PD-ABC-361

EVALUATION OF THE

AFRICAN

PRIMARY SCIENCE PROGRAM

Monograph Series

APSP

African Primary Science Program

This document, written by Eleanor Duckworth, is one of a series of monographs on the experiences of the African Primary Science Program during its first five years. They discuss the Program in the following general subject areas:

Origin and Development
Administration
Teacher Training
Evaluation
Making a Start - for teachers
Unit Construction

The Appendices will include:

Summaries of printed materials and films
Summary of Science Centres
List of Personnel Involved in all facets of the Program
SEPA - Science Education Program for Africa

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These materials have been developed with assistance from Education Development Center, Newton, Mass., U.S.A., operating under US/AID Contract csd-772, as part of the African Primary Science Program.

September 1970

PD-ABC-361
ISN 09269

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EVALUATION OF THE AFRICAN PRIMARY SCIENCE PROGRAM

INTRODUCTION

Anybody who is trying to do a complex job well is constantly asking himself questions about how well he is doing the job. This is true of all the people involved in the African Primary Science Program - the teachers in their classrooms, the educators who develop the teaching materials, the tutors who direct teacher training, Ministry officials who are responsible for science teaching, and so forth. All of these people are evaluating their own work day by day, trying to judge which of their ideas are useful and which need to be modified or discarded.

In addition to the evaluative work that everyone does for himself each day, the Program has had a team of people concerned with general problems of evaluation, under the leadership of Dr. E.A. Yoloye of the University of Ibadan, Nigeria. This committee has been composed mainly of participants who are also engaged in other aspects of the project. In addition, the author of this monograph was engaged for almost one year to work full time on the problems of evaluation, and a few other people from outside the Program have participated briefly as consultants. Our main job has been to develop ways to help people judge when their ideas are working well and when they are working less well.

This paper attempts to present the way evaluation has been conceived in this program, the work that has been done in accordance with this view of evaluation, and some indications of what remains to be done.

STATING THE GOALS AND ASSUMPTIONS

The first job undertaken by the evaluation committee was to try to state as clearly as possible what the Program was setting out to do. We could not help people to judge how successfully they were doing their job unless there was some agreement on what the job was. The committee drafted a statement of the goals as they understood them and presented it to participants in the Program for critical comment. On the basis of the reactions to this initial draft, we produced a few pages which all the participants seemed to agree stated what they were trying to do.

The Long-Range Goals

The central point that emerged was that they were trying to develop certain characteristics in children. They were trying to develop in children a first-hand familiarity with the world around them - with grasses, clay, torch lights, water, balances, the moon, little animals, charcoal, mosquitoes, soil - and many other things. First-hand familiarity meant more than just knowing the names of things. It meant knowing what to expect of them. It meant being able to predict what they would do if you did something to them. It meant knowing their habits. It meant knowing how they could be used.

Another characteristic they wanted to develop was curiosity about things - an interest in finding out more, so that children would be finding out more about the world around them even when they were not in school, so that they would investigate things on their own initiative.

A third characteristic was the ability to learn for themselves. That is, children would be able to think of things to do that would tell them more

than they could learn just by watching. They would know that sometimes they must repeat what they do over and over again, before they can believe the result. They would know when to count and measure, to help them learn more. They would know how to think of factors that might make a difference to what happened and they would know how to figure out whether those factors did make a difference. They would be willing to spend a lot of time, if necessary, and not give up in the middle.

A fourth characteristic would be that children realize that they might have good ideas themselves about how to find out something, or how to do something - that children feel confident to suggest ways of doing things, and try to act on their own, rather than waiting passively for someone else to tell them.

And finally, children would realize that they can help each other by collaborating - by writing down what they have done or noticed, for another person to read; by reading what other people have written; by knowing where to get more information.

14/6/68 JOHN KIRUYI

Powder No 1. BI-CARBONATE of SODA

A. What I did.

As I took bicarbonate of soda on the lid of pepsicola. And looked at it. It is white in colour. It is some how rough. It does not smell. It tastes like magadi

B. When I added water in bi-carbonate of soda, water does not dispear in completely water remains on top of the flour.

C. As I mixed it with vinegar in bi-carbonate of soda, it bubbled. The colour changed completely to light brown. It tasted sour and I didn't even enjoy it.

