODOLOGY

The goal of the Primary Science Programme as it is stated is to enhance the child's natural tendency to inquire by providing the opportunity to explore his natural environment beginning with the home and extending to the neighbourhood and into the community at large. In the process of acquiring inquiry skills and attitudes, the child would develop knowledge, basic skills of doing things, and positive attitudes towards his environment and problem solving.

Learning for the above purpose of developing scientific intellectual, and other attributes in the child would require that the child is given the opportunity at all times to find out the facts he should know, practice the skills he is to acquire, and demonstrate that he is thinking about science as a way of knowing about himself and the environment. The teacher therefore is required to guide the child in his exploration by assisting him to assemble or improvise the materials required. By asking the right questions or giving words of encouragement, the teacher would be able to guide the pupil through activities such as observing, classifying, guessing, record-keeping, making inferences and trying to solve specific problems.

The activities in the primary science programme are meant to make formal to the child, knowledg that he already has acquired about his environment even before going to school. The child gets to see that the light of the candle, the fire and the electric bulbs are the same thing because when studied they are seen to have the same characteristics. The child gets to see that experiences in his home, his community and the country are the experiences related to science that can be converted

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into technological ideas. The knowledge that science is all around us should excite the child to want to find out more about his environment and about science.

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V - MATERIALS FOR LEARNING SCIENCE

Receptacles:	Plates, empty tins, glass jars, piece of board, aquarium (bowl with water), insect box, paper, torch light, bamboo internode, funnels, wood, metals. seedbox, feeders, waterers.
Instruments:	Small sticks, garden tools, wire nails, insect net, rope, string, sieve, steam kettle, umbrella planetarium.
Cutting tool:	Knife, razor blades, mortar and pestle.
Hitting tools:	Large stone, pieces of wood, hammer, heavy metal.
Heat Sources:	Charcoal stove, candle, tin-lamp, electric kettle (if available).
Consumables:	Orange, flour, salt, sugar, bread, rice, bulbs, batteries, salt, dyes, wax, candle, matches. Vaseline, oil, grease, crayon, sheets or paper, chemical fertilizer.
Animals:	Ant-lion, chicks, feeds, fishes, insects, goat, sheep, rabbit, dogs, cats, pig, coco.
Plants:	Roots, leaves, seeds, stem, planting materials, lowers, twigs
Miscellaneous Materials:	Soil, water, wire, nails, stoppers, colours, carbon paper, grease-proof paper, blotting paper, writing paper, clay, gravel, sawdust, iron filings, bottle tops, coins, small objects, cow, flowers.
Photographs:	Of the sky, sun, eclipse, charts.
Sites:	Stream, house, backyard, garden, hen house, poultry shed, piggery, sky.

VI - ON EVALUATION - ASSESSING CHILDREN'S EXPERIENCE

Learning can be exhibited in different ways; it appears not only in mental skills, but also in the ways children react to various situations: changing emotions, feelings, interests. These are usually regarded as being in the AFFECTIVE DOMAIN.

The problem of evaluating children's progress and work is difficult when the teaching aims of a change, and when the course materials demand changes of behaviour for both teachers and children. The fact that evaluating a new course may be difficult is no excuse for not introducing these changes.

After having worked with your pupils for say a term, the teacher may wish to find out what experiences they have had and what they have gained from them. Giving the pupils a test is the usual way of evaluating pupil's achievement. The skills and attitudes gained should form part of the basis for examining what has been learnt. It may be difficult or even impossible to examine by a written test some aspect of their education such as self-confidence, the ability to ask intelligent questions, curiosity, or respect for other people's opinions. As an alternative or supplement to a written examination, the teacher should keep a continuous record of the performance of each pupil in one of the following forms:

(a) special notebook for the purpose

(b) a book with set of traits to be established. Indicate when traits appear

(c) The following characteristics can be observed:

- willingness to share one's work with others.
- patience and determination show when working on a problem.
- originality of ideas.
- offering one's opinion when in disagreement with others.
- willingness to change one's mind in the face of new evidence.
- willingness to compare one's result with that of other people.
- ability to keep records.
- ability to make accurate predictions.
- willingness to repeat investigations (perhaps more carefully) so as to establish validity of previous results.
- co-operation with other children.
- contribution of materials for investigation.
- ability to ask questions and to plan an experiment which will help to answer the question.
- eagerness to investigate after school.
- curiosity.
- self-confidence.
- respect for other people's ideas.

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(d) Range of activities pupils have been involved in.

Any special or extraordinary performances of a pupil.

General interest show in science lessons.

(e) The written test is only part of the total evaluation of the learning of a child.

(SEPA Handbook for Teachers of Science - 1978)

SAMPLE TEST ITEMS ON SOILS

1. If you shake a container of soil and water vigorously and leave it to settle down for a few minutes
   (a) The stones will come to the top.
   (b) The grass particles will sink first.
   (c) The smallest particles will sink at a very slow rate and settle at the top.
   (d) The smallest particles will be trapped at the bottom.
2. Big rocks can be broken down easily and cheaply by:
   (a) blowing very hard on them
   (b) buying and using dynamite
   (c) heating rocks and pouring cold water over them
   (d) using hammers and other stones.
3. Which of the following becomes soil when it is left to rot?
   (a) plants and soils
   (b) plants and plastics
   (c) plastics and rocks
   (d) none of the above.

Crushed stones give out a kind of soil known as

(a) silt soil

(b) loamy soil

(c) clay soil

(d)

5. Which of these soils is best for sowing our crops

(a) sand

(b) clay

(c) loam

rocks.

SUGGESTED SCIENCE SYLLABUS

FOR USE IN

PRIMARY TEACHER TRAINING COLLEGES

IN SIERRA LEONE

PRIMARY TEACHER TRAINING - SUGGESTED TRIAL SYLLABUS FOR GENERAL SCIENCE

INTRODUCTION

This suggested programme in General Science for Teacher Training College classes is an attempt to introduce the teacher candidate to the environmental approach in studying science. This is to be done in three stages set out as follows:

1. Ways of Exploring the Environment
2. Exploring Areas of Knowledge pertinent to the Primary School child
3. Treatment of Matter and Energy.

These stages are to be approached sequentially with the initial involvement of the teacher candidate taking place in the exploration of the environment.

STAGE I

WAYS OF EXPLORING THE ENVIRONMENT

Human Environment - Market and Other Human Environments.

Visit to the Market. Observation of - things: fish, vegetables, oils, etc.; quantities of - things, people, groups of items. Uses of things. Production of materials by fermentation, distil-

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lation, filtration, etc. Collecting and recording of data.

. Estimating and predicting.

Other Human Environments - School, School yard, Offices, Houses, Industries, Hospitals, the Local Blacksmith's, Carpenter, etc.

Environments for other lives - e.g. Well. Visit to the well, collection of specimens, observation of specimens, preservation of materials, study of things collected, classification based upon several different criteria, collecting and recording data, estimating and recording.

Other Similar Environments - River, Forest, Farm, Garden, sea-shore, ant hills, termite hills, etc.

STAGE II
EXPLORING AREAS OF KNOWLEDGE PERTINENT
TO THE PRIMARY SCHOOL CHILD

Motion - General concept of motion; motion in plants growth movements; motion in animals - locomotion;

Preservation includes keeping plants in: herbarium, botanical garden, garden or farm, can-garden; and keeping of animals in micro-zoo, aquarium, vivarium. etc.

motion by machines - wedge, inclined plane, etc.; motion due to gravity - falling of fruits, etc.

Energy - A general understanding of what energy is; fundmental sources; other sources and forms of energy; effects of sun and other forms of energy on plants, animals and other objects. (These effects should include change of state, destruction, production and preparation of food.)
Conversion (transformation) and uses of different forms of energy. Magnetism and electricity - how these affect the child in his immediate environment.

Food - What food is. Food from plant and food for plants, food from animals and food for animals.
Other forms of food: Water, mineral salts, Vitamins and their uses. Digestion of food in organisms. Parasites in the digestive tract.

Liging and Non-living Things - General characteristics of living things. Kinds of things according to their habitat - land water, air; according to structure and other criteria. Differences betweem plants and animals - classification according to modes of nutrition: free-living organisms, organisms with unusual methods of nutrition.
Life cycle of various organisms including above types,

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Water - Characteristic of and test for presence of water. Sources; water-cycles; hard and soft water; distilled water, drinking water and carbonated water; methods of purification; uses of water - by plants, animals, and other uses; as solvent, for hydro-electric power, floatation.

STAGE III
TREATMENT OF MATTER AND ENERGY

Matter— Properties of Matter: General properties - state, colour, taste, texture, size, weight, etc.
States of Matter - solid, liquid, gas. Common properties - mass, volume, density. Specific properties of common solids, liquids and gases.

Changes in Matter - Change of State: Ice water steam. Action of heat on solids: Melting, burning, sublimation. Growth changes: growing of crystals, growing by increase in number of cells. Deformation changes: Change in shape e.g. metal rods changed into needles or flat plate by hammering. Changes due to chemical reactions: decomposition, formation of new substances.

Agencies of Change - Changes caused by interaction with energy: Heat, chemical, light, sound energy.

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Changes brought about by matter in motion: wind, running water, motor-car, walking (e.g. on grass, on steps). Changes caused by the action of living things: Man - felling trees, building dams and roads; Animals - burrowing, eating; Plants - roots penetrating into soil; Bacteria - decay of matter.

Mechanisms of Change - Motion in the form of mechanical energy; Chemical and water pressure - on rock surfaces. Sudden expansion and contraction.
Air-current (wind). Use and disuse of matter.

Applications of Change in Matter by Man - Decomposition and erosion of rock, effect in agriculture. Ash, soot and charcoal in manufacture of other substances. Changes in organic matter over centuries - production of coal, petroleum and diamonds. Building of dams for producing electricity. Growth changes in animals and plants as related to economic productivity. Selection of desirable plants and animals.

Controlling Changes in Matter by Man - Erosion: planting trees, terracing. Floods etc. and dams and dykes. Effects of wind - planting trees to serve as wind-breakers. Decomposition prevented by processes such as cooling, drying, salting. Weathering of road surfaces and use of coal-tar. Decomposition of plants and buildings and the use of preventive materials such as paints etc.

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PRIMARY TEACHER TRAINING - SUGGESTED TRIAL SYLLABUS FOR AGRICULTURAL SCIENCE

Introduction to Agricultural Science - Understanding of Agriculture, importance of agriculture to the individual and to Sierra Leone.

Gardening - Role of gardening in schools: Selecting sites and tools. Preparing the land: Clearing, ploughing (digging) and levelling, laying out making of beds, manuring the land. Growing plants: Sowing seeds - direct, indirect (nursing), transplanting. Caring for the growing plants: Watering, weeding, mulching, fertilizing, controlling pests and diseases.

Harvesting and Storing; Marketing and Keeping Records; Making of compost. Soils - knowing the garden soil; understanding its properties; factors affecting soil fertility; preserving the soil: anti-erosion drainage etc.

Growing Animals - Understanding livestock and its importance. Poultry: Selecting site for poultry house; constructing house; selecting and equipping the house. Brooding chicks; making a brooder and using it - caring for chicks. Feeding and types of feed. Controlling diseases and parasites. Culling and knowing its importance.

Marketing products - Keeping records, mortality; cost and amount of feed; labour and profit margin.

Piggery - The above operations on other animals are also done in the rearing of pigs with the following additional consideration: Caring for sow and piglets; castrating the boar; weaning the piglets.

Farm Mechanics - Sketching and drawing plans of pens, tools and equipments. Constructing simple buildings e.g. piggery and poultry, seed boxes, nests, waterers, feeders. Caring for machinery and tools. Operating machines.

Factors affecting productivity - diseases and pests.

BUNUMBU TEACHER TRAINING COLLEGE

SYLLABUS FOR BASIC AND APPLIED SCIENCE

Bunumbu, Sierra Leone
1982

TERM II

PART TWO OF THREE (TERM TWO)

Basic and Applied ... Science Studies

I. THE TERMS MAIN THEME AND SUBTHEMES

A. MAIN THEME: "WHAT WE NEED TO KNOW FOR EVERYDAY LIVING"

B. SUB THEMES:

Solving Everyday Problesm connected with Area. Volume. Distance. Time

1. Interaction of Elements (factors) within the Environment

2. Common Animals which Affect Our Lives

3. How We Waste (save) Food

4. Fuels We Use for Cooking

5. Family Health and Hygiene

6. Simple Budgeting and Accounting (time and money)

7. Physical Activities for Leisure Time

II. BROAD OBJECTIVES

By the end of the second term's work in basic and applied science studies a student-teacher would have developed an awareness of environmental characteristics and their effects on everyday living through:

A. Developing (Acquiring) a concept of "The Environment", (ecosystem).

B. Observing, collecting, recording and interpreting data critically.

C. Learning the various forms of energy and matters, and, studying their importance and influence on everyday life.

D. Forming desirable health habits and practices.

E. Using mathematical and scientific tools i.e. rulers, scales, thermometers, lenses, compasses, watches.

F. Identifying and solving problems related to simple budgeting and accounting (time, money).

G. Identifying and solving problems with plain and space figures.

III. SPECIFIC OBJECTIVES

At the end of the second term of the second year student-teacher should have:

A. 1. Discussed the interactions of elements within the environment.

2. Investigated selected eco-systems in their environment.

B. 1. Observed, collected and recorded data of common animals in the environment which affect their lives.

2. Critically interpreted data collected.

C. 1. Observed, collected, and recorded data of food storage in a specific environment.

2. Critically interpreted data collected and made relevant recommendations.

D. 1. Discussed various forms of energy; and their importance and infludence on everyday life.

2. Identified various sources of heat energy used for cooking.

3. Investigated in detail the common sources of heat energy used in cooking in their environment.

E. 1. Discussed common diseases in their environment.

2. Recorded the incidence of diseases common in their environment.

3. Investigated in detail selected diseases in groups.

4. Presented a written report on selected diseases investigated in groups.

F. 1. Discussed the purposes of budgetting.

2. Examined the elements of a budget.

3. Planned a personal monthly and annual budget.

G. Identified common problems connected with area, volume, mass, time, distance.

1. Listed common problems connected with measurement.

2. Categoriesed these problems in terms of: area, volume, mass, time, tistance.

3. Solved the problems listed and categorized.

H. 1. Drawn up a list of physical acitivities appropriate for both adults and children to engage ir during leisure time.

2. Participated in daily supervised physical activity selected from the above list.

IV. ACTIVITIES

A. 1. Draw up a list of games, activities, exercises, etc. for adults and children to engage in which will promote good health.

2. Participate daily in a series of physical activities determined by interest and supervision.

B. 1. List and categorize various elements within the environment.

2. Examine interactions between:

a) Living and non-living elements

b) Living and living elements

c) Non-living and non-living elements

3. Observe and report on selected eco-systems e.g. forest, river, pond, field, garden.

C. 1. Establish guidelines for observing, collecting and recording data.

2. Observe, collect and record data on selected common harmful animals in their environment, e.g. mosquito, house fly, cockroach, worm, lice, bed bug, tick.

3. Through diagrams, figures, graphs or other means compare data for analyses.

4. Draw up conclusions based on the analysis and make recommendations.

5. Make predictions.

D. 1. Using established guidelines, observe, collect and, record data on food wastage in specific environment, e.g. students dining hall.

2. Through diagrams, figures, graphs or other means. compare data for analysis.

3. Draw up conclusions based on the analysis and make recommendations.

4. Make predictions.

E. 1. Discuss the meanings of energy, its forms and their importance to everyday life through class assignment, questioning and answering, lecturing and other means.

2. Survey the community to determine all possible sources of heat energy used for cooking and their frequency.

3. Analyse the information above to determine the most common sources of heat.

4. Conduct experiment using an open fire and various closed stoves to determine efficiency of fuel use.

F. 1. Through assignments, reports, note-taking, discussion or other means determine common diseases in the environment.

2. Survey and record the incidence of these common disease in the community.

3. Analyse and present data collected through graphs, diagrams, figures and other means.

4. (Groups of students assigned specific diseases) Investigate thoroughly stages of the disease.

5. Prepare and present a written report on the investigation (each group).

6. Discuss the contents of each of the reports written and presented.

G. 1. Examine the reasons for budgeting, e.g. a plan for action involving time or money through discussion of personal experience.

2. Analyze simple budgets from available sources including personal and institutional.

3. Prepare individual personal budgets for specified period of time.

H. 1. Make classroom use of measurement tools.

2. Survey the community house, market, shops, etc. and identify problems which may require measurement tools to solve.

3. Put these problems into categories according to: a) Mass, b) Time, c) Distance, d) Area, e) Temperature f) Volume.

4. By using standard tools of measurement, solve the problems listed above.

5. Examine discropancies between standard tool measurement problem solving and the methods employed in everyday life.

<u>Note</u>:

1. Broad objective E which deals with "use of mathematical and scientific tools and devises" is not treated as a separate item. This is because these tools and devises will be used to accomplish the other objectives.

2. Under the supervision of the physical education department, every second year student is required to participate in supervised physical activities (suggested time 5:00 - 6:00 p.m. Monday through Friday).

TERM III

PART THREE OF THREE TERM

Rural Development Studies

I. THE TERMS MAIN THEME AND SUBTHEMES

A. MAIN THEME: "A BETTER LIFE THROUGH CO-OPERATIVE EFFORT"

B. SUB THEMES:

1. Food for Human Beings
2. Tools/Machines, Equipment, Materials
3. Community Problems
4. Resources in the Environment
5. Meeting Community Needs
6. Encouraging desirable Attitudes

II. BROAD OBJECTIVES

By the end of the third terms work in rural development studies the student-teachers should have:-

A. Acquired knowledge of human and natural resources in their environment.

B. Demonstrated an ability to use and maintain appropriate technology and suggested improved designs on selected tools.

C. Acquired the ability to recognized community needs and problems.

D. Participated in the process of decision-making as related to community problems.

III. SPECIFIC OBJECTIVES

A. Defined human and natural resources.

B. Investihated how human and natural resources are used within the environment for food production.

C. Discussed alternative eays of using human and natural resources in the environment for food production.

D. Carried out assigned projects from: a) Agriculture b) Basic crafts, and c) Home economics.

E. Carried out relevant experiments in the Rural Technology Laboratory with existing tools, designs, methods, etc.

F. Investigated basic community needs.

G. Determined a list of community needs.

H. Applied the principles of decision-making to the solving of community needs.

IV. ACTIVITIES

A. Survey the local community and list human and natural resources available.

B. Discuss and analyze the findings and making generalizations.

C. Use the survey and establish generalization determine specifically how human and natural resources are used in food producation in the environment.

D. Make a list of alternative ways of using human and natural resources in food production in the environment.

E. Fulfill requirements laid down for practical projects in agriculture, crafts, and home economics.

F. Select one or two common tools, study them carefully in the rural technology laboratory and make suggestions for improvement. Alternatively make suggestions for improvement of design or method of use.

G. Through reading, lectures and discussions develop a list of community needs.

H. Using the list developed, survey an actual community and determine the extent to which these needs are met.

I. Analyze the data from the survey and identify community needs not met (if any).

J. Through reading, discussion, and lectures, list community problems not encountered.

K. Determine the principles involved in decision-making.

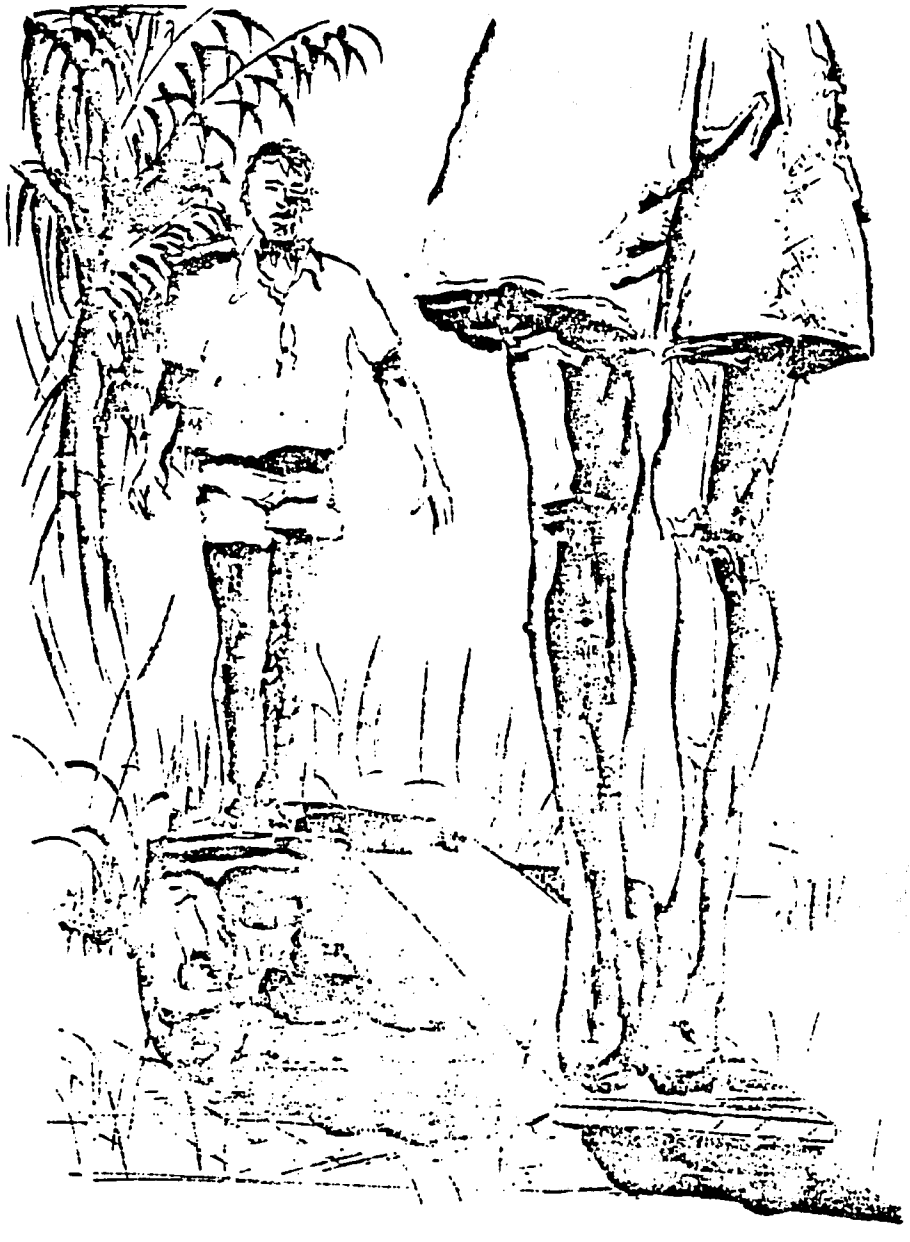
L. In small groups, apply these principles to specific common problem.

M. Present a written report detailing concrete proposals for solving these problems (for example, the detail may consist of statement of the problems, description, procedure, and proposal).

10 August, 1982.

/eym.

Science In Our Daily Lives



PUPILS' PAMPHLET

MINISTRY of EDUCATION — SIERRA LEONE BROADCASTING SERVICE

No. 54 1973/74 ACADEMIC YEAR

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SCIENCE BROADCASTS - PRIMARY SCHOOLS

OBJECTIVES:

1. To sharpen observation of pupils around the environment.
2. Increase pupils' participation in investigatory activities.
3. To encourage pupils to ask questions about their environment.
4. To encourage pupils to think out likely answers to their own questions i.e. Hypothesising.
5. To familiarize pupils with measurement of selected parameters of science problems.
6. To bring home to pupils the pervasiveness of science in their daily lives.

EMPHASIS:

Emphasis should be placed on activities for the children themselves to perform. The teacher is requested to try and provide sufficient materials for the children to handle.

1st BROADCAST **1st, 2nd, and 4th October, 1973.**

Observing Nature : 1. Plants, insects and other animals.

Preparation :

Before the programme : Let the children mention what they saw on the way coming to school and focus their attention on the natural things or phenomena.

Broadcast : **A General look at Nature**

1. Sky and Sun; Clouds
2. Hills (forested)
3. Big trees and small
4. Rocks and pebbles (and sand)
5. The plants and animals on the ground.

Follow-up Work :

1. Immediately after the programme, if time available, let the children make a list of things in nature they see every day.
2. Let them bring in samples later on or pictures of examples to form a chart that will aid reference and identification of plants and animals referred to in later talks.

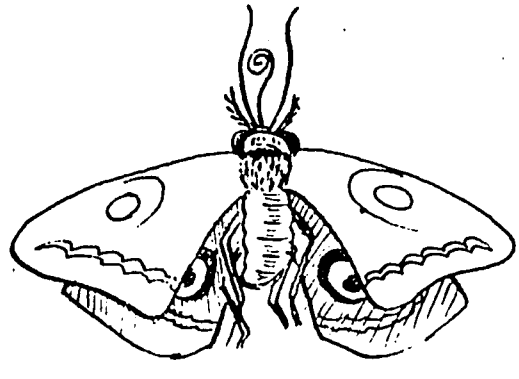
2nd BROADCAST **8th, 9th, and 11th October, 1973.**

Observing Nature : 2. Butterflies and moths and other insects.