D. When I added Iodine with soda it disloved in very quickly. It's colour changed completely to blood. And there was equeer smell.

Results:

E. When I added four things together which are: Iodine, water, and vinegar in bi-carbonate it surely bubbled, and I saw smoke coming up. And it seemed as if the table was burning. Ee, "wonderful!!" It's I went on sid watching, I saw something on top moving about side to.

Powder No 2 Posho

A What I did.

When I took posho flour on the lid of pepsicola, I saw that posho was rough. It is white in colour but not very as soda. It tasted some how sweet.

B When I added water in posho, it turned into liquid. Water disloved in. After for sometime the flour went down to the bottom and water remained on top.

C When I added vinegar in posho flour the (~~colu~~) colour quickly changed completely to some brown. It tasted some how sour. And it smelled badly.

D Seen:

As I compared with the one with water and vinegar the colours are different. With vinegar it is brown. And with water it is white.

E When I mixed Iodine and posho the colour changed completely to

purple. It smelled very bad. And Iodine that remained on top while the flour was at the bottom.

Results:

The differences between three of what I mixed are completely different in colour.

Powder No 3 Sugar

A Do: When I took sugar on a lid of pepsicola it is shinny in colour it is rough. It does not smell.

B What I did:

As I mixed water with sugar it dissolved. It tasted very sweet. Mixing vinegar in sugar the colour changed completely to brown. As I took little and tasted, it is some how sweet.

C When I mixed Iodine in sugar it dissolved. It smelled badly. When I mixed also water, vinegar and Iodine in sugar pots together, it bubbled. The colour changed completely to black.

Result:

Mixing potio, vinegar, water, Iodine, bi-carbonat of soda and sugar it looked as if it was relave beer.

Powder No 4 Salt

A As I continued with salt ~~on a~~ which was on a lid of pepsicola, It is rough It does not give any smell. It is not sweet when tasted. It is some time white in colour.

B When water was added to salt and stirred, it disappeared in water completely and the water was very saltly when it was tasted.

C When I mixed Iodine with the mixture of salt, water and vinegar it changed the colour into black. And smelled badly.

D When I mixed water, Iodine in salt it bubbled and when I mixed water,

JOHN KIMUYI

Iodine, vinegar it bubbled The colour come to dark brown. And on top there was fats.

Conclution: If you mixe bi-carbonate of soda, Iodine, Vinegar, Potio, flour, Salt, Sugar and water and you stir, and leave them for some minutes, you can see bubbles coming up. And colour changed to black. And there was avery bad smell.

Program participants were not interested in teaching children how to say scientific facts. They were not interested in having them memorize text books about science. They wanted children to do their own learning, so they would be able to continue to do their own learning, and be able to think for themselves when they were out of school.

The participants also had assumptions about how to approach their goals.

First Assumptions - Teaching in the Classroom

The major assumption was that these characteristics develop best by encouraging them in the children's work day by day. It is through trying to design experiments that a child learns how to design experiments; it is through appreciating the fascination of some seemingly ordinary things that he comes to appreciate that many other things may be fascinating too; it is through trying to communicate to other people what he has noticed that he gets better at being able to communicate; it is through doing things on his own that he gains the confidence to try other things on his own. In the short run, therefore, the participants wanted to have as much of this happening as possible, each day, in each classroom they could influence.

The components necessary for this type of teaching could be stated as follows:

1) The focus of study should be the concrete phenomena themselves - e.g., plants, animals, stones, liquids, stars, shadows, etc. First-hand experience with materials is essential.

   The phenomena of the natural and man-made world are complex. They have different significance for different people. Telling them about them does not carry all their complexities and fascination. Nor does 'telling about' them alone allow opportunities for children to develop ability and confidence in finding out for themselves.