Preparation :

Before the programme collect and bring to class and encourage children to collect and bring as well, specimens of caterpillars, pupae, moths and butterfly adults (also eggs if available). Commonest butterfly is Papillio.

1. Insects are (a) useful
   (b) harmful
2. Find out about insects : How to tell insect in flight.



Moth

2

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Follow-up Work :

Make breeding cages for various insects not only moths and butterflies. Keep records of stages and their duration up to imago.

3rd BROADCAST **15th, 16th, & 18th October, 1973.**

Observing Nature : 3. Animals in the Farm.

Preparation :

Get a pup or cat or both nearby.
Talk about larger animals, domestication.
How many domesticated animals can class name?
How are they different from wild forms?
What is a farm?

Broadcast : Animals in the farm : chickens, goat, sheep, cat, dog, rat, (ox, horse, mule).

1. How can one tell which animal is at a distance?
2. How can one tell with eyes closed which animal is nearby ?
3. What are the uses of each kind of farm animal?
4. Animal pests on the farm.

Follow-up Work :

Make a list of characters of the animals.
Use list to identify other familiar animals e.g. horse, wolf, fox, antelope.
Let pupils make chart showing what products of farm animals are used.
Let pupils prepare another list to show which animals are pests.
Let pupils make water lens to observe fleas (or ticks) on cat or dog (others also).

4th BROADCAST **22nd, 23rd, & 25th October, 1973.**

Observing Nature 4. Plants that behave like animals.

Preparation :

Get potted plants (a) maize, goat weed, (b) mimosa

Get insect, cat, mouse, etc.

Talk about how animals differ superficially from plants.

What happens when you stimulate e.g. by touch a maize plant and a cat or mouse ?

Broadcast : Plants sometimes behave rapidly like animals generally do.

1. Response to light/dark.
2. Response to water.
3. Response to gravity.
4. Response to touch.

Follow-up Work :

Let the children find out other plants that respond to touch similarly e.g. flycatcher.

Let the children find out what makes mimosa respond as it does.

5th BROADCAST **29th, 30th, October & 1st November, 1973.**

Observing Nature 5. Evaporation and condensation.

Preparation :

Get ready some ice blocks or ice-cold water. clean dry glass or bottle. Encourage the children to recall experiences of evaporation e.g. ironing damp clothes, seeing the vapour rise on the road after a slight rain on a warm day.

Do same for condensation e.g. liquid on inside of cover over food or water left to stand in a covered dish or vessel.

Broadcast : Evaporation and condensation of water.

Water is liquid.
It changes to vapour and gas when heated.
The vapour rises to form clouds.
The clouds condense to fall as rain.
The cycle begins again.

Follow-up Work :

Write on the blackboard such words as liquid, condense, condensation, vapour, evaporate, dew, cloud, rain, change of state.

Ask questions such as where does the water on outside of the glass/bottle come from when you blow on it?

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6th BROADCAST **5th, 6th, & 8th November, 1973.**

Observing Nature 6. Light and dark; shadows.

Preparation :

Find out by questioning what are the children's ideas or understanding of the concepts light, dark. What sources of light can they recall? (sun, moon, stars, lamps, torch, fire, candle) get ready a mirror. Get bulbs and batteries (torch type) with wires.

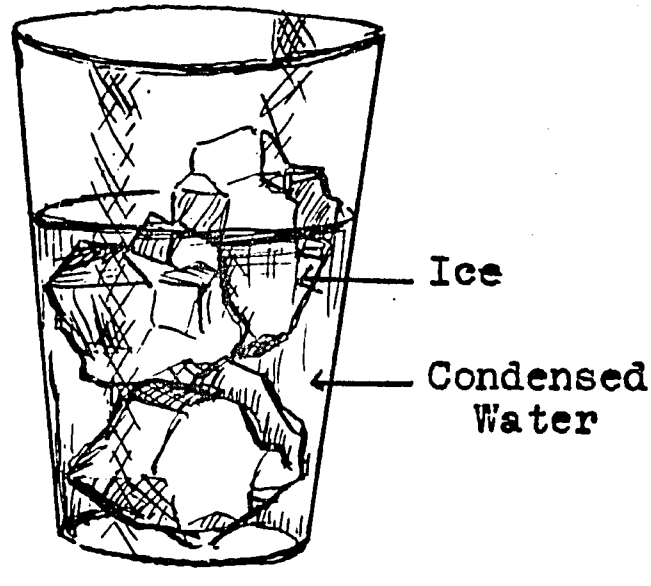
Broadcast : Light, Dark, Shadows.

1. Light enables us to see things producing light.

2. We see by reflection.
3. When there is no light we cannot see-dark.
4. When an object is in the path of light it casts a shadow.
5. Our shadow changes shape, length, direction and always follows us.

Follow-up Work :

1. Let the children observe and measure the length of the shadow of a short pole in the compound at different times of day, noting the direction it is cast.
2. Let the children look at their reflection in water and try to explain how it is formed.
3. Let the children study the changes of their shadow as they approach, pass under and move away from a single source of light.



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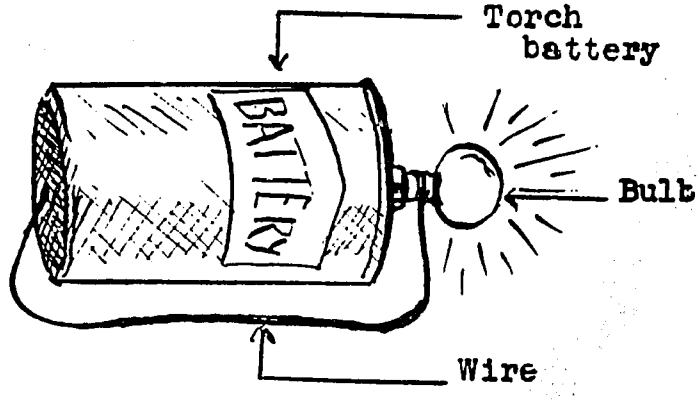

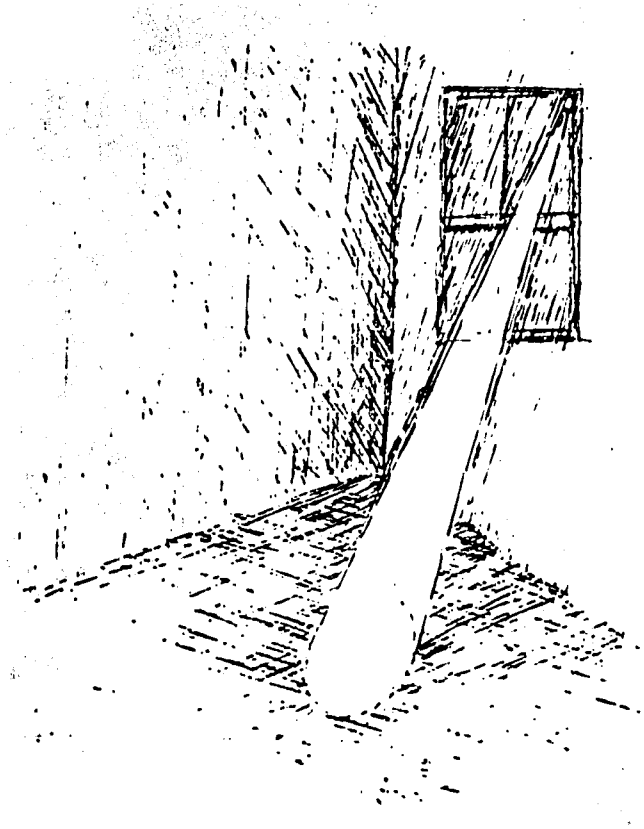

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Observing Nature 7. A seed developing.

Preparation :

About a week in advance, let the children bring in some seeds, soak them in the morning, and sow them in damp soil contained in about 5 pots (tins with one or 2 small holes on the bottom serve equally well). Place the set up securely away from insects e.g. ants, or pests.

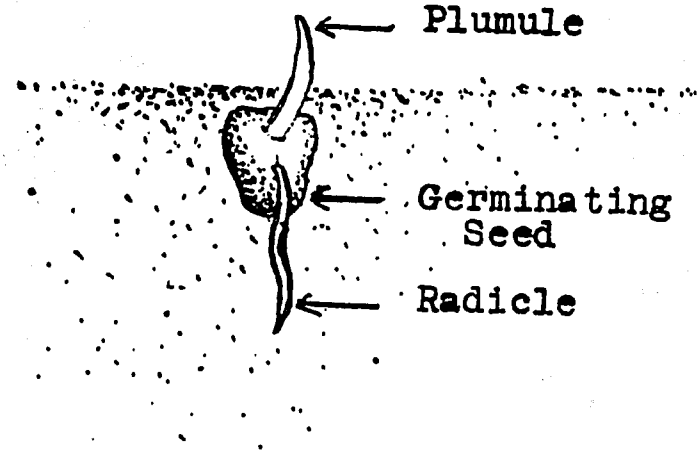
Encourage the children to dig out a couple of seeds every day to see how they are doing. Let them draw what they find.

Broadcast : **Germination**

1. A seed is the way a plant produces another plant.
2. A seed contains a young plant inside it called the embryo.
3. Much of the material in the seed is food for the embryo.
4. When the conditions are ripe the embryo begins to develop i.e. germinates.

Follow-up Work :

Let the children keep records of germination and compare different seeds in regard to (a) sprouting time, (b) position of seed on sprouting (c) number of 'leaves' (cotyledons) that first appear (d) direction of growth of radicle and plumule. Write on the blackboard words like embryo, material, conditions, germinate, sprout, growth, radicle, plumule, cotyledon.



8th BROADCAST **19th, 20th, & 22nd November, 1973.**

Asking Questions of the Environment, or Experimenting with Nature:

Preparation:

Start a discussion on air as an (invisible) gas by asking the children what is in the 'empty' jar. Prepare polythene bag, empty Jam jar or beaker, bowl of water about 3" deep, toy balloon.

Broadcast: **The Properties of Air**

1. Air is everywhere, even in 'empty' vessels.
2. Air is springy, you can squeeze it down.
3. Air has weight, force i.e. pressure
4. When air moves it is called (becomes) wind.
5. Air is what we breathe in and out.
6. Air is present in water and in soil.

Follow-up Work:

Write on the blackboard words like compress, pressure, force, weight, breathe. Encourage pupils to relate instances. When air is

(a) a nuisance e.g. with a lighted candle.

(b) not useful e.g. for sterility.

(c) very helpful e.g. sailing.

Let the children try to make a barometer.

9th BROADCAST **21st, 22nd & 24th January, 1974.**

Experimenting with Nature: 1. Air.

Preparation:

Get ready short pieces of candles (4"), jam jars, bowls or troughs of water. Ruler or graphpaper. Encourage the children to discuss their ideas of the nature and composition of air.

Broadcast: Something in Air supports burning.

1. Candle burns in air so long as oxygen is present and adequate.
2. Expired air is less effective in supporting burning.
3. The oxygen in inspired air has been taken up in the blood.
4. The oxygen in the blood is used for respiration i.e. like "burning" food.
5. Plants too need air's oxygen for respiration.

Follow-up Work :

Let pupils observe their own breathing movements. Relate air pressure to breathing by asking them to suck out air from paper cylinder, cup or funnel with a rubber sheet across its open end.

10th BROADCAST **28th, 29th & 31st January, 1974.**

Experimenting with Nature : 3. Plant behaviour.

Preparation :

Get some potted sensitive plants with some potted goat weed or bean, etc. also timer. Get pupils to discuss their experiences with these plants. Recall experiences with germination and revise vocabulary, introducing concepts like stimulus, response, sensitive, environment.

Broadcast : Plants respond to stimuli.

1. How plants respond to touch e.g. bean seeding.
2. Peculiar behaviour of Mimosa pudica, the sensitive plant behaves like an animal.
3. How long does it take for the leaves to open out again.
4. What happens when the touch is light, strong?
5. Do the leaves open out again in the same time?
6. How does the plant make these responses?
7. What conditions in the environment affect the response?

Follow-up Work :

1. Encourage the children to investigate effects of light, darkness, dry soil, moist soil etc. on the ability of the plant to respond to touch.
2. Direct children's attention to the swollen area at the base of the leaf-stalk. They might try to make a pin-hole there and see what comes out. Does this affect the response of the plant to touch stimulus?

11th BROADCAST **4th, 5th & 7th February, 1974.**

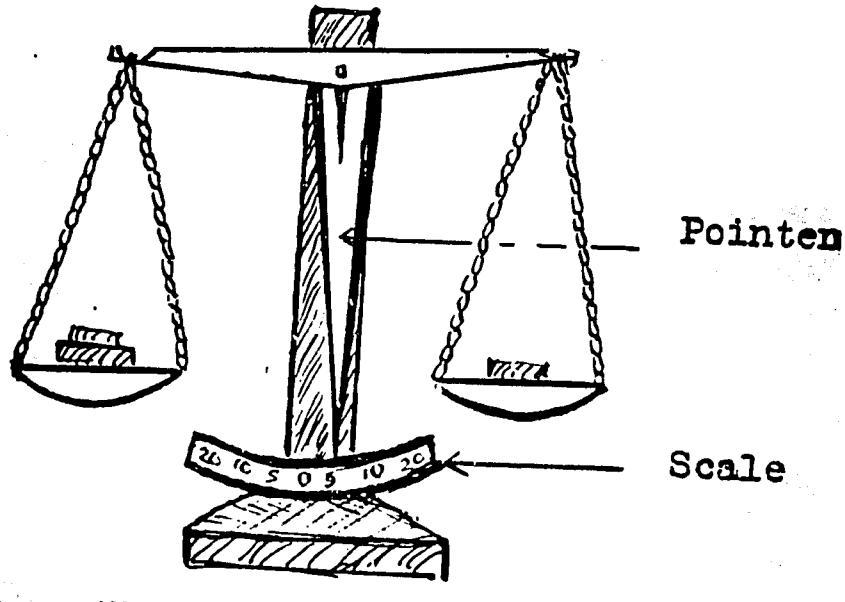
Experimenting with Nature 4. Measurement.

Preparation :

Introduce the terms measure, measurement, guess, estimate, exact, precise, size, quantity, amount, weight, distance, time.

Broadcast : Reasons for measurement in Science.

1. We measure to know exactly (with precision).
2. For somethings we measure size (how big, how small).
3. For other things we measure quantity or amount. (How much, how many).
4. For other things we measure weight (how heavy).
5. For other things we measure distance (space, how far).
6. For other things we measure time (how long).
7. We use aids to measurement (ruler, pendulum clock, balance, beaker.



Follow-up Work :

1. Let the children suggest what property they will measure to know about their classroom, the number of pupils in the class, their chairs and tables, their route to school, themselves, rice, maize plants, rainfall, sunshine, the period they are awake.

12th BROADCAST **11th, 12th & 14th February, 1974.**

Experimenting with Nature : Measuring size.

Preparation :

Get several pieces of cardboard (paper would do), flowers of different sizes, insects, small cardboard boxes, etc.

Encourage the children to suggest how they will measure the sizes of the objects and compare them as to which is big, bigger, biggest etc. You could ask them to estimate size and then check their estimates by measurement.

Broadcast: Dimensions and Size.

1. Size deals with length, area, volume.
2. In Science we must have exact size so that people know exactly what object we are talking about.
3. We measure size using ruler, dividers, graph paper; and sometimes doing some multiplication and addition.
4. We measure size of angles too; using a half circle, with marks on it, called a protractor.
5. You can make your own protractor, ruler.

Follow-up Work:

Encourage the children to make a protractor out of cardboard and use it to measure angles between objects in the classroom.

13th BROADCAST **18th, 19th & 21st February, 1974.**

Measuring Size and Density.

Preparation:

Get a piece of cardboard about the thickness of a metal washer (or a 20c piece) and cut out circles exactly the shape and size of the washers (or coins) enough for the class to handle and experience. Several pieces of rocks, glasses or beakers of water.

Broadcast:

1. Different objects of the same shape and size weigh differently. One may feel heavy, the other feels light.
2. The amount of matter in them is different.
3. When immersed in water in a jar the water rises to different levels.
4. The difference in weight and in water displaced is explained as a difference in density.
5. Which is denser, sand or salt? How can one find out?

Follow-up Work:

1. Let the children try to find out the volumes of pieces of rocks of irregular shapes.
2. Let the children try to find the volumes of their pencils.
3. Let the children try to find the areas of the surfaces of different leaves; a page of the note-book

14th BROADCAST **25th, 26th & 28th February, 1974.**

Measuring Weight.

Preparation :

Review different kinds of scales and balances in children's experiences. Get an equal arm balance with weights. (washers will do, or bottle tops, nails, etc.) Small amount of rice, sweet potato, cassava, some beans, various insects. (Bathroom scale).

Broadcast :

1. How heavy are familiar objects around the home e.g. one sweet potato, a handful of rice?
2. Weight is important so that 'safe load' is always maintained e.g. on a platform, in a lift, in the bus, poda poda, bicycle.
3. How heavy is (i) the tallest pupil in the class (ii) the shortest pupil in the class?
4. How can one find the weight of a bean seed, a grain of rice ?

Follow-up Work :

1. Which is heavier, water or oil?
2. Let the children make foot marks on either wet sand or moist soft soil and measure the depth of the print. Is there any relationship with body weight ?
3. Children may be encouraged to make an equal-arm balance, or spring balance.

15th BROADCAST **4th, 5th & 7th March, 1974.**

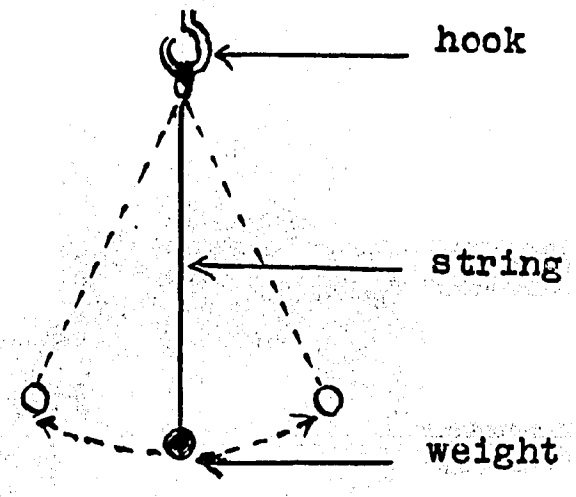
Measuring Time

Preparation :

Get a pendulum swinging (you can use a small pebble etc. at the end of a string), get two tins, one having a small hole at the side near the bottom, a quantity of water to fill one such tin about ¾ full, a watch.

Broadcast :

1. Time is a measure of how long something lasts e.g. a day, a week, the rainy season.
2. There are many ways of measuring time e.g. sun-dial, water clock, pendulum swings.
3. The clock and the watch are modern time-measurers.
4. Time of life, germination time, growing time, harvest time.



Simple Pendulum

Follow-up Work :

1. Children can make a pendulum that will do
   (i) one complete swing a second
   (i i) two complete swings a second
2. Children can measure how long it takes for
   (i) a shadow to pass from one side to the other of an object.
   (i i) direct sunlight to disappear from the classroom.

16th BROADCAST **11th. 12th & 14th March, 1974.**

Experimenting with Water

Preparation :

Prepare a clean glass beaker ¾ full of water (the meniscus is where the top surface of the water touches the glass and rises slightly) showing the meniscus clearly, get two glass slides handy (or any two flat pieces of clean glass; some oiled paper, a sheet of plain paper, a small piece of soap.

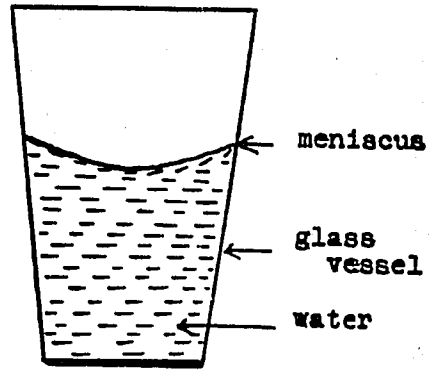
Broadcast :

1. Water can be sticky; in a clean glass vessel it sticks to the sides and rises up along the glass to form a meniscus.
2. What happens to some fine chalk dust blown on to the surface of the water?

3. This stickiness is called surface tension. It can be shown further by putting a small drop of water on a clean glass plate and then lowering another clean glass plate on the first. Then try separating the two glass plates. (Also wet tumblers).
4. Plain paper on glass behaves similarly; so does wet dress on the body. But oiled paper does not stick with water so we use "oilskin" overcoats ; plastic overcoats.
5. Water does not wet greasy surfaces; but if soap is added it wets the surfaces removing the grease. So soap is used in washing (cleansing).

Follow-up Work :

1. Let the children give examples in their own experience of surface tension e.g. formation of soap bubbles, rain drops rolling from surfaces of leaves but wetting the barks of trees; "water off a duck's back" insects walking on water surface.
2. Let the children make a list of things that water normally wet and things that water normally does not wet.
3. Using drinking straws let children study the formation of a water-drop.



4. Let the children try floating a needle, a match stick or tooth-pick on the water surface.

17th BROADCAST **29th & 30th April, 1974.**

2nd May, 1974.

Recording Observations

Preparation :

Start a discussion by asking questions like: "When do tadpoles first appear in the ponds and shallows of rivers ? When do mangoes, oranges produce flowers? When was the last eclipse of the sun?

Broadcast: It is important to make records of what we observe in Nature.

1. Science progresses through recording of observations we can use simply note-books and pencils.
2. The phases of the moon — new, first quarter, full, last, quarter.
3. Tides — high, low; neap, spring.
4. How many kinds of birds in your school compound this term, this year ?
5. How many different kinds of plants in the school compound ; in the neighbourhood ? Which ones are flowering now ? Shedding leaves?
6. How many different kinds of insects can be observed in the morning, in the afternoon, in the evening, at night ?
7. How many different kinds of rocks in the neighbourhood ?
8. When are caterpillars, grasshoppers, mosquitoes plentiful in your area ?

Follow-up Work :

1. Children are encouraged to collect and draw different kinds of flowers, leaves, shells, insects.
2. Children are encouraged to keep dates and places of collection of specimens, with note on season, time of day etc.
3. Observations on insect eggs (from the underside of leaves) larvae and pupae are encouraged to be made with drawings and rearing, if possible.

18th BROADCAST **6th, 7th & 9th May, 1974.**

Science Applied in the Home

Preparation :

Get bottle-opener, tin opener, spade shovel or hoe, grate, sieve (wheel-barrow?), strong hollow metal (pipe), bottles of soft drink.

Write on the blackboard lever, pulley and pivot.

Broadcast :

By using Science (knowledge) we can make our task easier.

1. It is easier to open a bottle with an opener if we extend the handle of the opener with a metal pipe.
2. It is easier to open a tin of ovaltine with a long handle knife than with a coin.
3. These tools use the idea of levers. So do the hoe and the shovel when we dig up the soil with them. So does the axe when we spilt open a piece of wood (and do a twisting motion).
4. The Scissors and garden shears also work on the same idea.
5. We can also use knowledge of science to open a screw-on lidded bottle when the lid gets stuck — we heat the lid.

6. The metal roofing creaks when heated in the sun the metal expands. Also cold egg in boiling water.
7. We can carry a heavy load in a wheel-barrow more easily than on the head or on the shoulders. And it is easier to pull the barrow than to push it e.g. Omolanké.
8. It is easier to separate particles with a sieve than by picking with the hands.
9. It is easier to mash cassava, etc. with a grate.

Follow-up Work :

Let the children suggest other labour-saving devices about the home e.g. egg beater, electric mixer, meat grinder, pressure cooker, and say which act as levers, which act as pulleys, etc.

Children can visit a local blacksmith to see how metal is forged into hoe, cutlass, etc.

19th BROADCAST **13th, 14th & 16th May, 1974.**

Science in our Daily Lives.

Preparation :

Some tea soaked in cold water.
Some tea brewed by boiling.
Sun glasses, knife and sharpening stone.
Write on the blackboard : Friction, evaporation, glare.

Broadcast : We employ science every day.

1. When we sharpen a knife the edge gets hot, due to friction. Friction from rubbing produces heat.
2. We rub the hands together when we are cold to develop heat. Try rubbing the bare hands briskly over the thigh. What happens if we put some grease on our hands before rubbing them together?
3. If we pour boiling water into a cold tumbler it cracks and breaks; but if we heat it first it does not break.
4. In bright sunlight sun glasses cut off the glare and we have less eye strain and better view. Photographers use light filters.
5. We can keep eggs cool by covering them with damp cloth. The same thing happens to our bodies when we sweat. The dog pants.
6. We add ash to the base of plants to provide plant food-minerals (fertilizer).
7. We can tenderize meat by adding paw paw sap from leaves, fruit, etc.
8. We keep water cool in an earthenware pot in a place where there is a draught.
9. Some substances dissolve better in hot water e.g. salt, tea extract.

Follow-up Work :

1. Let the children try to explain what happens when a bucket of water is left to stand in the sun.
2. Let the children suggest what would be the effect of
   (a) hot knife on cold margarine, pea-nut butter.
   (b) damp cloth on margarine.

20th BROADCAST **20th, 21st & 23rd May, 1974.**

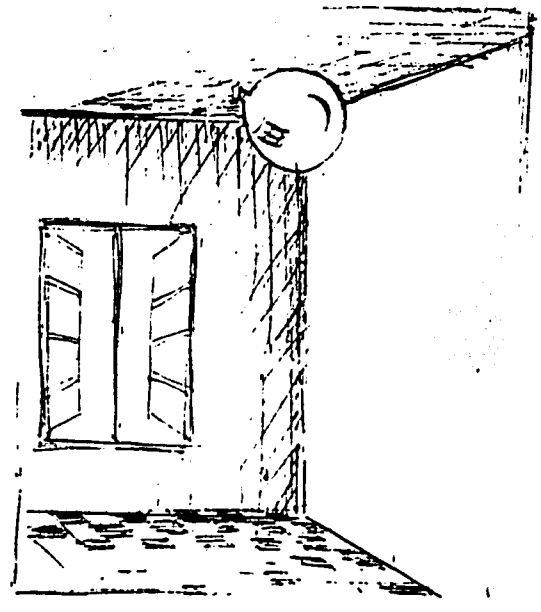
More Science in our Daily Lives.

Preparation :

Torch batteries, torch bulbs, pieces of wire, toy balloon, soft flannel cloth, nylon or terylene cloth, pieces of paper (1" squares). Write on the blackboard. Electricity, battery, bulb, current.

Broadcast :

1. A torch or flashlight gives light because it has a bulb and one or more batteries connected together.
2. You can arrange a bulb and one battery to produce light. What else do you need to succeed?
3. This light is produced by electricity-current electricity.
4. There is another form of electricity-static electricity. Try combing your hair when it is very dry-you get some crackling noise. Rub an inflated toy balloon on a piece of flannel or nylon and put it near the wall. It gets stuck by static electricity.
5. Lightning is a form of static electricity.



Follow-up Work :

1. Let the children suggest what kind of electrcity produces light in a bus or lorry.
2. Let the children try to light their bulbs by arranging them in several different ways and finding out which arrangements are successful and which are not.

21st BROADCAST **27th, 28th & 30th May, 1974.**

Sound to be illustrated by line drawing of a guitar (preferably home-made).

Preparation :

Short lengths of case board, some lengths of thin wire, some nails, six pints (empty $\frac{1}{8}$, $\frac{1}{3}$, $\frac{1}{2}$, $\frac{3}{4}$, 5/6, full of water); a fine-toothed comb.

Broadcast : We produce sound in various ways.

1. By using wind e.g. blowing over an empty bottle; the pitch of the sound depends on the space in the bottle. Try blowing with different amounts of water in six or eight bottles. The organ works this way.
2. By plucking a taut string; the sound produced depends on
   (a) the tautness of the string.
   (b) the thickness of the string.
3. By rubbing a comb over a ridge. This is how the cricket produces its sound.
4. The sound can be made louder (amplified) if the string is stretched over a hollow box e.g. as in the guitar.

Follow-up Work :

Let the children suggest how the sound is amplified in a xylophone.

Let the children list and describe how sound is produced in other local musical instruments.

22nd BROADCAST **3rd, 4th & 6th June, 1974.**

Substances about the home.

Preparation :

Some salt water (can be artificially made). Source of heat, some caustic soda, some oil, stirrer (Wooden).

Broadcast : How salt is produced, How soap is made.

1. Salt comes from the sea water; the water is evaporated and the salt is left behind.
2. You can reproduce the process by heating some sea water or salt water provided, in a beaker so that all the water evaporates. Does the salt produced look like the salt you eat?
3. Soap is made by boiling oil and caustic Soda or potash.
4. You can reproduce the process by heating some oil and water to boiling, and then adding some caustic soda and stirring until you get a thick soapy mass. Allow to cool. It hardens and you can cut it into several small cakes.
5. Scented soap has the perfume added as it cools.

Follow-up Work :

1. Children can visit salt factory or salt wells in their areas.
2. Children can visit soap factory in their areas.
3. How is the black soap made?

23rd BROADCAST **10th, 11th & 13th June, 1974.**

Starting a Science Club.

Preparation :

Start discussion on science activities that children can do as out-of-class engagements e.g. make small equipment, rearing small animals. Who would like to do these things?

Broadcast : How to form a Science Club.

1. The spirit of discovery is vital in science study. Through science clubs children develop the joy and adventure of scientific discovery.
2. Time and place should be arranged with the head teacher.
3. The children should hold responsible positions in the club, and the club should start small.
4. There is an inaugural meeting to elect officers and a committee to formulate the constitution.
5. The constitution should specify whether dues are to be collected and, if so, how much; and should specify sources of financing the club.

Follow-up Work :

1. Children can start off forming their club.
2. Children should seek a sponsor for the club.

24th BROADCAST **17th, 18th & 20th June, 1974.**

Starting a Science Club (continued).

Preparation :

Let the children review the progress of their arrangements for forming a Science Club.

Broadcast : Activities for a Science Club.

1. The need for a well-thought out schedule of activities to maintain interest and enthusiasm.
2. The role of the sponsor.
3. Guest speakers.
4. Field trips.
5. Maintaining and augmenting school equipment and apparatus.
6. Science projects.
7. Science Fairs.

Follow-up Work :

1. Children can begin to draw up schedule of activities for the term or the year.
2. A committee may be set up to take care of (5) above.

SCHOOL BROADCASTING TIME TABLE (PRIMARY) 1973/74

TIME	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
09.05 — 09.25	Let's Try and Understand		Music for Primary Schools		
09.30 — 09.50	Science in our Daily Lives			Music for Primary Schools R	
09.55 — 10.15		Science in our Daily Lives R		Let's Try and Understand R	
16.15 — 16.35	Music for Primary Schools R	Let's Try and Understand R		Science in our Daily Lives R	
19.40 — 20.00				Calling all Teachers R	
22.30 — 22.50			Calling all Teachers R		

First Term : 1st October — 23rd November, 1973.
Second Term : 21st January — 15th March, 1974.
Third Term : 29th April — 21st June, 1974.

R = Repeat broadcast.

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MINISTRY OF EDUCATION - SCHOOLS BROADCASTING UNIT

Time - Table 1981/82

Time	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
09.05 09.25	Lets join In	Eng. Literature Forms 4 & 5(R)	Lets Join In (R)	SOCIAL STUDIES (PRIMARY)(R)	Lets Join In (R)
09.25 09.30	-	MUSICAL INTERLUDE		-	
09.30 09.50	Science (PRIMARY	Eng. Language (Upper Primary(R)	French for Junior Forms(R)	Science (PRIMARY)(R)	Social Studies (PRIMARY)(R)
09.50 09.55	-	MUSICAL INTERLUDE		-	
09.55 10.15	Eng. Language (Upper Primary)	Social Studies (PRIMARY)	Science (PRIMARY)(R)	French for Junior Forms(R)	Eng. Language (Upper Prim. R.
		AFTERNOON BROADCAST			
16.00 16.20	Eng. Literature Forms 4 & 5	French for Junior Forms(R)	Eng. Language (Upper Primary)(R)	Social Studies (PRIMARY)(R)	Eng. Literature Forms 4&5 (R)
16.20 16.40	French for Junior Forms	Eng. Language (Upper Prim.(R)	Social Studies (PRIMARY)(R)	Eng. Literature Forms 4 & 5 (R)	Science (PRIMARY)(R)

FOCUS ON TEACHER EDUCATION: is broadcast each Sundays at 16.00 and repeated on Mondays at 19.45

(R) = Repeat Broadcast

BROADCASTING TERMS:

1st Term: 5th October, 1981 - 27th November, 1981
2nd Term: 25th January, 1982 - 19th March, 1982
3rd Term: 3rd May, 1982 - 25th June, 1982

SERIES

Lets Join In - Nursery & Infants
Social Studies-Primary
Science - Primary
Eng. Language -Upper Primary
Eng. Literature- Forms 4 & 5
French - Junior Forms.

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APPENDIX C

Materials Related to Science Education in Botswana

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DEPARTMENT OF
CURRICULUM DEVELOPMENT
AND
EVALUATION
BOTSWANA
Ministry of Education

PRIMARY SCIENCE SYLLABUS

1982 DRAFT

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F O R E W O R D

Seldom does one get the opportunity to participate in the transformation of voiced suggestions into the reality of classroom activity. It has been my good fortune to have been involved in the development of the Primary School Science Syllabus since its earliest days and to have seen its evolution from the words:

> "Children could, with profit, spread less of their time being made to sit still and to listen, and spend more time sitting down to write things or draw things or make things. ..... Teachers might well accept, as an alternative to the purveying of information, a duty to give to children the ability and taste and the means to acquire their own information and by discussion assess it."

These views were reported by the Primary Curriculum Task Force to the National Commission on Education (1977). They became the guiding foundation for the Primary School Science Panel of the Department of Curriculum Development and Evaluation when they set out to produce a more timely and appropriate course of study in primary school science. As a result, we are now able to present a draft version of the Primary School Science Syllabus for teachers to use and evaluate through their classroom activity.

The syllabus was designed to help teachers make decisions about what to teach in science lessons and know to teach it. Though the knowledge component is exceedingly important, the syllabus emphasizes more the techniques, or approaches, to be used in helping children gain this knowledge. Teachers are encouraged to permit their pupils to seek first-hand, concrete experiences in the real world. Questions are to be answered and problems solved through the efforts of the pupils themselves both in the classroom and outdoors. In this type of science learning, teachers tell less and guide more to aid the pupil's search for answers to questions which rose from earlier teacher devised experiences.

The Primary School Science Syllabus is only a beginning. The development of more detailed teacher's guides and pupil science materials for every Standard will continue. Already, Standard I, II and III teacher's guides are undergoing evaluation in trial schools throughout the nation. Soon the materials will be ready for broader distribution. In the meantime, all teachers will find this syllabus to be a useful guide to planning instruction in science.

I highly commend the efforts of the Primary School Science Panel members and urge all primary

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school teachers to avail themselves of the opportunity provided by this syllabus.

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3) develop the ability to express themselves clearly in a scientific manner which would include using a logical order, using scientific terms appropriately, and using relevant illustrations;

4) find out information for themselves by observation and investigation while using the teacher's assistance in drawing conclusions;

5) gather knowledge which will enable them to understand science concepts likely to be met in everyday life;

6) develop skills in using simple scientific apparatus such as rulers, thermometers, etc.;

7) express awareness of the involvement of science in other school subjects and everyday life;

8) express awareness of science contribution to the social and economic life of the community.

These objectives should be the foundation for all that you do in science. They describe the overall aims for your pupils and, for you, the teacher, a measure for selecting activities and evaluating achievement.

In the syllabus, you will find specific objectives for each topic. Read these carefully and see how they relate to our eight basic objectives. The specific objectives will be attained when the topic activities have been conducted with your pupils. The basic objectives should be attained as a result of the total science experiences gained in Standard One through Standard Seven. For now, you will want to concentrate on the specific objectives associated with each topic.

Activities in Science Learning

"Getting started" in teaching science has been a problem for most teachers. The syllabus was designed to help you overcome this old problem by suggesting activities that you might carry out with pupils.

Of course, these are not the only things that can be done. You may be able to devise others that suit your school situation even better. Feel free to improvise in procedure, materials and evaluation whenever you wish.

The major concern is to make sure that pupils are physically and mentally involved in the science activity. Pupils must be encouraged to touch, smell, listen and examine in every way, the world about them. They should compare their findings, look for meaningful relationships and differences, and record what they find. As the guide to these kinds of experiences, you must provide ample time for children to tell you, and one another, what they have discovered. If possible, display the pupils records of observations in a prominent part of the room.

Maybe you will want to develop a "Science Corner". A table in the corner of the classroom where student findings are displayed can be a device which strongly motivates pupils toward science. Let the pupils make posters for the background of the science corner. Keep the displays changing. To add to the variety, you may wish to set up a puzzling situation, or a problem, for the pupils to ponder and solve at the table.

Don't forget that in teaching science, you have a "classroom without walls". The whole outdoors is your laboratory. Take the students out often to conduct their investigations and to see for themselves the wonders of the world.

It is important to remember that science learning, like most learning, is accomplished by doing. Encourage your pupils to participate by selecting activities that involve you least. Do not spend much time telling your pupils; let them find out for themselves through careful observation, measurement and classification. Make sure that every pupil has a part to play in making the activity a success. If it is not possible to have each pupil perform the activity, select the smallest groups possible to ensure greater involvement of individual pupils in the learning experience.

Finally, we should recognize that teachers need not have a science background to help pupils participate in science. Teachers and pupils can learn together. No one knows <u>all</u> the answers. Therefore, a mutual spirit of exploration and adventure should fill your classroom. Science time should become a time for finding out, for combining efforts without the usual classroom barriers.

It is hoped that this brief introduction will orient you toward the task of helping children learn more about their world and how to live in it. Your role is an important one, for, as planner, guide and evaluator, you provide young children with a sound foundation for good citizenship.

STANDARD ONE SYLLABUS

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
WEATHER	To develop the skills of observation and recording.	Observing and recording weather throughout the year. Recording weather using symbols.	The weather can be sunny, rainy, windy or cloudy.	Learn to dress according to weather.
SEASONS	To develop the skills of observation and to make children aware that there are two main seasons.	Observing, describing and recording activities carried out at different times of the year.	There are two seasons. A cold winter (which is dry) and a hot summer (which could be wet or dry).	Know how to dress during the cold dry winter and the hot dry and hot wet summer. Know when to do certain activities e.g. ploughing, harvesting, etc.
WATER	To make children aware of the different water sources in their communities. Children should know the importance of keeping water clean at its source and at home.	Visiting water sources, observing and recording activities and discussing. Carrying out a simple purification process - filtering muddy water using cloth or paper.	We get water from different water sources e.g. dam, tap, river, etc. We need to keep our water clean all the time.	Children will know where to collect water for home use. They will also know how to keep water clean at the water source and at home.
SOUND	To develop the skill of observation using the sense of hearing.	Producing sounds using locally available materials imitating		

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
		sounds. Constructing simple musical instruments.	Noting the variety of sounds that exist in the environment.	Producing Sounds; imitating and recognising various sounds from the environment.
ANIMALS (a) Dipholo-golo	To introduce names and simple classification of Dipholo-golo.	Observing common domestic animals. Nature walks to observe animals in their natural environment. Discussing and recording.	Usefulness and harmfulness of domestic and wild animals.	Taking care of domestic animals and knowing names of common domestic and wild animals.
(b) Ditshidi-nyana	To introduce simple classification by comparison.	Collecting and sorting Ditshidinyana. Observing and discussing and recording.	Usefulness and harmfulness of common Ditshidinyana.	A child will know names of the common Ditshidinyana and recognise the differences between them.
PLANTS	To make children aware of the uses of different plant parts, through the skills of observation, comparing, recording and communication.	Observing, collecting, comparing, recording and discussing different plant parts.	Different plant parts can be of great help to man.	Knowing when and where to find plant parts.

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
SOIL	To know that soils differ. To make children aware of the different uses of soils found in their vicinity.	Observing, collecting, and modelling or playing with soil. Discussing and recording observations.	Soils are different. Different types of soil have different uses.	Knowing which soil to use for modelling, plastering, building, etc.
CARE OF THE BODY	Children learn that they should keep themselves and their surroundings clean, and that they should develop good eating habits.	Demonstrations, discussion and daily inspection of children by the teacher.	Good eating habits. Simple first aid rules.	Appreciate the need for tidiness, know basic first aid, and be aware of good feeding habits.
COMMUNICABLE DISEASES	To make children aware of precautionary steps to be taken against communicable diseases.	Daily inspection by the teacher. Discuss precautionary steps to be taken against communicable diseases such as scabies, ringworm, common cold, etc.	Dirty habits can promote spread of communicable diseases.	Children will be able to take precautionary steps against communicable diseases.

STANDARD TWO SYLLABUS

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
WEATHER	To develop skills of observation and recording.	Observing daily weather changes and recording observations on charts using more symbols.	Weather changes daily. These changes bring about Seasons.	Learning to dress according to weather.
SEASONS	To develop basic skills e.g. observation, etc., and link weather with seasons and seasons with months of the year	Observing daily weather changes, making monthly recordings of hot or cold days.	Months of the year are related to seasons. Different activities are carried out at different times of the year.	Know how to dress during hot or cold seasons. Know when to do certain activities e.g. ploughing, harvesting, etc.
WATER	To develop practical awareness of parts of the water cycle and the importance of keeping water clean.	Carrying out activities related to water:- evaporation and water collection. Cleaning and purifying water by boiling and filtering.	Water comes from rain. Water evaporates. Water can be cleaned or purified.	Drying washing by evaporation. Building dams for water collection. Drinking and using safe water.

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
SOUND	To develop the sense of hearing and awareness of sounds in the environment and their sources. To make pupils aware that the ear receives sound.	Activities whereby children have to produce, listen for and observe the source of different sounds.	Producing sounds. Different objects produce different sounds.	Ability to listen to sounds in the environment.
ANIMALS				
a) Insects	To start the classification of animals.	Collection, observation and discussion of live specimens. Recording observations made.	Insects are a group of animals that have 6 legs.	Distinguishing insects from other small creatures.
b) Domestic animals	To know that domestic animals are useful to man. How to look after animals.	Observation of a live domestic animal. Recording of observations made.	Domestic animals are of help to man. How they should be cared for so that they continue to be of use.	Stating how animals found at home, at the lands and at the cattle post are helpful.
c) Birds	To make the children aware of what birds look like, where they are found, and their habits.	Visiting places where birds are found. Observing their appearance and their nests. Children record what they have observed.	An awareness that birds have feathers over their bodies and that they live in nests.	Appreciation and respect for wild life through conservation.

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
PLANTS	To show that different parts of a plant have various uses. Some are used as food others as dyes or medicine.	Collection, observation and experimenting using the parts of plants - crushing, boiling, etc.	Different parts of certain types of plants are of use to man for medicine, food, and dyeing clothes etc.	Carrying out practical work, collecting, experimenting and relating their findings to how these plant parts are still put to use in some areas in Botswana.
SOIL	To know that the enrichment of soil improves plant growth.	Comparative study of growth in soil which has been enriched and soil which has not been enriched.	Soil is a better medium of growth if enriched with manure or fertilizer.	Relating experiments to the children's experience in the school garden or at the lands.
CARE OF THE BODY	To continue teaching aspects of personal cleanliness. Make pupils aware of safety rules at home, on roads and in playgrounds, and the importance of reporting accidents.	Discuss daily habits - washing hands, feet, face, toilet training, keeping nails clean and short, keeping hair, eyes, ears clean, brushing teeth. Use of personal handkerchief (demonstrating and practising)	Formation of healthy habits.	Observation of healthy habits and daily training through related activities.
		Discussing and demonstrating safety rules at home and in playgrounds.	Knowledge of safety rules.	Observation of safety rules on roads and in the playground.

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TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
COMMUNICABLE DISEASES	Children will be able to take precautionary steps against communicable diseases.	Discuss precautionary steps against communicable diseases, including immunisation.	Awareness of precautionary steps to be taken against communicable diseases.	Visit the clinic. Role play.
NUTRITION	To teach the importance of foods for the well-being of the child and stressing breakfast as an essential meal of the day.	Discuss the variety of food, stressing locally available wild foods. Demonstrations and practising.	Awareness of the (i) need of sufficient quantity and variety of foods. (ii) Need for eating locally available wild food. (iii) Need for a good breakfast.	Avoiding eating non-nutritious foods like bubble-gum. The need for eating breakfast daily.

STANDARD THREE SYLLABUS

TOPIC	REASONS	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
WEATHER	Children will observe, describe and record prevailing weather conditions. Investigating the movement of air and the direction in which the air blows.	Doing simple experiments to show the direction of the wind .. to be included with general daily weather recordings.	A daily record of the weather throughout the year - also knowledge that (a) wind is the movement of air (b) wind blows from different directions at different times.	Making daily use of class chart or calendar, the children fill in symbols in the appropriate spaces. Children will be able to record weather using symbols already learned in Stds. I and II.
SEASONS	1. To relate the weather recordings made in Std.II to seasonal activities. 2. To observe plant and animal life during the various seasons.	1. Talking about stages of growth i.e. seeding; leafing and blooming of flowers. 2. Drawing of animals that are prevalent during a certain season.	1. Seasonal changes affect plant and animal life. 2. Knowledge of activities done in different seasons, related to the "seasons" chart kept from Standard 2.	Looking at the stages of growth of plants and what sort of animals are seen at certain times of the year.

TOPIC	REASONS	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
WATER	To develop in children a knowledge of the value of water.	Discussion, observations, recordings, painting, drawing and modelling on the daily uses of water. Demonstration and practice by the children on the uses and conservation of water.	1. Water should be conserved as it is used daily by all people. 2. Water should be kept clean to prevent contamination.	Using water.
SOUND	Continued development of skills of observation through the sense of hearing.	Using their immediate environment, the children should be able to identify the sources of sounds and the effect of distance on sound (volume).	Different objects produce different sounds and these sounds diminish in volume with distance.	Awareness of sounds in the environment.
ANIMALS a) Insects	Using a fly (which is a readily available common insect) it can be shown why some animals are classified as insects. To discuss the harmfulness and usefulness of a variety of insects so that the students can protect	Reinforcing knowledge of what an insect is, through the study of a FLY. Looking at its life history and establishing whether it is a useful or harmful animal by observing its life-style.	The fact that certain animals are insects because they have 6 legs. How to take advantage of useful insects and to avoid those which are harmful.	Identification of useful and harmful insects

TOPIC	REASONS	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
	themselves against harmful insects and benefit from the usefulness of others.			
b) Birds	To continue the classification of animals. Birds are animals which at some stage in their lives have feathers.	Observation, discussion, drawing, modelling etc. after "nature walks" and study of live specimens.	The children will know that animals that have feathers are birds.	Identification of birds.
c) Wildlife	The children must have an awareness of the wildlife of their own country and of the importance of nature conservation.	Discussion, storytelling, drawing, tracing and collage work.	An appreciation of the wildlife of the country.	Conservation and appreciation of wildlife.
PLANTS	Plants are made up of roots, stems, leaves, and flowers.	Collection of different plants and study of their form. Comparison of different plants, to show their similarities. Drawing painting etc.	Plants are made up of the same parts (i.e. roots, stems, leaves, and flowers).	Growing and harvesting plants at the lands, in the garden, or at school, for decoration and food.

TOPIC	REASONS	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
SOIL	To find out how soil is formed by examining the component parts of the soil.	Discussion of and experimentation with the different ways in which soil is formed.	How soil is formed.	Proper use of soil in gardens and at the lands. Prevention of soil erosion.
CARE OF THE BODY	To continue teaching every aspect of personal cleanliness and safety rules so that children will be able to form healthy habits.	Repeat discussion of all the aspects of body care introduced in Standards I and II. Discuss new items of daily habits - Proper clothing, reading habits. Demonstrate and make children practise.	Knowledge and formation of healthy habits. Knowledge of safety rules and formation of habits observing them.	Observation of healthy habits and appreciation of those habits. Helping junior students to appreciate health habits. Observation of safety rules in school, road and playground. Helping junior students to observe safety rules. Prompt reporting of any accidents.
COMMUNICABLE DISEASES	To continue teaching precautions against named childhood communicable diseases.	Continue discussion of the precautions (including immunization) against communicable diseases of childhood.	Knowledge of childhood communicable diseases and of precautions to be taken against them.	Observation of precautionary steps taken.

TOPIC	REASONS	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
NUTRITION: a) Eating porridge for breakfast	To show the children how to prepare simple breakfast.	-Reinforcing the importance of breakfast for good learning in school. -Discussion of the reasons why some children do not have breakfast and what they can do about it. -Preparation of a simple breakfast(e.g. soft porridge) by the pupils.	Children will be aware of the importance of breakfast and will be able to prepare their own breakfast (soft porridge).	Children will prepare soft porridge (or any other simple food) for breakfast when it cannot be prepared by other members of the family.
b) The building of a mud-stove	Owing to a shortage of firewood for cooking, children will learn how to build a mud stove, which is a fuel-saving device.	Discussion of the types of fuel used for cooking, their cost, and possible shortages. Building of a mud-stove on the school premises (preparation of mud bricks and building of the stove).	-Low-cost technology exists to overcome some nutrition problems (e.g. mudstove) -Mudstoves use less firewood (to protect the environment and conserve it for future generations).	Children will build a mud stove on the school premises, to enable them to build a mudstove at their homes /lands etc.