2) The materials selected should capture and hold the attention and interest of children. In some cases, the concrete materials may be

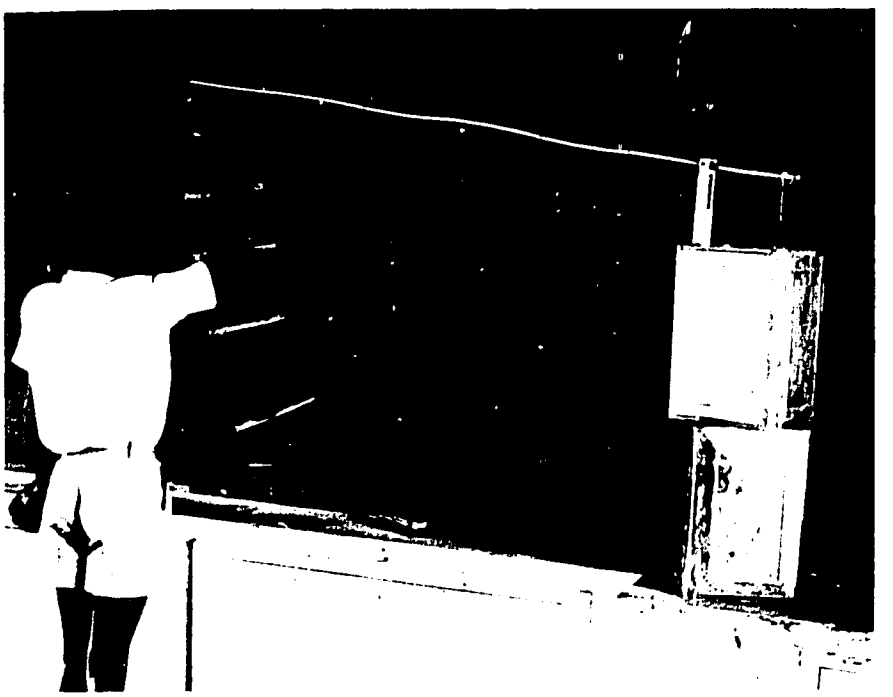
sufficient in themselves to suggest things to do. In some cases, questions and suggestions from the teacher are necessary to reveal interesting possibilities which the children may not have thought of themselves. In some cases, alternatives should be available for children with divergent interests.

3) Children should be encouraged to do things on their own, in their own ways. This means that unexpected things are likely to happen in the classroom. Teachers should be prepared for and welcome the unexpected.

4) To a large extent, the materials should be simple and familiar - so the children's experiences outside school are met here in a fresh way. This in itself may develop the awareness that the children can continue their investigations on their own in

everything they do. More directly, some materials may take the form of setting out to work on a problem that comes from outside school - health, care of food, cooking.

5) Materials should allow opportunities for a variety of different ways to find out - some patient watching, some resourceful tool making, some clever experimental design, some sudden insight, some constant repetition, some imaginative guessing, some tight logical thinking, some trying out a tentative idea, some frustration; some recourse to other people, books, radio, pictures, etc.



6) The materials should reveal that there is not always one right answer. This can be at a variety of levels. At one level children may arrive at different answers to the same question and all the answers may be equally acceptable. At another level, the teacher will often not be able to answer questions that arise, and there is no other way to find out in the classroom, except by