TOPIC	REASONS	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
SANITATION	To provide elementary knowledge about toilets	Discuss different types of toilets available to the community and inspect some of them.	Identification of different types of toilets	Appreciation of the proper use of toilet and of the need for the one tiolet per house. Steps taken to protect food from dust and insects.
	To teach about food hygiene.	Discuss and carry out activities to demonstrate ways of protecting food from dust and insects.	Knowledge of the proper handling of foods and ways of protecting food from,dust and insects.	

STANDARD FOUR SYLLABUS

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
WEATHER	To help children learn about the direction of the wind.	1) Introduction of cardinal points. 2) Construction of wind rose. 3) Construction of simple wind vane. 4) Recording weather daily.	Know the direction from which the wind blows.	Know more about weather.
SEASONS	1) To show children all the effects of seasonal changes by the position of the sun. 2) Direct sun rays are more powerful than rays falling at an angle.	1) Measuring shadow length at noon every day of the year. 2) Experimenting with direct light rays and rays falling at an angle. Experimenting with lenses. (Force of heat).	The appearance of the sun at different positions on the sky at different times of the year brings about the different seasons. (Winter and Summer).	Know seasons and their effects on length of day and night.
WATER	Introduce all the parts of the process involved in the water cycle.	Evaporating water and condensing it.	Children will know what evaporation and condensation are.	Boiling water in a kettle, allowing the steam to condense. Drying of clothes or wet objects.

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
SOUND	Children will know that sounds are produced by vibrations.	Experimenting with musical instruments, knives, metal strips, rubber bands, drinking straws and bottles to produce sound by:- i) blowing ii) plucking iii) beating	How sound is produced.	Playing musical instruments.
ANIMALS	To develop in children respect for animals and the ability to identify and classify mammals and birds.	Observing mammals around their homes and discussing their similarities and differences - observing, describing and discussing domestic birds.	Characteristics of animals. Usefulness of birds.	Observing and classifying animals and being able to generalise from their observations
PLANTS	1) Children will know that plants are living things. 2) The conditions necessary for the germination of seeds.	Experimenting with seeds:- 1) Investigating conditions for germination. 2) Types of seed dispersal.	A plant is a living thing. Seeds germinate, seeds can be dispersed,	Knowing when, where and how to start a vegetable garden.

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
SOIL	Children will observe the effects of soil erosion.	Discuss and experiment with the different factors which cause soil erosion - wind, water and animals.	Water, wind, and animals can cause soil erosion.	Observation of cattle trek routes; improper watering of pot plants or gardens with a hose pipe or watering can.
CARE OF THE BODY	Grooming and posture To make the pupil aware of the importance of grooming and good posture in different situations.	-Explain and demonstrate ways and means of grooming. -Describe and demonstrate proper sitting and walking posture and the proper ways of lifting and carrying heavy objects.	Children will be aware of:- -grooming -good posture -proper ways of lifting and carrying heavy objects.	Children will:- -groom themselves daily -sit and walk properly -lift and carry heavy objects properly.
COMMUNICABLE DISEASES	To provide knowledge about germs as carriers of communicable diseases. To provide knowledge of transmission of diseases.	Explain what pathogenic and non-pathogenic germs are. Illustrate how the germs transmit diseases.	A child will be ableto differentiate pathogenic from non-pathogenic germs and to describe the transmission of diseases.	Children will take precautionary measures.
NUTRITION i) The usefulness of	To make the children aware of the useful-	-Illustration of body-building foods:	A child will be aware of the different functions	-children will observe people who need body-

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TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
NUTRITION				
different types of foods in Botswana.	ness of different types of food according to their function in the body.	bricks to build a house. -Illustration of energy foods; diesel oil for tractors. -Illustration of protective foods: lock to keep the house safe.	Children will be aware of the different functions of food in the body: -body-building -energy-giving -protective.	-children will observe people who need body-building foods and discuss why they need them. -children will relate their need for energy foods to their activities. -children will classify foods according to their usefulness in the body.
ii) Three meals a day for a school-age child.	To make the children aware of the importance of three meals a day to maintain good health.	-Discussion of the children's eating habits -Discussion of the food needs of a school-age child -Children will write health menus which can be easily prepared and which every one can afford -Preparation and cooking of some balanced meals on the mudstove	-A school-age child needs three meals a day if he wants to be healthy and bright. -A balanced healthy meal is a mixture of the three food groups.	-Children will write daily menus for themselves. -Children will cook some balanced meals on the mudstove.

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TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
SANITATION	Waste disposal To provide knowledge and skills for proper disposal of waste products.	Describe and demonstrate the various ways of proper disposal of waste products.	A child will have knowledge, attitudes and skill for proper waste disposal.	Children will have dispose of waste products properly.
HUMAN BODY	To revise the names of external parts of the human body and impart awareness of its main systems.	Name the external parts of the body. Name and describe general purpose of body systems-skeletal, digestive circulatory, respiratory, nervous and excretory.	Children will be able name the general purposes of body systems.	Children will use correct terminology.

STANDARD FIVE SYLLABUS

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
WEATHER AND SEASONS	Children will measure accurately the amount of water in a container Making and using a rain-gauge. Relating rainfall to seasons i.e. most rain falls during summer.	Measuring water with rulers. Using variously shaped containers. Making a rain-gauge. Recording weather daily. Observing at which particular season of the year rain falls, i.e. summer.	Ability to measure accurately the water in a rain-gauge. Rain falls at a particular season of the year i.e. summer.	Ability to make and record accurate measurements.
WATER	The children will have an understanding of the Water Cycle.	Experimentation with evaporation, condensation and collection.	The child will know the Water Cycle.	Relate to weather recordings and collection of rain water for home consumption.
SOUND	Children will have an understanding of why sounds are different and of how they can be controlled.	Experimenting with vibrating strings of different length and thickness, hitting objects e.g. tins, consisting of different materials like wood, metals.	Vibrating objects produce different notes - some low; others high. How sound can be controlled.	Playing and constructing musical instruments e.g. guitars.

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
ANIMALS	1) Children will know the different uses of a cow and its parts. 2) Children will be able to identify a fish by observing external features.	Looking at a fish and studying its appearance. (Where possible) Observing a cow and discussing what it gives us and its uses in the community and in Botswana.	Characteristics of a cow and a Fish. Usefulness of mammals, particularly cows.	Identifying the cow as source of meat, milk, labour, fertilizer etc.
PLANTS	Children will find out that flowers, fruits and seeds appear at different stages in the life-cycle of a plant. To help children find out the effects of sunlight, water, and different kinds of soils on plant growth.	1) Growing plants from seeds - observing each stage of growth, noting when flowers, fruits and seeds appear. 2) Sowing seeds in different types of soil, giving each varying amounts of water, placing them in different degrees of light, observing their growth, and discussing the differences.	1) Life cycle of seed-bearing plants. 2) Plants need sunlight, water and nutrients to grow.	1) Knowing when to make use of different parts of the plant. 2) Knowing what sort of conditions are best for plant growth in fields or gardens.

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
SOIL	Children will know the various causes of soil erosion and ways of limiting or preventing erosion.	Experimenting and demonstrating how wind, water and animal erosion could be controlled by planting, keeping surfaces wet, making wind breakers, contour ploughing, etc.	Causes and control of soil erosion.	Conservation of soil through the control of soil erosion.
LIGHT	Children will be made aware of sources of light and know that light travels in straight lines. Children will know how light can be controlled for the benefit of man.	SOURCES OF LIGHT Children suggest and classify the different sources of lights e.g. man-made and natural sources.	Children should know the difference between man-made and natural sources of light.	Using candles and torches; fire-making.
		HOW LIGHT TRAVELS Experimenting.	Light travels in straight lines.	Identifying the positions of objects.
		SHADOWS Children observe shadows outside and do experiments producing shadows.	Objects cast shadows when exposed to light.	Making a shadow clock.
		MIRRORS Children play games using mirrors e.g. looking at themselves trying to write their	Shiny surfaces reflect light.	Everyday uses of mirrors.

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGED GAINED	DAILY APPLICATION
		names using mirrors etc. They use different surfaces to observe the reflection. FUN WITH LIGHT Children experiment with 1) flicker pictures 2) colour-wheels etc.		
HEAT	Awareness of uses of heat in the home; effects of heating things; expansion and contraction of liquids and gases.	1) Activities using different sources of heat (friction, sun and fire). 2) Expanding and Contracting liquids and gases by heating and cooling.	a) How heat is produced b) Uses of fire c) Expansion of heated air and liquids.	Effective heating of the home.
ELECTRICITY & MAGNETISM	Children will know about simple electric circuits. Children will be able to control the flow of electricity.	ELECTRICITY Making Simple Circuits Children try to light a bulb by making a simple circuit.	How a simple electric circuit is made.	Understanding how a torch works and how electricity travels.

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TOPIC	REASONS	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
		Conductors & Insulators Playing with the circuit to see which things will allow the bulb to light.	Not all objects allow electricity to flow through them.	Safety measures in the home.
CARE OF THE BODY	Personal care of the Body To provide knowledge and skill for personal care of the skin hair, feet, eyes, ears, teeth, etc.	Describe why it is important to care for the skin, hair, feet, eyes, ears, nose and teeth and explain how to care for them.	Children will be able to explain the importance of caring for those parts of the body and ways and means of caring for them.	Children appreciate care for those parts of the body and observe schedules and habits of proper and regular care
	SAFETY To provide knowledge and skill in preventing falls, accidents to cyclists or pedestrians, etc.	Explain and illustrate where and why people fall or become involved in traffic accidents. Demonstrate and simulate falls and accidents.	Children will be able to identify places where accidents involving falls and cyclists are likily to occur and develop skill in preventing them.	Children observe safety rules, viz safe walking cycling, cautions and skilled climbing.
COMMUNICABLE DISEASES & PERSONAL HYGIENE	Worm infestation To provide knowledge about the different kinds of worm infestations.	Discuss and illustrate worm infestations:- hookworm, roundworm, tapeworm. Exhibits samples of worms.	Children will know about different kinds of worm infestations. They will be able to discuss the effects of environments on living organisms.	Children will take precautionary measures and mantain sanitary habits viz, proper waist disposal, hand washing, avoiding exposed and dirty foods, etc.

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
NUTRITION Checking your younger brothers and sisters as to whether they are growing well.	-To show the children how to use the weight chart (road to health chart) to check whether or not their younger brothers and sisters are growing well.	-Discussion of whether or not mothers bring their young brothers and sisters to the clinic: how often? why? etc. -Discussion of how to find out whether a child is growing properly -Weighing exercises of under five children using a simple scale -Exercise with the weight chart: record age and weight and explain the growth curve of a healthy child.	-We can measure a child's growth by measuring his weight -When a child is growing well, his weight increases every month.	Children will check the growth of their young brothers and sisters (under five)to see whether they are growing well.
What happens when a child does not grow well.	-To make the children aware of the importance of the weight chart to help detect under five children who are not growing well. -To discuss the problems that may occur to an underweight child.	-Discussion of the importance of the weight chart to detect underweight children (or the thickness chart) -Exercise with the weight chart using the growth curve of an underweight child (below the road to health) -Children will visit	-An underweight child does not grow well if malnourished. -Underweight children can only be found by weighing them. -Underweight children become ill more easily -Underweight children do not grow up as clever as they should be.	Children will work with the Village Health Committee in order to help find all the underweight children in their community and explain the dangers that may occur to underweight children.

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TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
		their neighbors to check the growth chart of all the under five in order to find all the underweight children in their community. -Discussion of the problems that may occur to an underweight child	-Underweight children do not grow up as strong and tall as they would have if they had been well nourished.	
SANITATION	Waste disposal To make children aware of individual and communal responsibilities for proper waste disposal.	List and discuss individual and community responsibility for proper waste disposal and organise field trips to observe these and interview health inspectors.	Children will be able to differentiate individual from communal responsibilities.	Children appreciate and carry out their individual and community responsibilities They help junior students in these matters.
HUMAN BODY	Digestive system To provide knowledge about major parts and functions of the digestive system.	Describe with illustrations the major parts and functions of the digestive system.	Children will be able to name and identify the major part and functions of the digestive system.	

STANDARD SIX SYLLABUS

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
WEATHER AND SEASONS	Children will know about evaporation, speed of wind and how to build an anemometer, and to measure the frequency and force of wind at certain times of the year.	Relating evaporation results to the effects of weather. Construction of an anemometer. Recording weather daily, using an anemometer and instruments constructed in the previous classes.	How to measure factors which change weather.	Ability to measure and record weather factors.
WATER	Children will have a practical knowledge of the properties of water (expansion and contraction).	Experiments with bottles corks, straws (reeds), and water.	Water expands when heated and contracts when cooled.	Pots should not be filled to capacity before the contents are heated.
SOUND	Children will be aware that they are able to hear sound because sound can travel through solids, liquids and gases.	Experiments showing how sound travels through liquids, solids and gases.	Sound travels through solids, liquids and gases.	Knowing the effects of the states of matter on sound. On wet days sounds are clearer.
ANIMALS	Children will take a closer look at some common reptiles and amphibians.	Collecting and observing frogs - studying the frogs in their natural habitat.	Characteristics of amphibians and reptiles (frog and lizard).	Ability to observe, classify and generalize.

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
	Children will learn about the 1) feeding habits of a frog and a lizard 2) appearance and growth of frogs and lizards.	Nature walks to observe common lizards.		
PLANTS	Children (i) will know the effects of manure and fertilizers on plant growth, and (ii) that crop rotation helps soil conservation.	Growing plants on plots that have been treated with (i) manure (ii) fertilizer. Observing effects of crop rotation in the school garden.	Plants growth can be improved by (i) manuring (ii) fertilizing (iii) crop rotation (iv) control of soil erosion.	Adding manure to their garden plots and practising crop rotation.
SOIL	Children will know how soil could be improved by the use of fertilizers, manure.	Growing seeds in soil with manure, and soil with no manure and comparing observations. Making a compost heap (Std.3 work).	Fertilizers and manure can improve the nutrient level of the soil.	Using kraal manure and artificial fertilizer in vegetable gardens and fields.

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TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
LIGHT	Children will be aware of how light behaves. Children will realize how light can be controlled for the benefit of man.	HOW LIGHT IS REFLECTED Children do experiments which will show them the way in which light is reflected.	Light can be reflected.	Uses of car mirrors and ordinary mirrors.
		BENDING OF LIGHT (REFRACTION) Children do experiments to see what happens when light passes from:- e.g. air to water or from air to glass. Suggested experiments: 1) Bend ruler in water. 2) Bending light using a torch and a bottle or a prism. 3) The appearing coin.	When light travels from air to glass or water, it changes its direction.	Fishing in water.
		LENS: Children do experiments to discover what happens when light passes through a lens and find out what lenses could be used for e.g. 1) making fires 2) making things look	Light and heat can be concentrated by using a lens. A lens can be used to enlarge things (magnify)	Understanding how the eye, camera, binoculars, spectacles etc. work.

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
		bigger 3) improving pin-hole cameras. **Absorption of light** An experiment to show that when light hits a dark surface, it is turned into heat, whereas, when light hits a light or shiny object, it is reflected. **Colour and Light** Children split sunlight into the colours of the rainbow by experimenting.	Light can be obsorbed and turned into heat. Light is a mixture of different colours of the rainbow.	Using solar power. Dressing according to weather - dull colours for winter and light colours hor summer.
HEAT	Children will know the skin is sensitive to temperature but that the thermometer can give us a more accurate measure of temperature 2) that heat can travel from one end of a certain object to the other end (conduction) 3) that heat can move	**Our sense of temperature** a) Simple experiments using a thermometer to show that mercury rises and falls. b) How to read a thermometer. c) How heat travels through objects -	Children will be able to detect temperature using their senses and using the thermometer, reading and recording.	Reading and recording body temperature and the temperature of the air.

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
	when warm air or water moves (convection). 4) how to retain heat by using various insulators e.g. black and woollen clothes..	conduction and convection. d) How heat is retained through use of insulators e.g. black and woollen clothes.		
ELECTRICITY AND MAGNETISM	Children will be aware of the relation between electricity and magnetism. 1) Children will know how a piece of iron can be magnetised. 2) that magnets can attract some objects and cannot attract others. 3) that magnets have poles. (N and S). 4) a compass needle also rests pointing North and South.	Making a simple electro-magnet. Making a Permanent Magnet Stroking a piece of iron with a magnet. Properties of Magnets Have assorted objects e.g. wood, metal, iron paper, etc. Test with magnets. Magnetic Poles Suspend a magnetized needle. It will rest pointing north and south. Compass Magnetize a razorblade and let it float on water.	Children will be aware that electricity can cause an iron object to have magnetic power. A piece of iron can be magnetised by a magnet. Magnets will always attract metallic objects (magnetic objects). Awareness of the two poles of a magnet. That a magnet points north and south.	Make simple electric magnets. Use bar magnets to make a simple compass. Reading a compass.

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TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
CARE OF THE BODY	To provide knowledge about poisoning and fire accidents and simple first aid.	Illustrate substances which are poisonous. Discuss how to prevent poisoning. Discuss and demonstrate first aid treatment for minor cuts, bruises, burns and poisoning and precautions against fire accidents.	Children will be able to name the substances which are poisonous and prevent poisoning, give simple first aid, and take precautions against fire accidents.	Children will take action to prevent poisoning and fire accidents and to administer simple first aid if needed.
COMMUNICABLE DISEASE	To teach about tuberculosis, measles, and schistomiasis(bilharziasis).	Explain the cause and symptons of T.B. and how it can be prevented and cured. Discuss the problems of T.B. in the community. Interview a clinic staff-member.	Children will be aware of T.B. as a preventable and curable disease and of its prevalence in community.	Children will observe correct healthy behaviour related to preventing T.B.
NUTRITION What must you do with underweight children?	To teach the children what they should do when they find an underweight child.	-Discussion of what school children should do with underweight pre-school children: -refer them to the VHC -bring them to the clinic -make sure they receive more food	-Underweight children should receive more food. -Their mothers should bring them to the clinic every week or every day when the child is very thin. -Direct feeding is a	Children will assist the VHC in pre-school children defaulters, particularly in tracing underweight children.

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
		-follow them up during and after their treatment -Pupils will continue checking the growth chart of the young children in their community and refer any underweight children to the VHC.	special programme for underweight children.	
Feeding a pre-school child including the importance of breast-feeding.	To show the students how they feed a pre-school child in order to keep him healthy and prevent him from being malnourished.	-Children will ask their parents how they feed their young brothers and sisters. -Discussion of how to feed a pre-school child emphasizing the importance of breast milk. -Preparation of a simple weaning food (e.g. porridge, ground-nut paste and green leaves) by the pupils. -Reinforcing the importance of body-building foods for normal growth.	-Food needs for a young child. -A young child should eat 4 to 5 times a day -Importance of breast-feeding. -Importance of adding body-building foods to the weaning foods -How to prepare weaning foods with body-building foods.	Children will assist their parents in food preparation for their young brothers and sisters.

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TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
HUMAN BODY	To provide knowledge about the respiratory system.	Describe and illustrate the purpose of the respiratory system, major structures and their functions, and the breathing process.	Children will be able to describe the respiratory system.	Children will use correct terminology.
NARCOTICS	To teach about the dangers of smoking and alcohol.	Discuss the immediate and long-range effects of smoking. Role play on how people start smoking and drinking.	Children will be aware of the dangers of smoking and alcohol drinking.	Children will avoid smoking and drinking.

STANDARD SEVEN SYLLABUS

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
WEATHER	A childwill use instruments to make accurate records of rainfall, wind speed and temperature.	Recording weather using constructed weather instruments and thermometers.	Ability to record weather accurately.	Use of weather recording instruments.
WATER	To show the value of water to the community and its value as a source of power.	Making water-wheels and moving small objects with water (relating to soil erosion). Discussion of the uses of water to the community.	Water can be used to do work. It moves objects and this power can be harnessed - hydraulic and hydro-electric power.	Conservation and proper use of water.
SOUND	Children should know how to take care of their ears.	Discussing and demonstrating proper ways of cleaning the ear.	The ear receives sounds.	Daily cleanliness and care of the ear.
ANIMALS	Children develop the skills of observation and classification.	Observing and classifying local animals as fish, birds, mammals, etc. Discussing feeding habits and relating them to food chains.	General classification of Animals into groups. Simplified food-chains.	To appreciate nature conservation.

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
PLANTS	Children will recognize: 1) plants as the main source of food for herbivorous animals. 2) the interdependence of living and non-living things.	Growing plants in sunlight and darkness, observing their growth. Discussing a simple food-chain. Experimenting with moulds to demonstrate decomposition.	Plants manufacture food. Simple food-chains or food-cycles.	Appreciate nature.
SOIL	To make children aware of the common problems of soil conservation in Botswana. (TGLP)	Discussing the Tribal Grazing Land Policy and identifying the common problems of soil conservation in Botswana.	The importance of conservation in Botswana.	Understanding and implementation of Tribal Grazing Land Policy.
LIGHT	Children will understand how the eye works	Experiment to show how the eye works in relation to light and to compare the pin-hole camera with the eye.	Children will know how the eye works.	Children will know how to take care of their eyes.
SIMPLE MACHINES	Children will know how work can be made easier by simple machines.	Discussion and listing of various kinds of simple machines e.g. levers, pulleys, inclined planes, wedges, gears etc.	Simple machines make work a lot easier.	Making work easier.

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
ELECTRICITY	Children will know about electrical applia-nces and how to wire a plug correctly.	Discuss electrical appliances and practise wiring a plug.	Usefulness of electricity.	Use of electrical appliances.
	Children will know dangers of electrical appliances.	Discuss the dangers of electricity and use teaching aids to show children what risks there might be.	The dangers of electricity.	Care when using electrical appliances.
CARE OF THE BODY	To make the children aware of the diseases associated with unclean-liness.	Discuss the effects of diseases associated with unclean habits on different parts e.g. skin, hair, feet, eyes, ears and teeth.	Children will be aware of diseases associated with unclean habits.	Children practise clean habits and help juniors to do the same.
COMMUNICABLE DISEASE	To teach about veneral diseases.	Explain the causes and symptoms of venereal diseases and how they can be prevented and cured. Discuss the problems of VD control in the community. Role play on VD interview with a clinic nurse.	Children will be able to describe the causes and symptoms of VD.	

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
NUTRITION 1) Feeding a family properly on the lands and in villages	To teach the children how to feed a family properly on the lands and in villages.	-Children will make a list of foods available 1) at the lands and 2) in the villages -Groups of pupils will plan a balanced meal for a family 1) at the lands, and 2) in the villages -Demonstration of food preservation techniques and preservation of nutrients -Preparation of a balanced meal planned by each group of pupils -Discussion of the food needs of the different members of the family -Discussion of how to increase and improve food production.	-How to choose healthy foods competible with the family budget (food budgeting) -How to preserve food at home (sun-drying, salting, fermenting, smoking How to preserve nutrients , -How to prepare a healthy balanced meal (cooking methods, hygiene, etc) Optimum distribution of food among members of the family -How to increase and improve food production in order to improve nutrition (gardens, etc.)	Children will plan and prepare healthy food for their family whenever they are at the villages.
SANITATION	To provide knowledge about water contamination and elementary knowledge of water-	Review the various sources of water. Describe and illustrate various sources	Children will be able to identify various sources of water and explain ways in which	Children will avoid contaminating water and avoid using contaminated water. Help and

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TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
	borne diseases.	of water. Explain with illustrations how water becomes contaminated. Name water-borne diseases prevalent in Botswana. Interview with a health inspector. Demonstrate and practise aerosol preparation.	water becomes contaminated. Students will be able to name water-borne diseases. Students will be able to prepare aerosol.	motivate juniors and friends to adopt these good habits.
HUMAN BODY	To provide knowledge and understanding about the human reproductory system.	Explain the purpose and illustrate the major parts of the reproductory system and describe their functions. Discuss secondary sexual characteristics (male and female) breast, pubic hair, etc.	Children will have knowledge about reproductory system and secondary sexual characteristics as normal and natural growth.	
FAMILY LIFE	To make the children aware of puberty, pregnancy, childcare and spacing of pregnancies.	Explain puberty and the physical emotional and social changes that it involves. Describe the menstrual cycle with illustrations. Describe conception and	Children will have know-ledge about puberty, the menstrual cycle, preganancy, and their problems and possible solutions.	Children will take human growth and development as normal and natural processes. They will avoid any act likely to cause them bodily, moral, or social harm.

TOPIC	REASON	APPROACH AND ACTIVITY	KNOWLEDGE GAINED	DAILY APPLICATION
		Discuss health, social and emotional aspects of pregnancy. Discuss consequences of irresponsible sex with particular emphasis on early preganancy, unwanted pregnancy, and VD. Discuss how to avoid early and unwanted pregnancies.		

MINISTRY OF EDUCATION

DEPARTMENT OF SCHOOL CURRICULUM AND EVALUATION

SCHOOLS' BROADCASTING UNIT

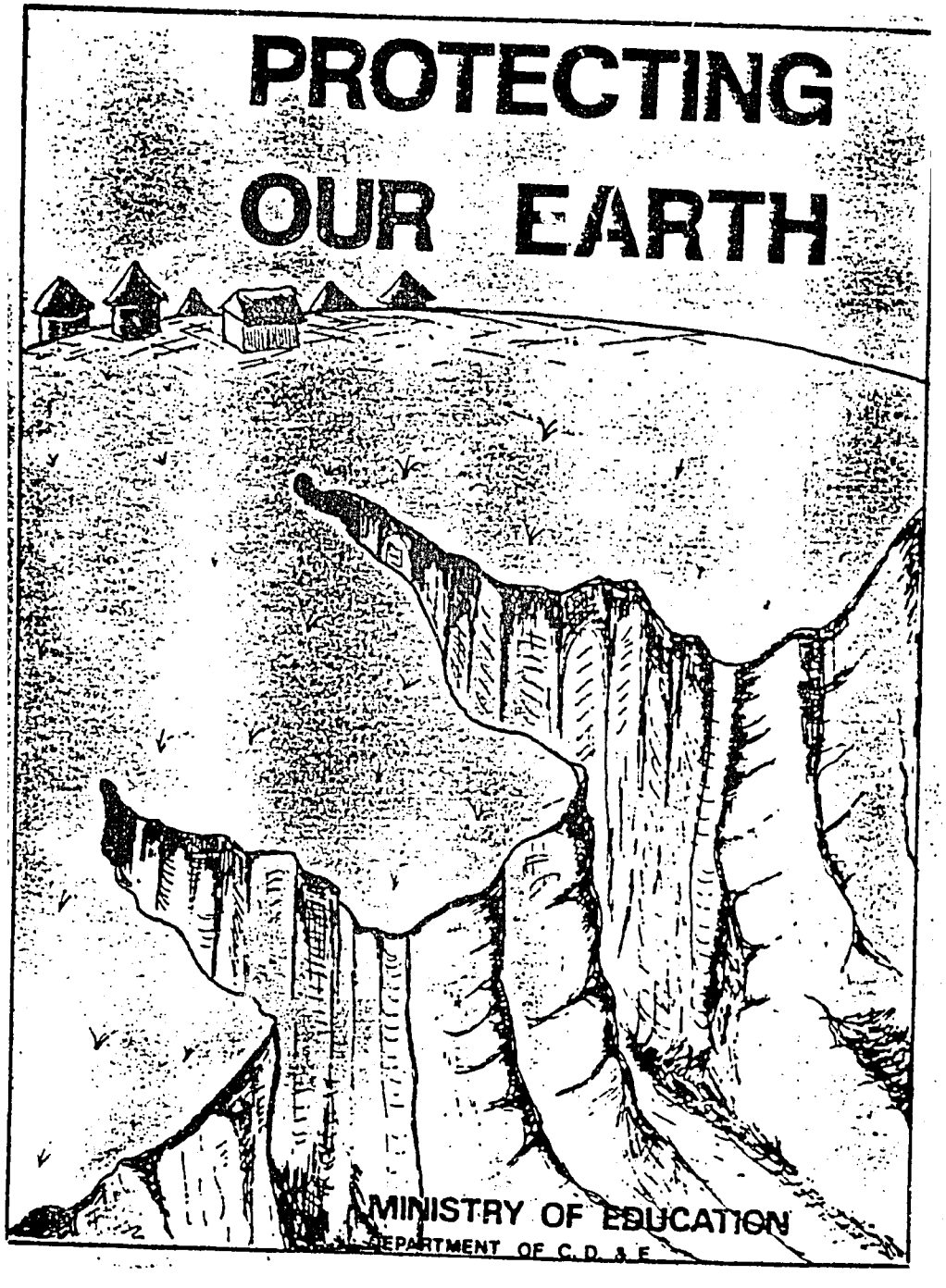
1982 3rd TERM TIMETABLE 13th SEPTEMBER-20th NOVEMBER

TIME	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
8.30 - 8.45	ENGLISH 2	ENGLISH 5	SOCIAL STUDIES 3	RELIGIOUS EDUCATION	RELIGIOUS EDUCATION
8.50 - 9.05	ENGLISH 3	SOCIAL STUDIES 6	SOCIAL STUDIES 7	SOCIAL STUDIES 6(R)	SCIENCE 4 (R)
9.10 - 9.25	SOCIAL STUDIES 5	STORY TIME 2&3	SOCIAL STUDIES 5(r)	ENGLISH 5(R)	ONCE UPON A TIME 6&
9.30 - 9.45	ENGLISH 7	SCIENCE 6 (R)	ENGLISH 6 (R)	SOCIAL STUDIES 4(R)	STORY TIME 4&5 (R)
9.50 - 10.00	ENGLISH 4	SCIENCE 4	ENGLISH 7 (R)	SCIENCE 5 (R)	SOCIAL STUDIES 4 (R
0.10 - 10.25	SCIENCE 6	SCIENCE 5	ENGLISH 2 (R)	SOCIAL STUDIES 3 (R)	SOCIAL STUDIES 7 (R
0.30 - 10.45	SCIENCE 7	ENGLISH 3 (R)	STORY TIME 4&5	SCIENCE 7 (R)	CURRENT AFFAIRS
0.50 - 11.00	ENGLISH 6	ONCE UPON A TIME 6&7	SCIENCE 7(R)	STORY TIME 2&3 (R)	ENGLISH 4 (R)
2.15 - 2.20		STATION	INDENT.		
2.20 - 2. 35	SOCIAL STUDIES 5	SCIENCE 4	SOCIAL STUDIES 3	SOCIAL STUDIES 4	ENGLISH 6
2.40 - 2.55	SCIENCE 6	SCIENCE 5	ENGLISH 6	SOCIAL STUDIES 6	ENGLISH 4
3.00 - 3.15	ENGLISH 2	ONCE UPON A TIME	STORY TIME	ENGLISH 5	ENGLISH 3
3.15 - 3.30	TEACHING EXAMINED		END OF THE ROAD		

(R) REPEAT

PRIMARY SCIENCE (Third Term '82) "CRASH" PROGRAMMES !

	SOUND		WATER — Floating + Sinking.				AIR.			QUIZ.
4.	LISTENING How is Sound made? Blowing, Plucking, etc	High + Low Notes. Soft and Loud.	Listening to Water. Washing + Drinking Evaporation	Evaporation (2) Dissolving	Floating (Heavy and Light.)	Sinking. (Experiments)	Wind. What we breathe. How we know it's there	Movement in air. Birds, aircraft, gliders parachutes	Air Pressure. (Tyres and Balloons.)	
	SOUND.		WATER		LIGHT.					QUIZ.
5.	Listening Game! Vibrations	Simple Scale. Variations in length of string, etc.	Rain. A guage. Evaporation	Boiling, dams and dams. How animals survive.	Sources. (Sun, electric fire, etc) Sunlight + Shadow	Reflections in water Symmetry.	Illusions - real and contrived. Mirage ~~etc~~	Rainbow. (Storm - Sun) Soil, flower leaves.	Paintings. Mixing Colours, etc	
	SOUND AND HEARING.				AIR.		WATER.			QUIZ.
6.	BIRDS. African bird song. Making, hunting, etc.	ANIMALS. 4 typical animals. How they hear.	REPTILES. Methods of hearing Experiments	INSECTS. Sounds they make.	Force of Air Pressure Slow + fast breathing	Experiments in Breathing. Oxygen.	Evaporation and Dissolving	Condensation Clouds and Steam	Gas. liquid - Solid.	
	SOUND (COMMUNICATIONS).		WATER.		LIGHT.		EYES.			QUIZ.
7.	High + Low Notes Scale	Vibration and pitch.	Humans communicate Voice / Morse	More advanced version of 4. (5+6)	Movement in Water (Shapes + stability)	Colour. Rainbow. Spectrum	Road Signs. Safety. Camouflage in animals	Basic observation and Experiment	Vision. Testing, Spectacles, Colour.	


PROTECTING
OUR EARTH
MINISTRY OF EDUCATION
DEPARTMENT OF C.D.S.E

This book was adapted from a story

Linda Pfotenhauer

Illustrated by

Mika-Mika Valente

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We get from the earth many of the things we need. The earth provides soil in which we can grow food. The earth also provides forests. These forests give us wood to use in making houses, or lighting fires for heating and cooking.

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2

The earth provides fields and plains where our cows, goats and sheep can graze.

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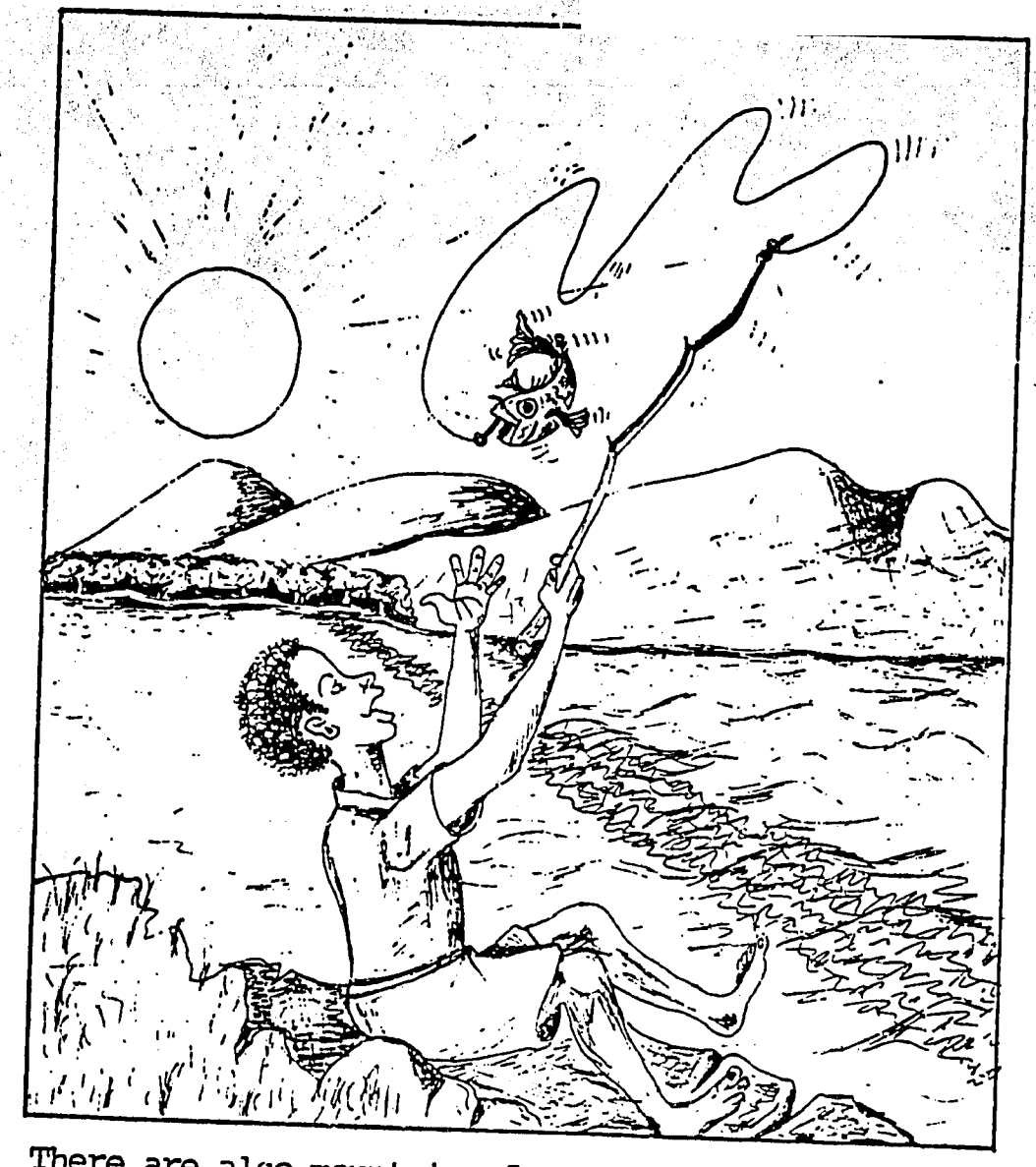

There are also mountains from which water flows down into valleys and lowlands. There are rivers, eas, and oceans where millions of fish live. Many of these fish provide food for people and animals.

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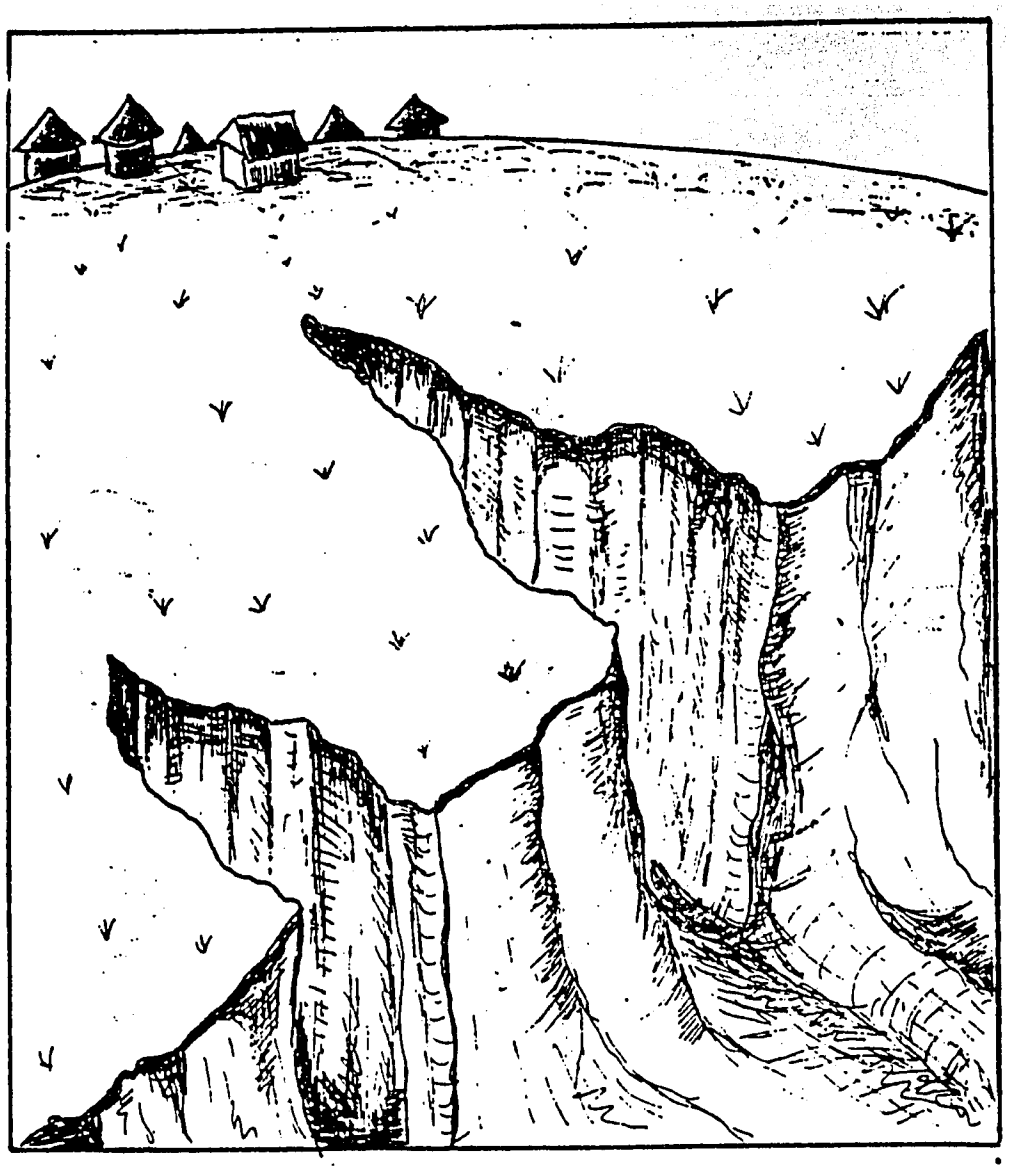
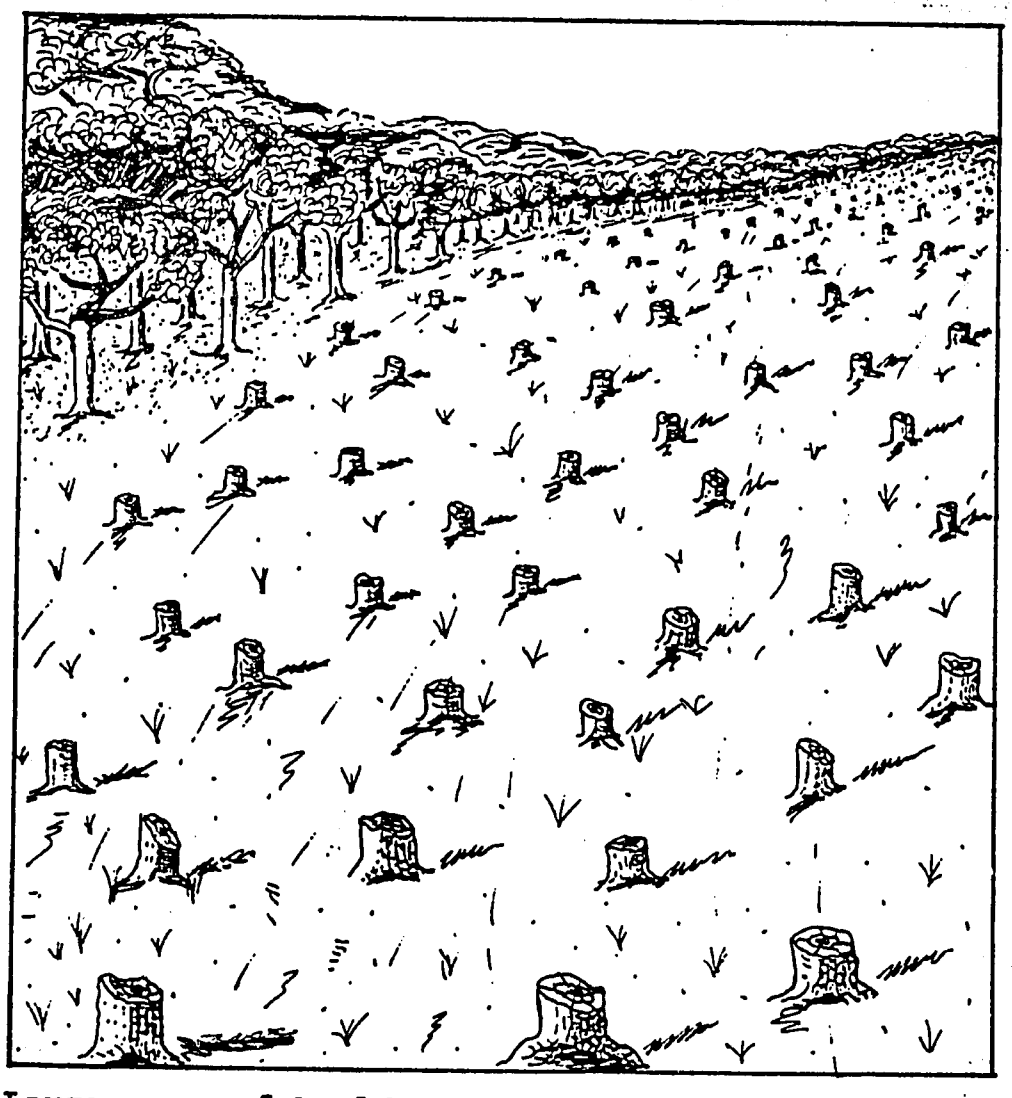


But we have not always looked after the earth well. We have not always made good use of seas, forests, and mountains. That is why we have so many problems with them today.



Large areas of land have been cleared of trees to make fields where we can plant crops.

We have cut down trees and sold them so that people can make paper, rayon, and special kinds of plastic from them. We have burnt down forests to make wild animals run away and to leave open spaces where new grass can grow as food for farm animals.

All over the world, people use wood from trees as fuel for cooking their food and heating their houses.

We have chopped down trees and burnt them. Often we have made no plans to replace them. In many places we have left the earth bare.

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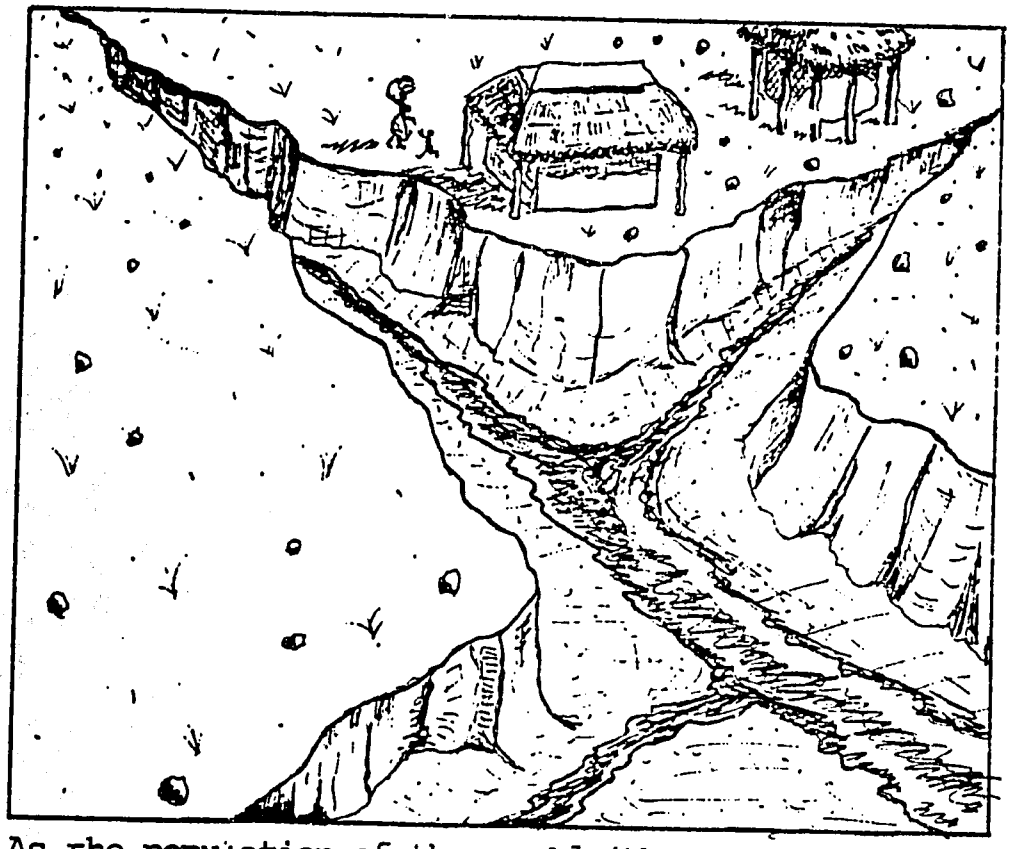

As the population of the world (the number of people in it) has got bigger, people have moved higher and higher up the slopes of hills and mountains.

They have cut and burnt trees and bushes even on the mountain-sides.

This has harmed us. There are no longer enough trees and bushes on the mountain-sides to hold the top-soil in place. Rain washes it away. Too much water runs down, and causes flooding in the valleys. On the hills, the land becomes hard, dry, and bare. No plants will grow there any more. In the valleys, river-beds become clogged with the soil which the rain has washed down.