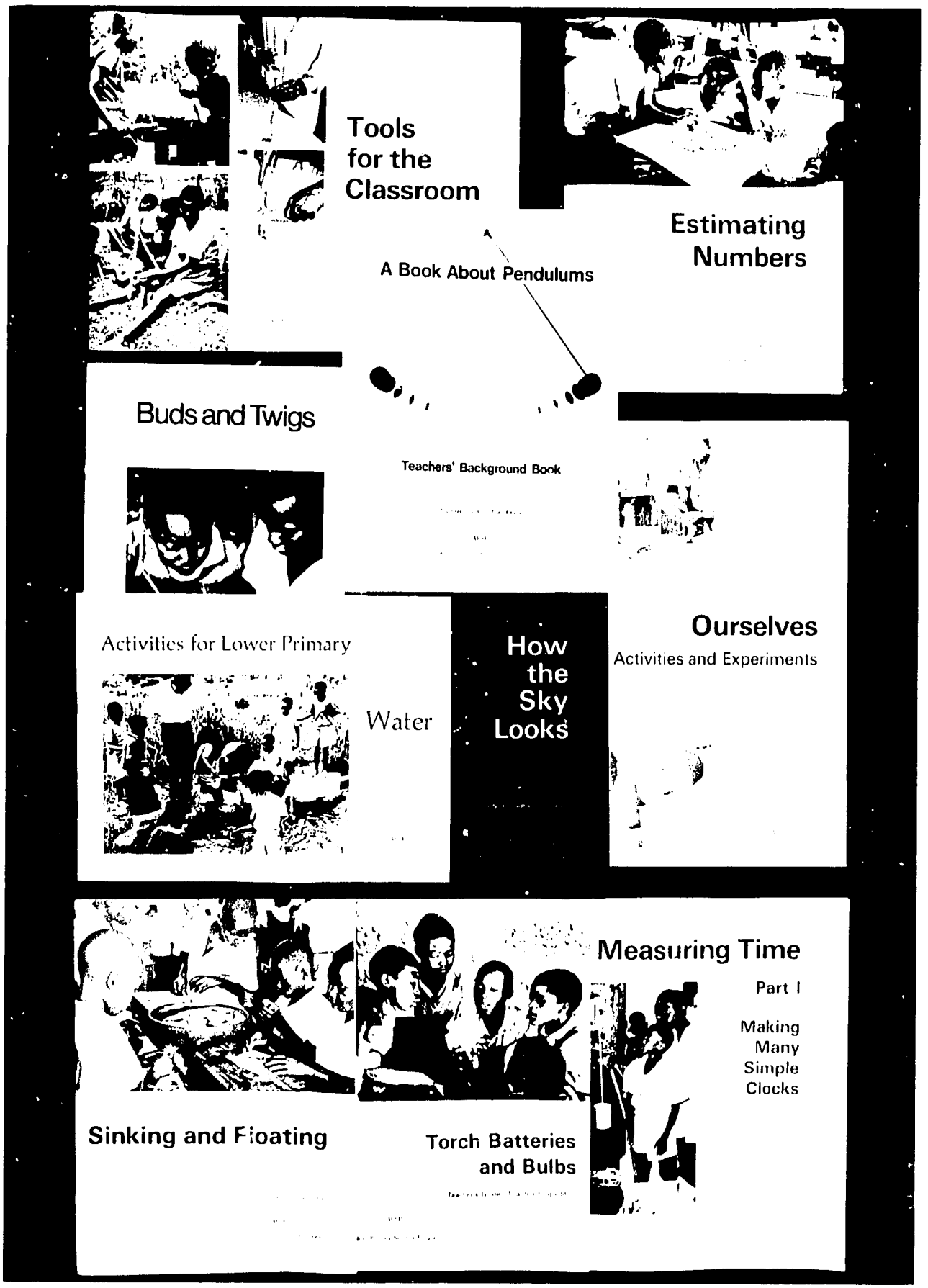
carrying out an investigation. At another level, questions may arise to which no one can find an answer, and to which, indeed, no one in the world yet knows the answer.

7) The classroom experiences should lead to social interaction among children - where they develop a common body of experience, accept and respect other points of view; attempt to substantiate their own points of view; co-operate to solve problems together.

Further Assumptions - Helping the Teachers

The participants also had assumptions about how to help teachers accomplish these things in their classrooms. They believed it would be essential to work out many different ideas for concrete materials that teachers could use in their classrooms, and activities that children could do with these materials.

They believed that these ideas could be written for teachers in the form of teachers' guides and that, in addition, teachers would need help in the form of workshops, courses, discussions with other teachers who were trying to teach in the same way, and guidance from local education officers and inspectors.