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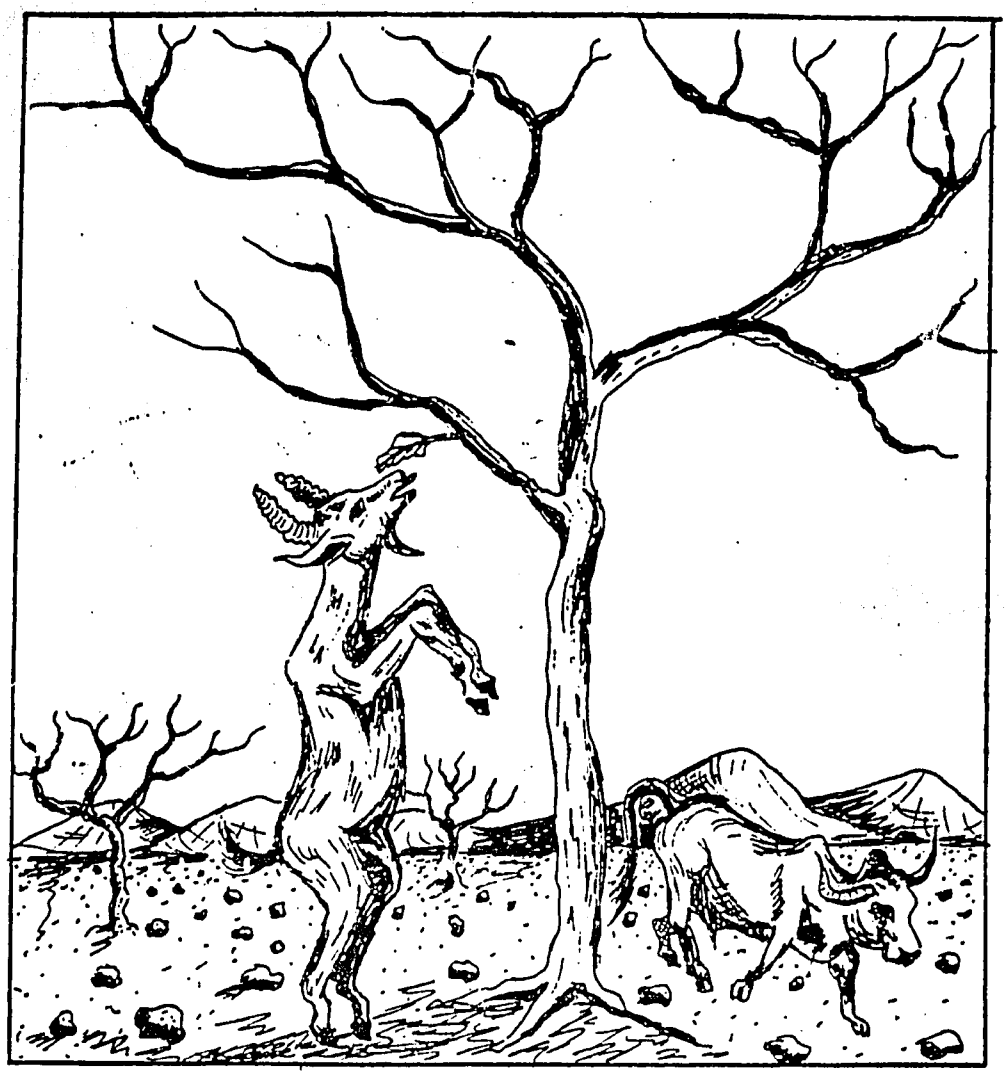
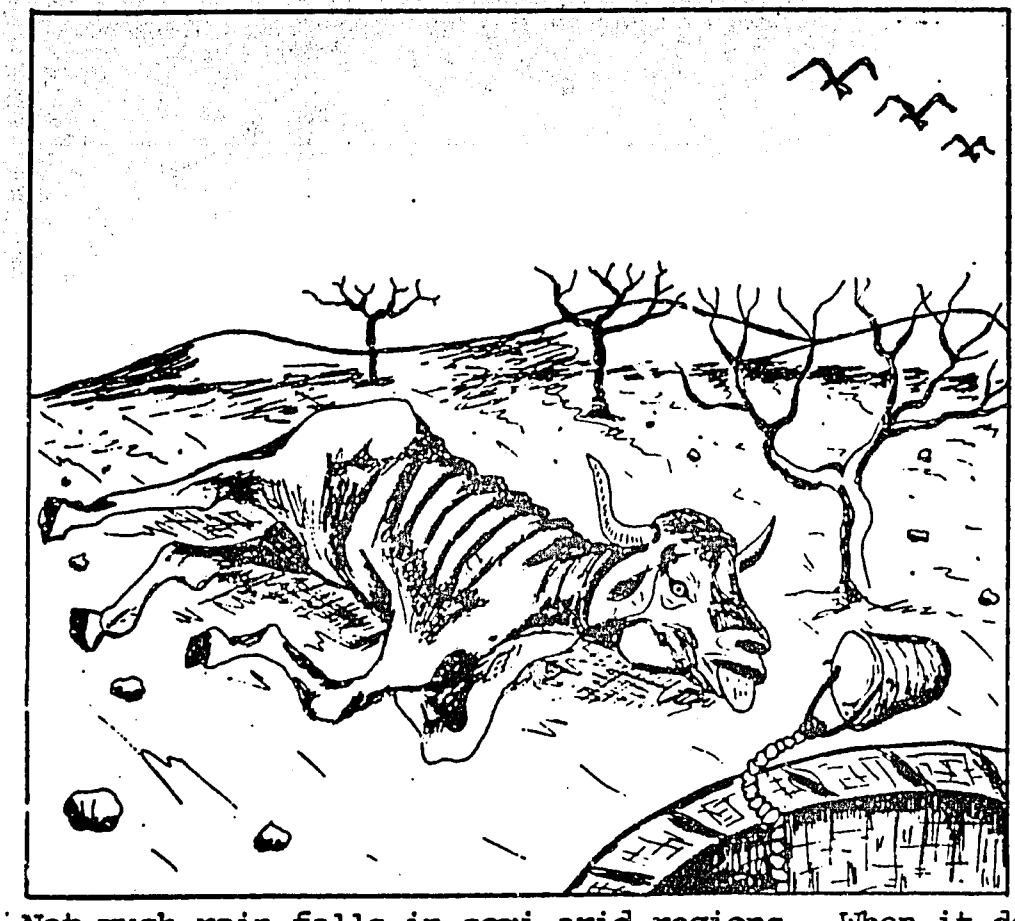


Semi-arid regions are mostly dry. Not much rain falls there, but, when it does rain, herdsmen keep too many cows, goats, and sheep. They bring too many animals to feed there. These animals eat all the grass and all the leaves. Not enough time is allowed for the leaves and grass to grow again, and the animals soon have no more food. This is overgrazing: too many grass-eating animals with not enough grass to feed them.

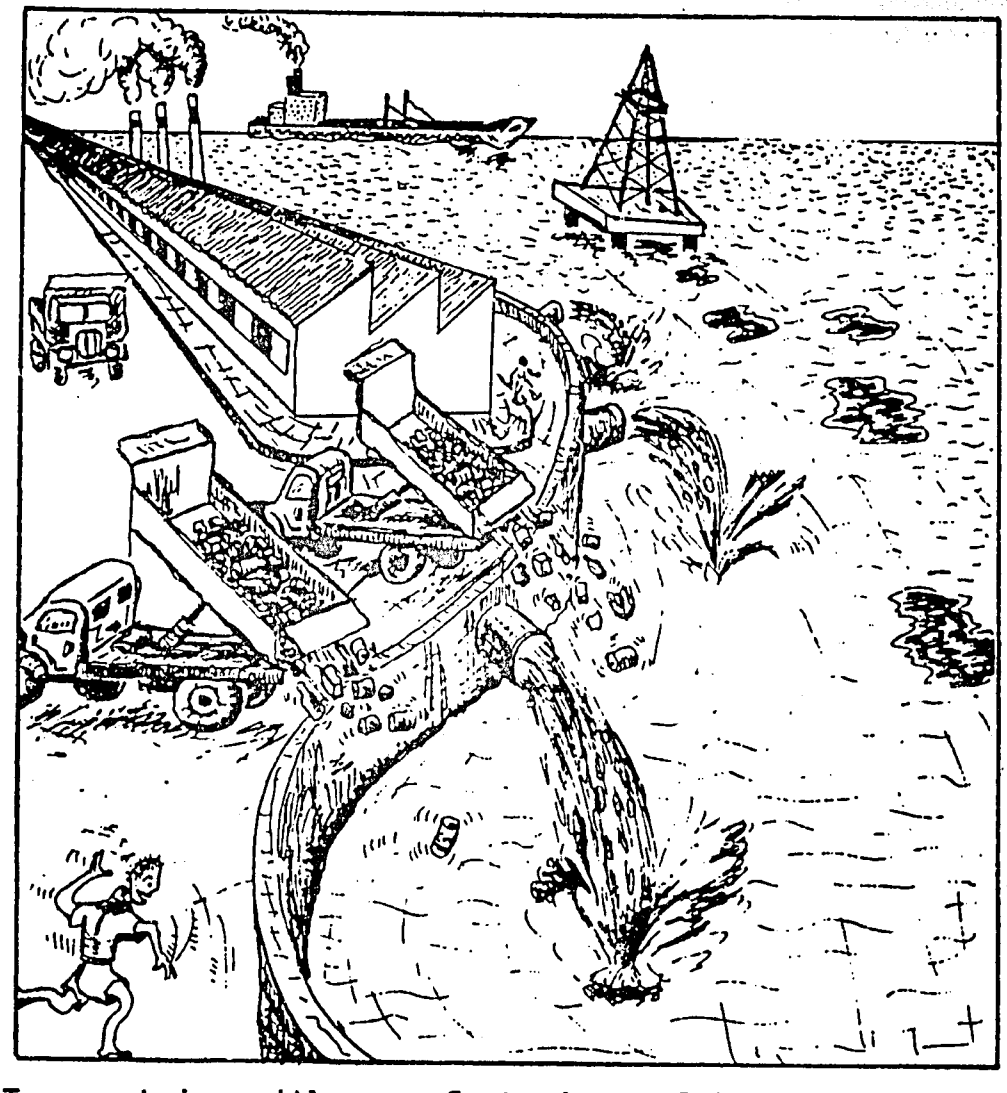
Overgrazing causes soil erosion: the soil wears away When people burn bushes and plants, cut down trees, and let too many animals eat the grass, they can make new deserts.

In many parts of Africa, we are making old deserts bigger, or producing new deserts - in the north (near the Sahara), in the west (in Chad, Mali, Mauritania, Niger, and Senegal), and in the east (in Ethiopia, the Somali Republic, and the Sudan), as well as in Botswana.



Not much rain falls in semi-arid regions. When it does fall, some farmers wrongly believe that they can keep as many animals as they want. After the rain has fallen, animals eat up every fresh blade of grass and all the leaves on trees or bushes. Without shade and moisture from plants, the earth becomes burnt and scorched. Crops can no longer take root in it. There are no longer any plants to hold the soil together. Winds can easily carry it away. Before long, sand-dunes are formed.

When no rain has fallen for several years, a new patch of desert may appear. There will then be less farm-land and less food. People and animals become ill and begin to die for lack of food and water.



In countries with many factories and industries, the land, the air that people breathe, and the water of lakes, rivers, and seas often become dirty and unhealthy.

Waste from towns and factories and unwanted chemicals are dumped into the sea or into rivers. This dirties the water, or pollutes it. It also kills fish, or makes them unfit for eating.

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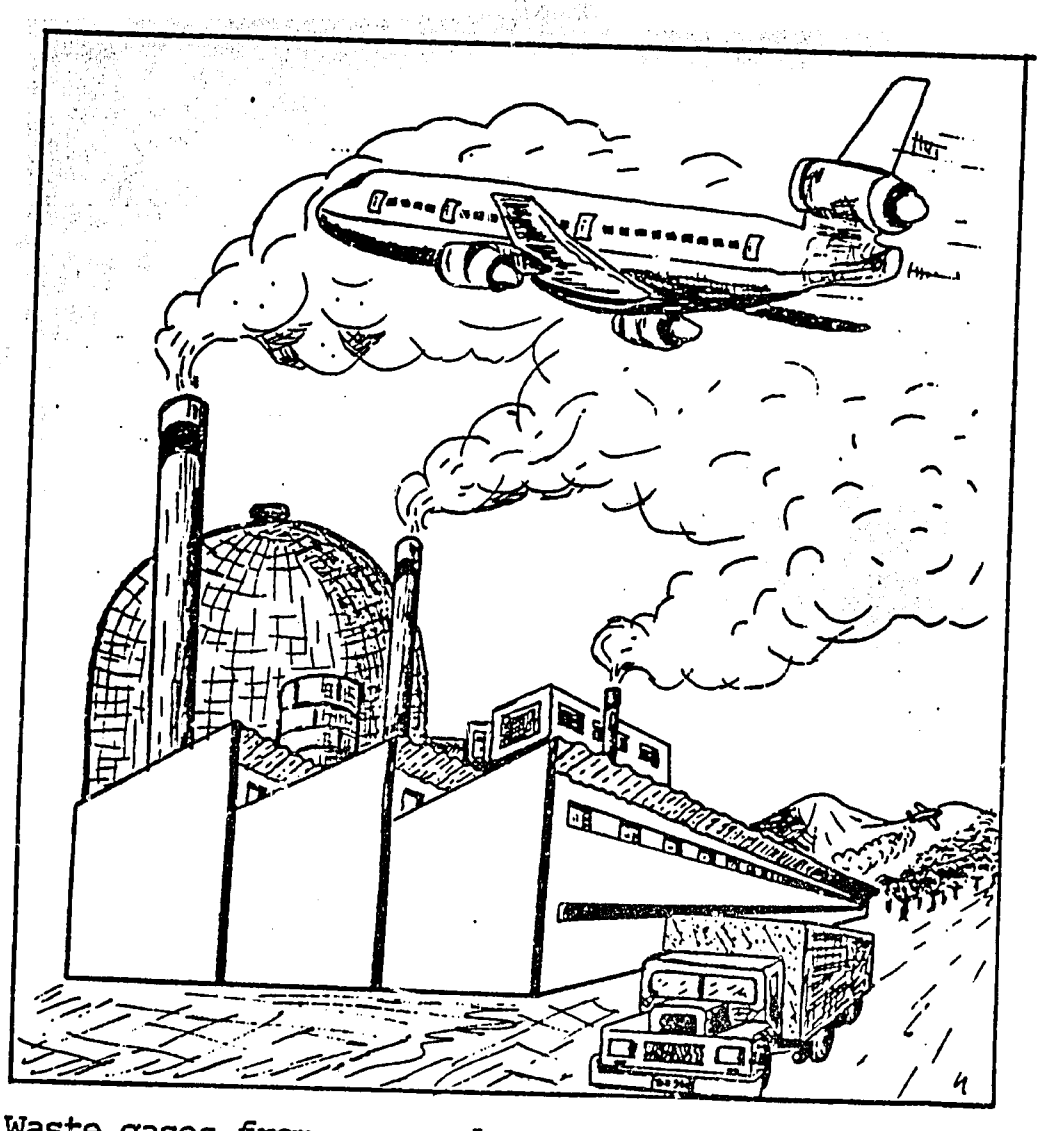


Waste gases from cars and aeroplanes, or from chemical sprays, and smoke from factories have made the air so dirty that, in some big cities, it is difficult for people to breathe.

People are poisoning or destroying the very things that keep us alive - soil, plants, rivers, oceans, mountain forests, and even the air around us.

413

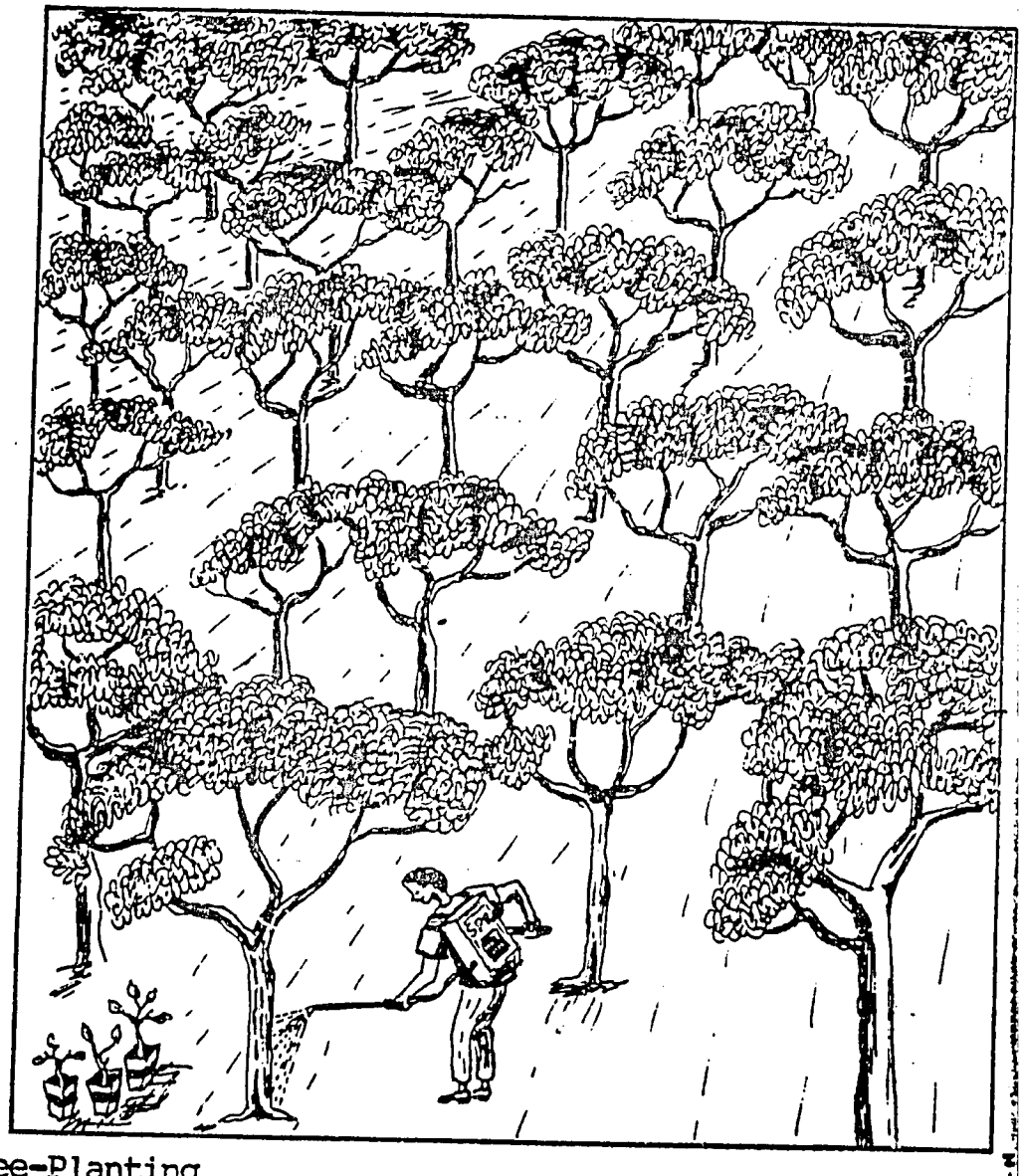
But there is still hope. There is still something we can do to save the farm-land, the forests, and the oceans of our world.

Education

All of us (grownups as well as children) must learn how to protect the earth and how to keep people from harming or destroying it. People must be shown how important it is for us to use the land wisely and well.

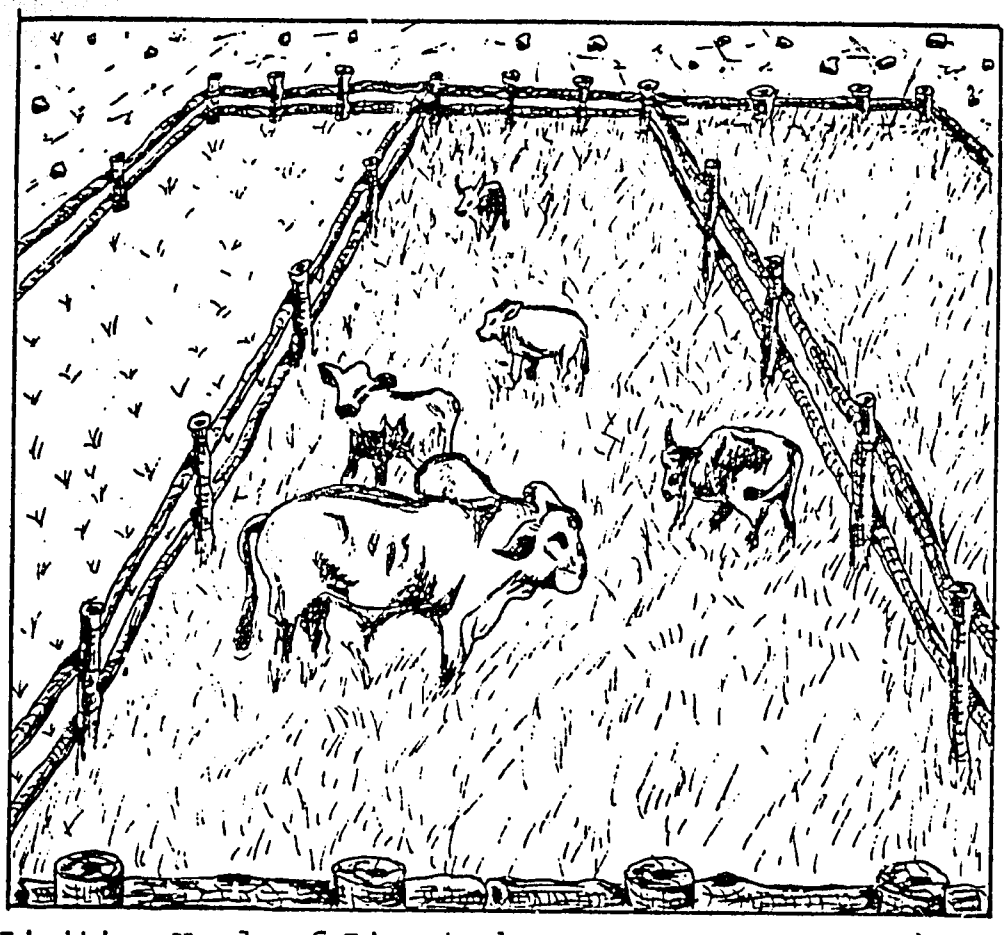
Not only schools but also village committees, government agencies, films, newspapers, magazines, and radio programmes can help to teach that lesson.

414



Tree-Planting

We need to plant a lot of trees. They can be planted on farms, on unused land, and along the sides or roads. We need to replace old forests, and to replant bushes and trees on the slopes of hills and mountains.



Limiting Herds of Livestock

We need to understand that, by keeping too many cows, goats, and sheep in one place, farmers may take the life out of the soil and make new deserts where no grass will grow.

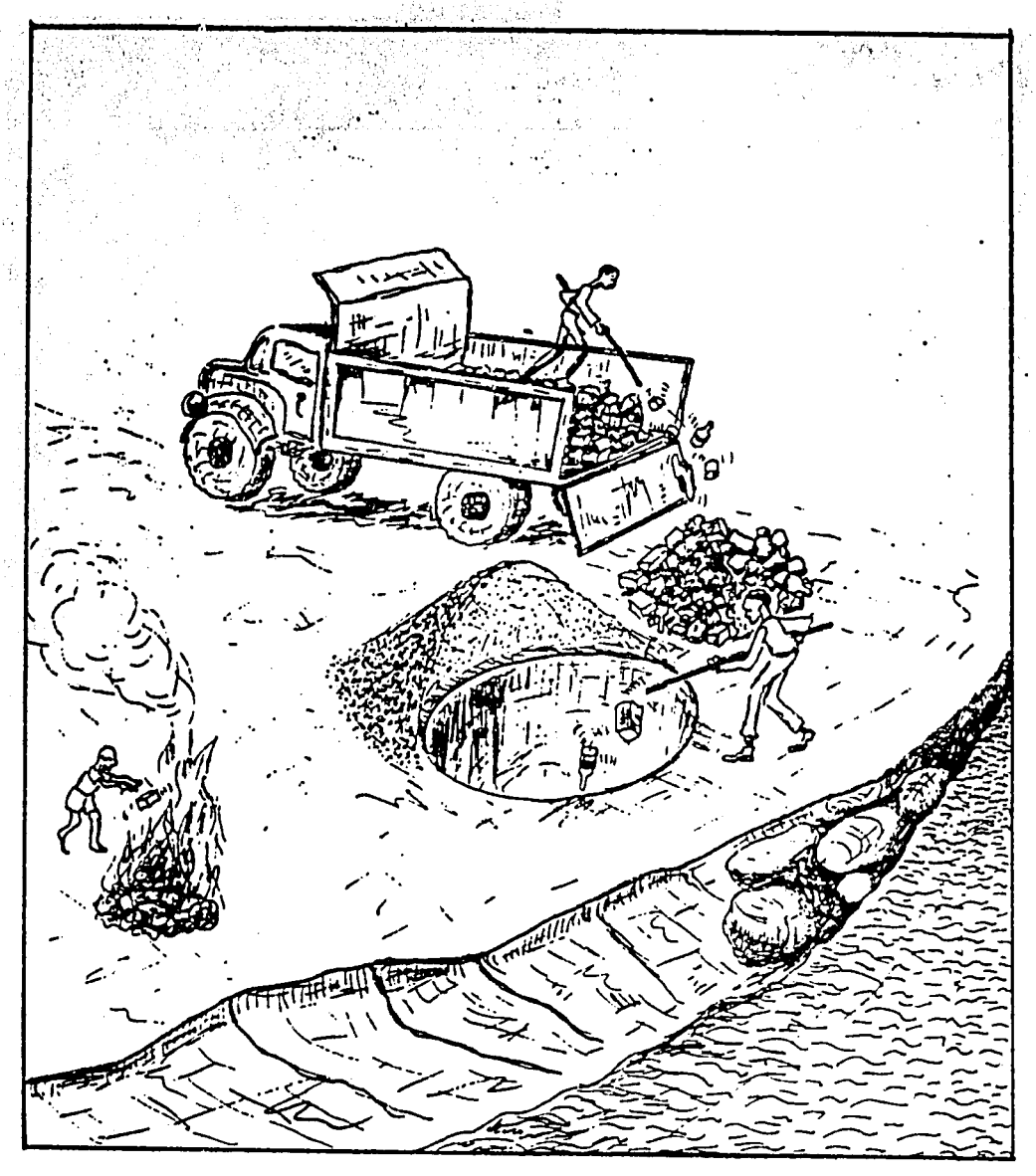
If they keep fewer animals, but better, healthier animals, they will help to save the land, so that they and other farmers will still be able to use it.

416

Improved Fanning

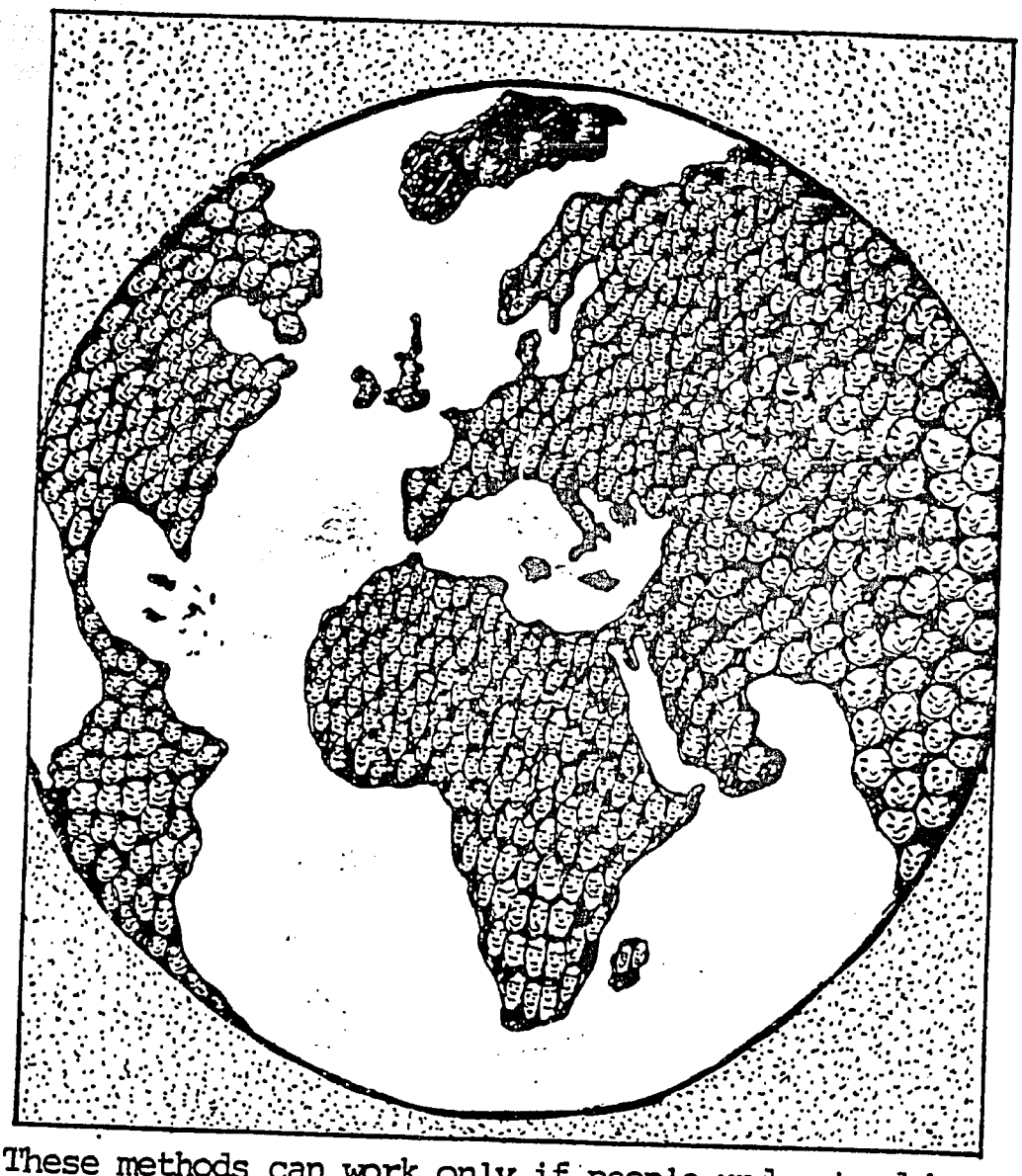
Government workers can teach better ways of farming. They can tell us and show us how to prevent soil erosion and how to make the land more fertile and productive.

47



Pollution Control

Governments and industrial companies should find ways to stop dirtying our rivers, our soil, and our air.



These methods can work only if people understand how important it is not to let the number of people on earth become too big. Overcrowding, like overgrazing, makes life much more difficult for everybody.

What can YOU do?

Talk to your friends about this book and ask them to read it.

Plant a bush or a tree.

There are many ways of giving back to our earth the clean rivers, pure air, and fertile soil it once had.

Think of things that you can do to help in protecting our earth.

420

look around in botswana

VEHICLES

OF BOTSWANA

C72

421

VEHICLES
OF BOTSWANA

No 1 in the series

look around in botswana

Text: Jan Goedhart

Illustrations: Bram Dilrosun

produced & printed by TAPU

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Ministry of Education

Department of Curriculum Development & Evaluation

C73

422

People go to many places,
far and near.
They carry heavy or light
things.

They often go on foot,
sometimes a long way.

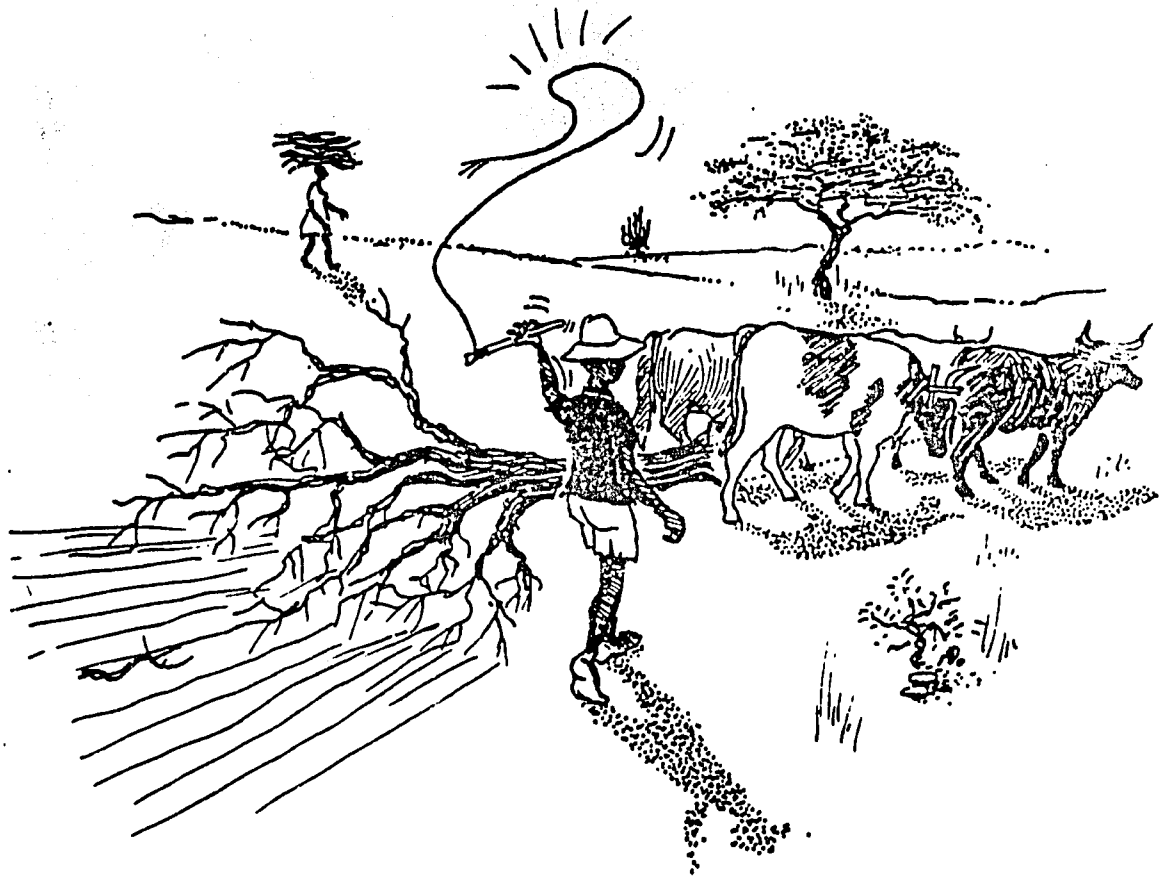
Animals or vehicles
can help people
to carry a heavy load.

They can also take people
from one place to another.

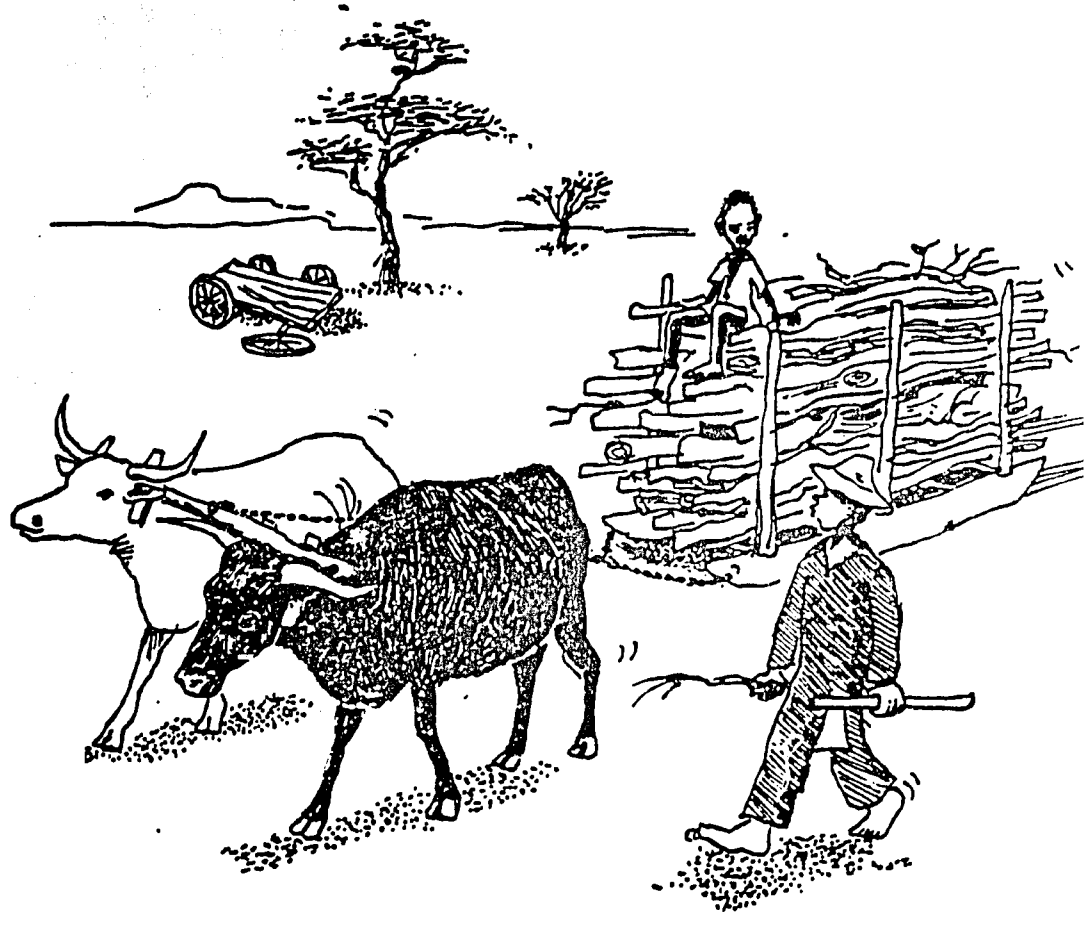
So you can walk,
you can carry things,
you can ride on a donkey,
you can drive a car.

All this is called
<u>transport.</u>

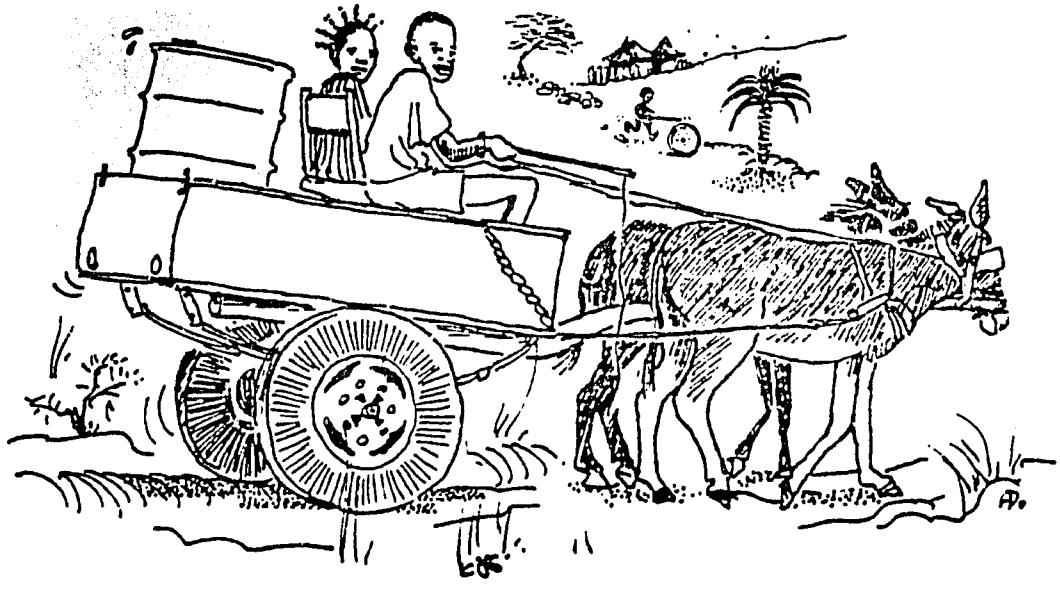
Some transport is done
without vehicles.
The woman carries firewood
on her head.
The oxen pull the tree
across the ground.



Things go easier with a sledge.
It slides across the ground.
You can put a lot of firewood on it.
And the oxen do not have to pull so hard.

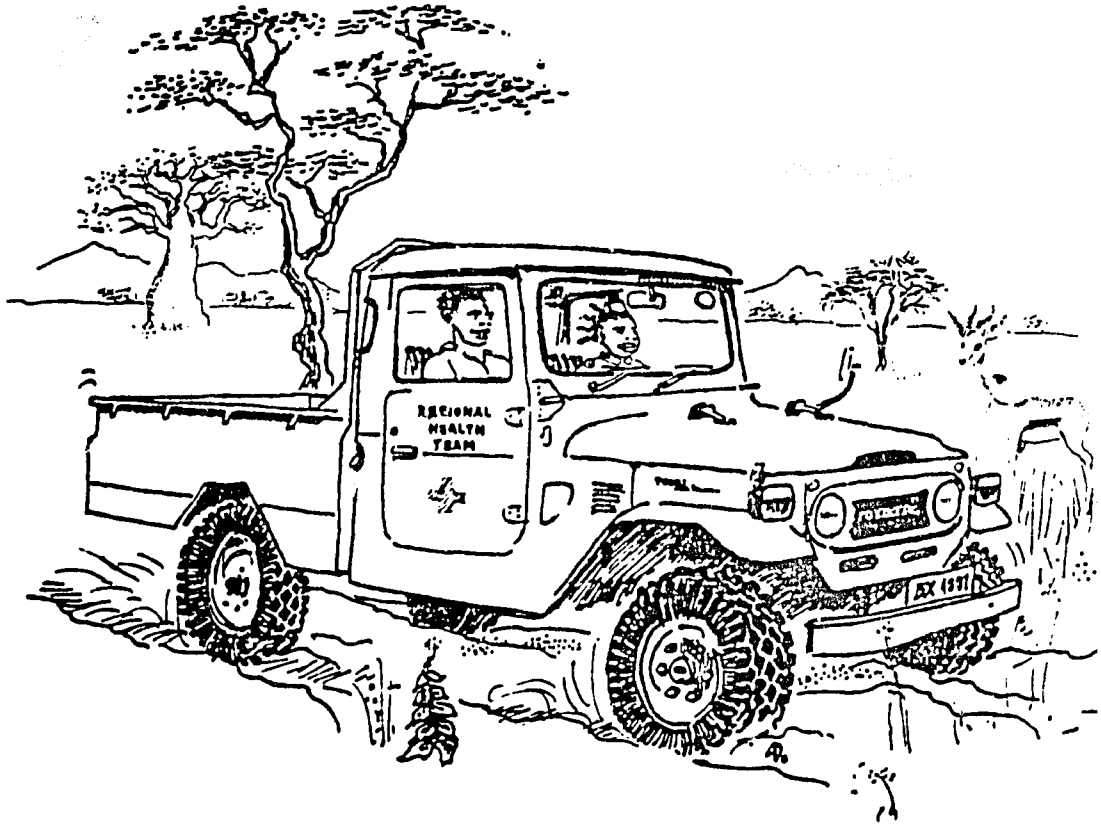


With wheels it is still easier
to transport a load.
This is a donkey cart.
The donkeys are small and slow,
but they are very tough.
They work hard
if you take good care of them.



On some roads
you need a strong car,
with four-wheel drive,
to pull you through sand and mud.

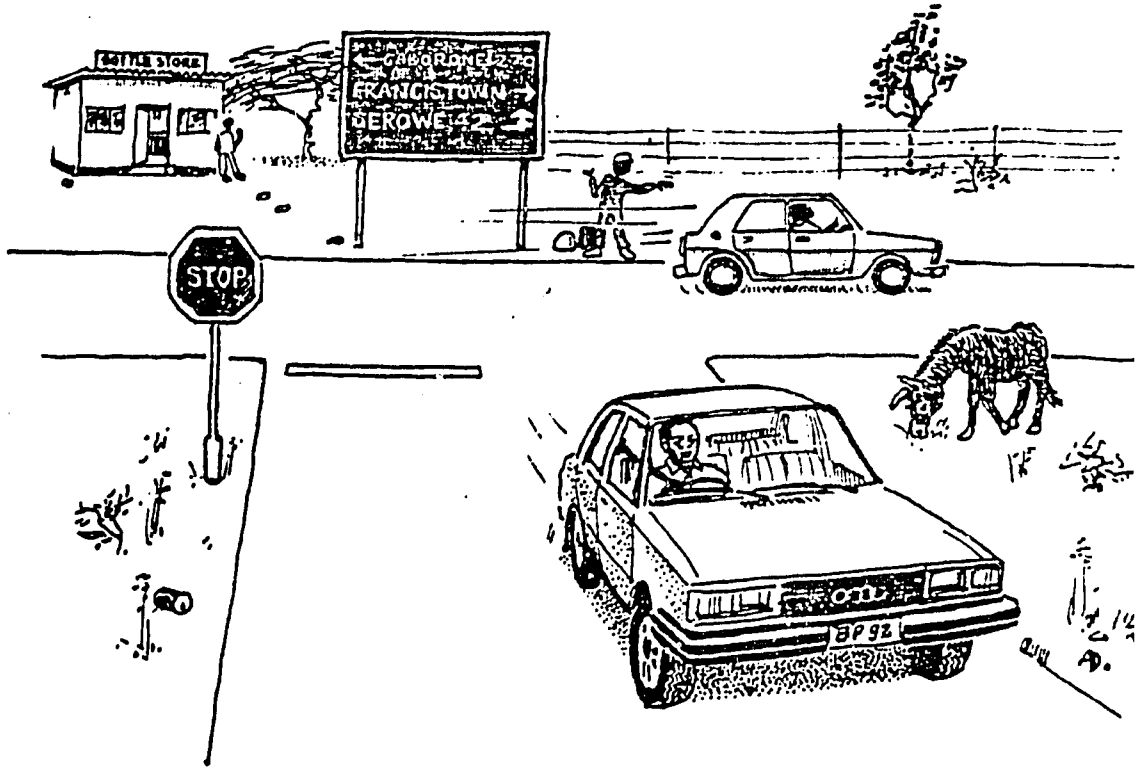
Such a car is very expensive
and it uses a lot of petrol.



421

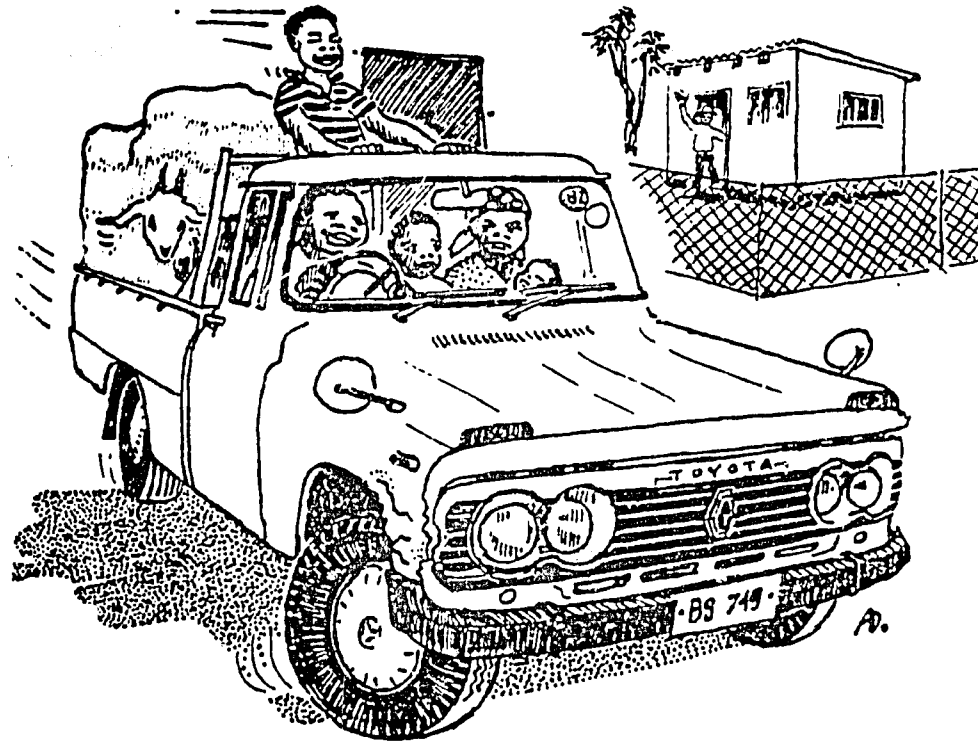
On tar roads
some people travel in a small car.
It cannot carry a lot of things.
But four or five persons
can sit inside.

A small car -
does not use so much petrol.



48

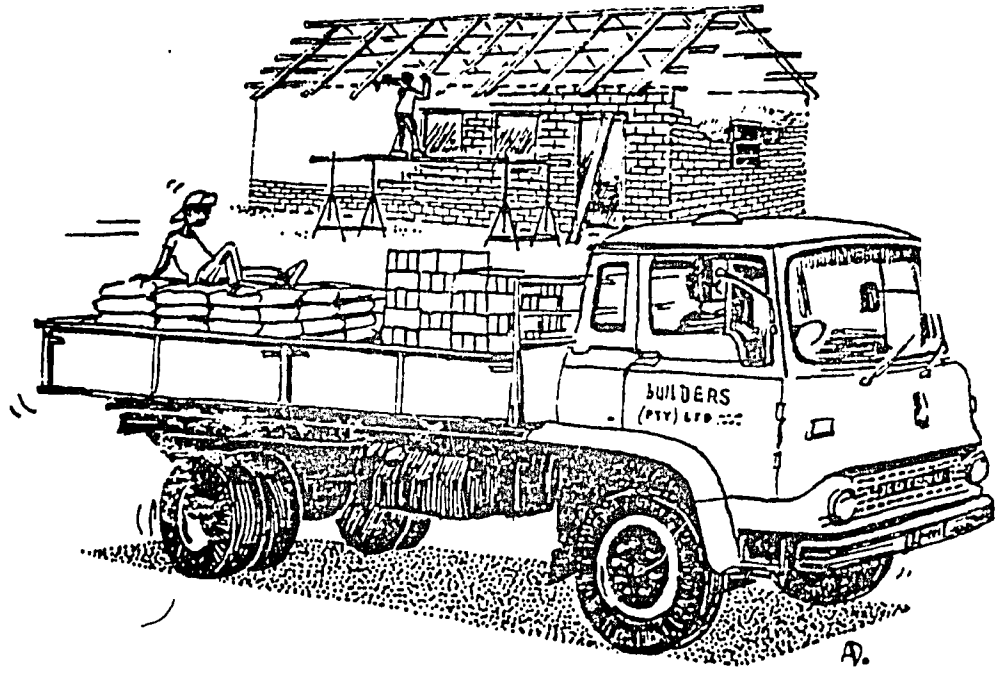
This is a pick-up truck.
Most people call it a "bakkie".
You can transport small loads with it.
But these people
have put on quite a lot ...



429

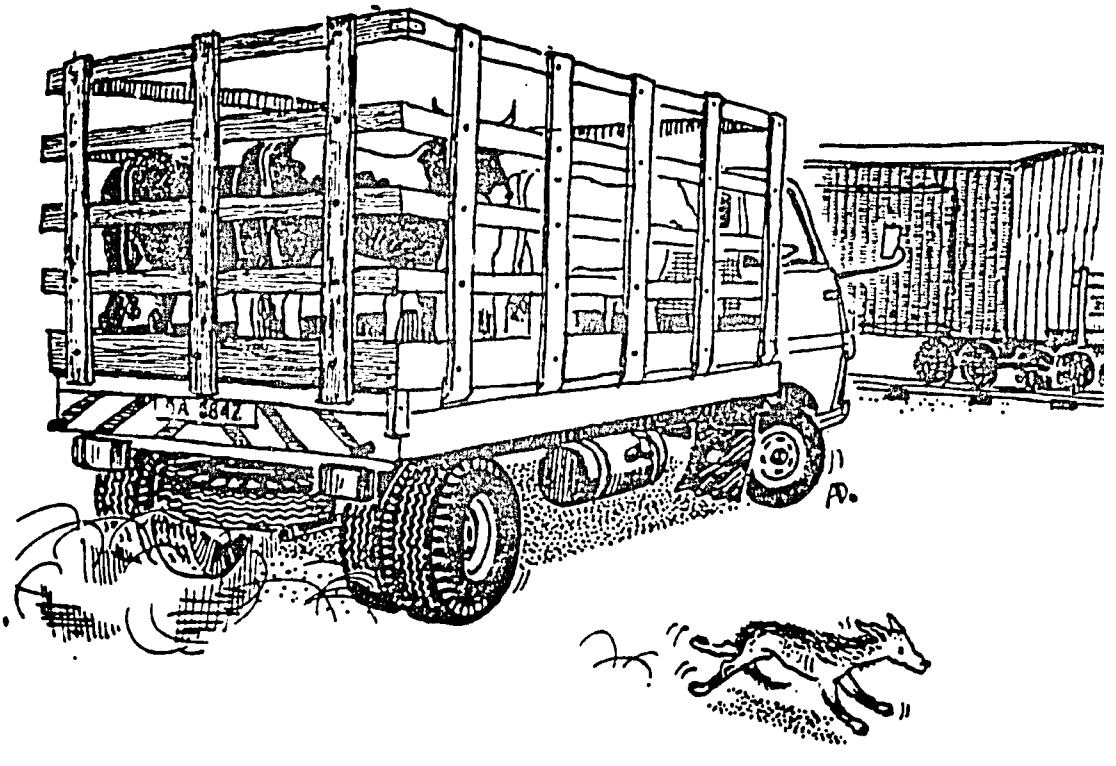
This is a bigger truck,
or a lorry.
It can carry a heavy load.
The double wheels at the back
make it even stronger.

This lorry carries
bricks and bags of cement.



430

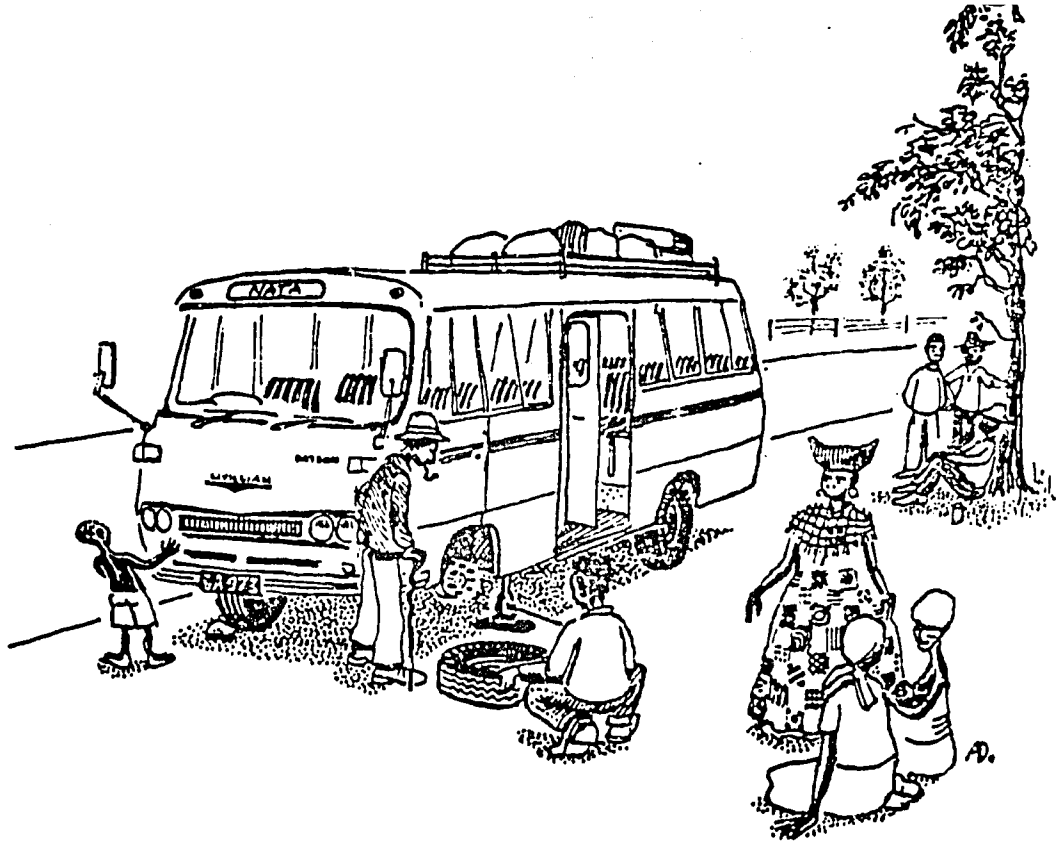
This is a cattle truck.
It goes to the railway.
The cattle will go to Lobatse
by train.



431

The bus has a flat tyre.
The driver is changing the wheel.

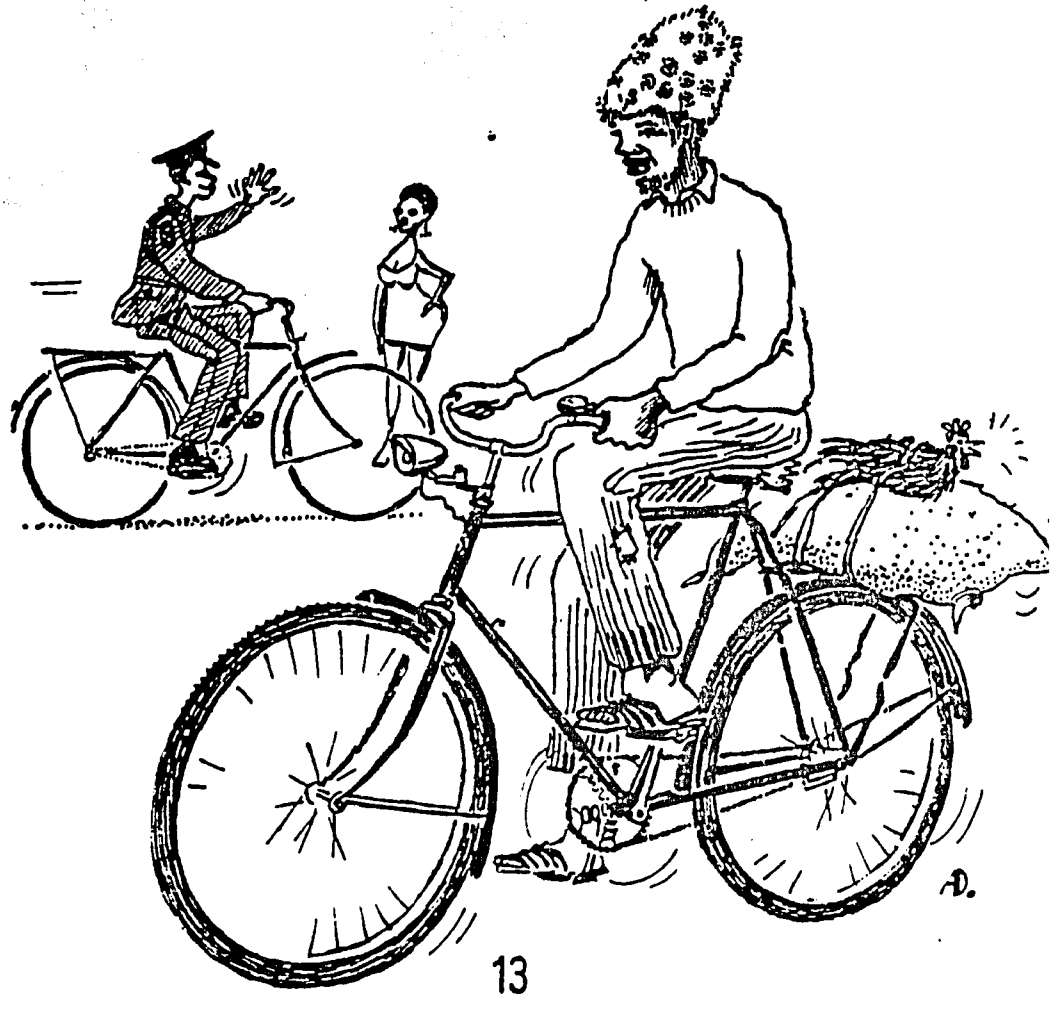
All the people are waiting ...



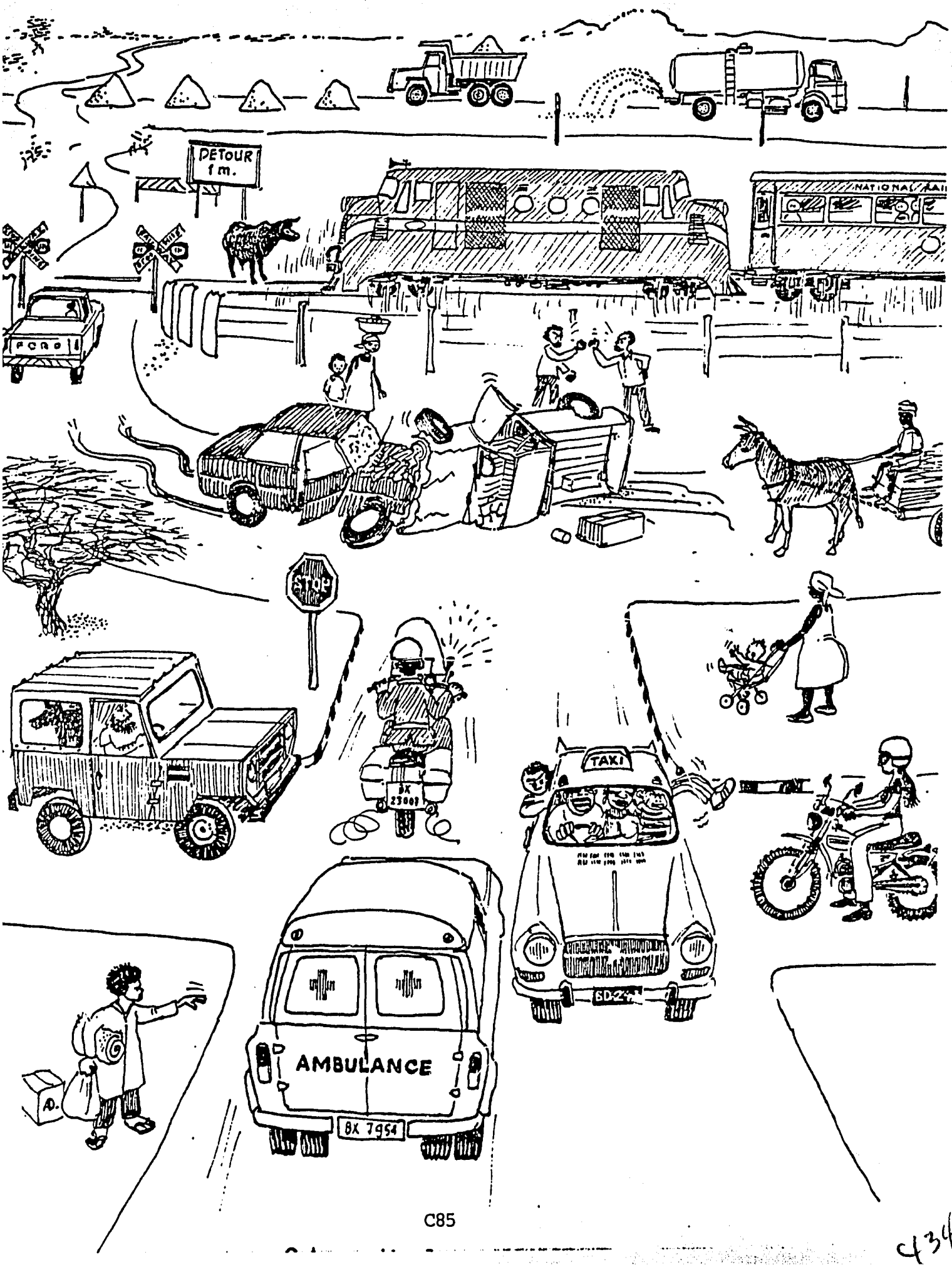
232

You do not need animals
to pull this vehicle.
You do not need petrol for it.
You only need strong legs.

You cannot transport much
on a bicycle.



What vehicles do you see in this picture?



434

LEBA LEBA MO BOTSWANA

LOOK AROUND IN BOTSWANA

A series of 20 bilingual booklets: Setswana + English.

Supplementary readers for standard 4.

Story-type presentation of subjects that resort under Science (mainly flora and fauna) and Social Studies.

Production, printing and guided introduction by TAPU (Teaching Aid Production Unit in Francistown).

SPECIFICATIONS (also for potential authors and illustrators)

titles A provisional list is appended.

genre Factual information is supplied, not with a view to treat subjects exhaustively or in textbook fashion, but in such a way that children will read (and look) simply for the pleasure of it.

formula Each booklet concerns itself with one subject and presents 10 items which fall under that sub[illegible] Selection of those 10 items is based on various criteria:
- relevance to Botswana;
- a fair cross-section of the subject treated;
- preference for items that will be interesting, even spectacular, or that will offer the pleasure of recognition;
- avoidance of too much overlap with other booklets in the series (trains e.g. are not treated under "Vehicles of Botswana", because a separate booklet is devoted to "Railways").

pictures These may be photographs or illustrations. The latter may be naturalistic or a bit cartoon-like, depending on the subject. Pictures do not merely support the text, just as the text is more than a caption under the picture. We assume that a child will first look at the picture, then turn to the text and 'consult' the picture again. Both text and picture should have independent elements so that they do not entirely duplicate each other: they must be complementary and there <u>must</u> be room for individual discovery in the pictures, such as certain humourous elements

bilingual arrangement From one cover the booklet may be read in Setswana; from the other cover (turning the booklet upside down) it may be read in English. A centre-spread illustration without text should offer an array of aspects that are covered in the booklet, serving both as pictorial review and as a device to separate the two versions.
The Setswana and English versions are not each other's translations, they offer a parallel and complementary treatment of the ten selected items. The pictures will also be variants (as often as possible) rather than duplicates. This means that the subject can be treated more widely and that children only get a more or less comprehensive idea if they go through both versions. Certain possibilities of working in pairs arise from this arrangement.

435

level

The target group is standard 4, but teachers may find that certain booklets can already be used in standard 3 or that the Setswana version is suitable for that level. We do not recommend using only half the booklet in standard 3 and then the other half, later, in standard 4. But shortage of suitable Setswana material may be so acute that teachers, using their wisdom, decide otherwise.
There is no doubt that many children (especially slow readers) can still benefit from the booklets in the upper standards. There is little sense in forcing all standard 4 children to read the series. Great harm is often done by demanding too much from individual chidren.

language level

Children in standard 4 have only had English as a subject, taught during certain periods. The transition to English as the medium of instruction takes place in standard 5. It is a well-known secret that very often this transition does not take place at all.
It is clear then, that better language control may be expected for Setswana than for English. But that is only true in general. First of all, many children are not native Setswana speakers. And secondly, the availability of printed material tends to create a situation whereby standard 6 pupils have acquired better reading ability in English than in Setwana. This is even the case with native Setswana speakers. (Taking a random sample of educated Batswana, one will find that very few turn to the Setswana section of the Daily News before they read the English; many skip the Setswana section altogether, saying that it is more difficult and that the language is not so good.)

For the time being we see no way of methodically aligning the language levels of the two versions; we can only ask authors to write with the standard 4 pupils in mind, taking into account their linguistic grasp as well as the field of their interests.

More specifically, we ask authors
- to use basic vocabulary, avoiding difficult words; if difficult words are essential to the subject, they ought to be explained, rather in the text than in a glossary, rather through contextual devices (such as repetition in a variety of sentences and situations) than through explicit definitions. Of course, the pictures may be a great help here;
- to use short and simple sentences;
- to write in the present tense as much as possible;
- to use the active rather than the passive (except, perhaps, in phrases like 'this is called' and 'that is done by');
- to use the I-form if applicable (it is doubtful whether speaking animals should be introduced); etc.

Since there is far more experience with using level-controlled English, the Setswana version will usually be produced as a variant of the English one, rather than the other way round. Semi-translation of the English text is a clear danger here. A lot of production work is devoted to checking and crosschecking or having a second Setswana author working from the first Setswana version and the pictures only. A laborious procedure. But a tradition of writing Setswana for children, in controlled and gradable language, must yet be established. (TAPU has recently embarked on writer' workshops for teachers; we hope to learn at least as much from this as the teachers, indeed, hope to learn from us.)

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size/ format/ appearance

On A5 (15 x 21 cm per page).
Stapled.
24 or 44 pages per booklet, which comes to either 1 or 2 pages per item for each version.
The first 10 booklets will have only 1 page per item, so that the text will comprise 1/3 to 1/2 of the page, under or over the picture. Since we will use fairly large type and do not want the pages to be too crowded, this comes to a maximum of 60 words per item, or 8 to 10 short sentences.

For the cover we use Cambric Cover (216g/m) and for the inside Hammermill Ledger 105g/m). This is good and heavy quality, so that photographs will be no problem and so that the booklets may be fairly durable.

For the first 10 booklets the cover will be Bamboo (a bit browner than buff) with dark green print.
The second 10 booklets will be thicker, contain more text, be at a slightly more complicated language level and the cover will be Casaba (a goldish-brown).

provision

The booklets will not be supplied singly but only as a series of 10 or 20, with 2, 3 or 4 copies of each. They will be supplied in a library box, to overcome the problem of storage, damage and loss. Instructions for use will be printed on the lid. Question cards will be glued on board. The pieces of board will serve as partitions between each set of 2, 3 or 4. When a child turns in a booklet, the teacher can then quickly check whether it is within the child's reading ability. In a separate slot there will be record cards on which the teacher may note what each child has read.

use in the classroom

One thing must be absolutely avoided: these booklets should not be used as lesson material until after all <u>individual reading for pleasure</u> has taken place. Children must enjoy the booklets and build up a reading habit through reading a lot. They should not be asked to learn from them, to memorize the contents, or anything like that.

Another thing to be absolutely avoided is mismatching the booklets with children who cannot possibly read them in a meaningful way. This would cause great frustration and it would discourage children from trying to read. They would give up and never acquire a reading habit. To them reading would be associated with trouble.

Children could read in pairs, one taking the Setswana version and the other the English version; they could compare the two, note similarities and differences, etc.

Supplementary readers should not only be used for children who quickly finish their math work. This would only benefit the bright. It would be good, therefore, to set aside periods for supplementary reading, mainly a silent and individual activity. Those children whose ability is too poor to attempt the booklets from the library box might get some simpler reading material and the teacher could give them individual help.

cost

One box containing 20 copies would cost about P15.00. After a certain period the box could pass from one class to another.

LEBA LEBA MO BOTSWANA

LOOK AROUND IN BOTSWANA

Provisional List of Titles

1. BIRDS
2. INSECTS
3. WILD CARNIVORES
4. WILD HERBIVORES
5. DANGEROUS ANIMALS
6. DOMESTIC ANIMALS
7. TREES
8. FLOWERS
9. EDIBLE WILD PLANTS
10. CROPS
11. HILLS
12. WOMEN
13. PEOPLES
14. JOBS
15. HOUSES
16. VEHICLES
17. CRAFTS
18. SMALL INDUSTRIES
19. RAILWAYS/STATIONS
21. PLACES

438

REPORT OF MEETING

ON

LOW-COST PRODUCTION OF SCHOOL EQUIPMENT

HELD IN

MANZINI, SWAZILAND FROM 19 - 23 FEBRUARY 1979

439

FOREWORD

Pursuant upon the Dakar Manifesto proclaimed by the African Consultation on Teaching Materials, the Government of Swaziland hosted this meeting under contract with UNESCO. This meeting was attended by educational officials from Botswana, Lesotho, and Swaziland to investigate the possibility of establishing a sub-regional low-cost school equipment production unit or, alternatively, one or more national units. Other countries in eastern Africa were invited to send observers but only the United Republic of Tanzania was able to accept the invitation.

Before the meeting was convened, a Unesco consultant in low-cost equipment production visited the Ministries of Education in each of the three countries to discover their interest in such a project in view of their needs for low-cost equipment and their resources for producing it. All three countries were in the process of reforming their schools' curricula and common elements of the reforms were an increasing emphasis on education in practical subjects and a movement towards methodologies involving the use of equipment in all subjects. All three countries were already producing some small low-cost items, particularly of science equipment.

These discussions with Education Officials also brought out the need for a strong training element to be added to the functions of proposed production unit.

The meeting resulted in all representatives preparing positive recommendations to be presented to their Ministries. In general these were that the facilities for the production of low-cost equipment already existing in their countries should be extended both physically and in their functions, and that sub-regional co-operation should be fostered initially by regular bi-annual meetings. Clearly, it was felt that such exchanges of ideas were the best way to build full-scale co-operation should this be found to be economically sound in the future.

The representatives of all three countries foresaw the need for some foreign assistance to implement their modest initial extensions. The question of whether the technical elements of this assistance could be organized sub-regionally was not discussed however, although it is clear that the type of assistance required

Recommendations to the Ministries of Education in Botswana, Lesotho and Swaziland

The following recommendations were prepared by the working groups so that they may be used to assist their respective Ministries of Education with the improvement of science and technology education.

The points embodied are considered feasible within the existing framework. If acted upon they could provide a considerable improvement in the equipment and teaching situation with minimum increased expenditure and external assistance.

The participants felt that a further meeting would be beneficial, and to be held in Botswana, after a period of 6 months, to discuss activities implemented from the present meeting. Such meetings on a regular basis were felt to be beneficial.

Recommendations to the Ministry of Education - Botswana

1. There should be established a central purchasing unit for Maths and Science Equipment. This Centre should be administered and operated by an experienced science teacher. It should be made compulsory for all schools to order equipment through this centre.

2. The Ministry should instigate a survey of the facilities of T.A.P.U., Francistown. T.A.P.U. is based on a training college and produces some apparatus for primary schools. It may be more appropriate for such a Unit to be located at BRIDEC in a new purpose-built building. Assistance could be sought to construct and equip the building.

3. The siting of the above Centre at BRIDEC would give direct contact with the Brigades who could produce apparatus. Initially difficulties could be experienced with large production orders but the Brigades are fully equipped with machinery and trained personnel and problems would eventually be overcome.

4. Examination time produces difficulties in obtaining equipment, and co-ordination of activities could overcome some of these difficulties.

   On receipt of the report of this meeting the Ministry should circulate copies to all interested parties. Subsequently a meeting of these parties should be convened to consider the role to be played by these different institutions.

Aid Requirements

5. (i) Assistance to investigate the possibility of setting up resource/distribution centre, in selected locations.

   (ii) Assistance may be needed to provide wood, metal and other machinery at the Centre for constructing prototypes.

   (iii) Assistance may be needed to provide a managerial accounting person for the Centre, as well as other staff.

   (iv) As mentioned in 2 above assistance may be needed in construction of a building.

   (v) Assistance may be needed as to the requirements of a Design person for equipment and for his training. His role is envisaged as being

   - to obtain ideas of requirements from teachers and other relevant persons;

   - to prepare plans for constructing items;

- to decide on appropriate methods of construction;

- to make prototypes for testing.

(vi) Assistance may also be needed to train suitable persons in specialised techniques such as glass-blowing and repair and maintenance of equipment e.g. much glassware can be made from old fluorescent tubes. Such training would include the initial specialisation as well as a period of industrial attachment and a short study tour of appropriate production centres in different countries. At least two persons for each requirement should be considered for training.

6. A survey should be carried out as soon as possible of all schools and their facilities. Following on from this survey all schools should be brought up to a certain standard using locally produced items and imported ones. Assistance may be needed for this latter activity.

7. Transport for the maintenance, and distribution, of equipment to schools would be needed.

Regional Co-operation

8. An interchange of ideas and designs would be desirable, both on a sub-regional and worldwide basis. The establishment of an International Clearing House and newsletter would be appropriate for such an interchange .

The transfer of equipment between countries was not felt to be practicable at this point in time, or in the foreseeable future.