Tools for the Classroom
Estimating Numbers
A Book About Pendulums
Teachers' Background Book
Buds and Twigs
Activities for Lower Primary
Water
How the Sky Looks
Ourselves
Activities and Experiments
Measuring Time
Part I
Making Many Simple Clocks
Sinking and Floating
Torch Batteries and Bulbs

These statements of goals and assumptions gave us three levels at which to offer help with evaluation. The next three sections deal with each of these levels in turn. First, IN THE CLASSROOM: we could try to help teachers to tell whether they were doing as good a job as they could day by day in their classrooms. Secondly, HELPING THE TEACHERS: we could try to help science educators, tutors, inspectors, and Ministry officials to know which were the best ways to help teachers. And finally, IN THE LONG RUN: we would have to try to see whether classroom teaching like this did lead to the development in children of the characteristics that are the prime concern of this program.

Briefly, what we could do to be most helpful was to suggest specific questions for people to ask themselves at each of these levels.

IN THE CLASSROOMS

As most schools have been conceived until fairly recently, there have been rather well-defined ways for a teacher to judge whether he is doing his job well. His job has been to transmit to the children the content of certain text books and syllabuses so they could answer written questions about them. The teacher could feel he was doing a good job if the children in his class did well on examinations. Some teachers, of course, have always seen their job more broadly than this. They have realized that there are important things for children to learn which are not tested by written examinations. There are such things as whether children develop confidence in themselves and their abilities, whether they respect the ideas of other children, whether they like learning and want to learn on their own, whether they know important things about their own localities which are not included in the syllabuses. Examinations cannot tell the teacher how well he is doing in these areas. He has to

have other ways of his own and he can never be sure.

The teachers who are involved in teaching science as it is presented in this program are in the position of the teachers just described. It is complicated for them to know how good a job they are doing. There are no examinations they can give to let them know how they are getting along. There are no memorized answers the children must know how to give. It is mainly by what happens every day in the classroom that the teacher can tell his progress.

We have learned from experienced teachers some of the indications that those teachers use to judge for themselves how well they are doing their job. In addition, through watching many classes of children working in the Program, we have been able to find other elements to look for. On the basis of these observations, and of discussions with teachers, we wrote a short paper called "What You Can Look For" that can serve to help teachers know how they are doing. (See Appendix.)

Another possibility for evaluation (one which has not been done to date) would be to write a short, similar paper for each unit of study, describing more specifically indications a teacher could use to recognize progress in that unit. Such indications might include suggestions of special problems for children to do, that focus on certain aspects of the children's work. Some problems might focus on how familiar children have become with the phenomena they have been investigating, by asking them to predict what will happen in some new situation. Others might focus on how good the children have become at inventing ways to make new equipment. Others might focus on how careful they are in doing experiments.

In the few attempts of this sort that have been made, an interesting aspect of this program has come to light: the problems which are good for finding out how children are progressing are the very problems which are good for the children to learn from; the problems could just as well be - and often are - included in the teachers' guide as a good classroom activity. And, since children are working, every day, in the ways we hope they will develop, the situations that are used for evaluation turn out to be very similar to the teaching situations.

HELPING THE TEACHERS

As described on page 10, there are several ways in which this program tries to help teachers. They include suggesting materials and activities, writing teachers' guides, giving courses and visiting teachers in their classrooms, helping teachers fit this program into the rest of their teaching. This section examines ways people have of evaluating their attempts to help teachers.

1. Developing materials and activities

In developing a teaching unit, an educator starts with some ideas about activities children can do to investigate some phenomena, for instance, the behaviour of certain liquids and dyes, or what happens if you do certain things to buds or twigs. To find out how good the ideas are, he has to try them out in a classroom with children, usually with the help of a local teacher in whom he has confidence.

Sometimes, ideas do not work out very well, and they must be changed or dropped. The children do not get interested; or they do not have ideas of what to do; or the activities are too difficult; or they use up costly mate-

rials too quickly. What an educator looks for when trying out a unit for the first time is exactly the same as what a teacher looks for when he teaches in this program. Are the children excited about what they are doing? Do they think of interesting things to do that he had not anticipated? Can they think of ways to answer questions that arise? Are the materials adequate for what the children try to do?

In addition, the evaluation team has developed a classroom observation system which gives scores about how involved the children are in a unit.* This could be used by science educators to check whether a class lesson is really as good or as bad as they thought it was. It is a relatively new development, however, and it remains to be seen whether this instrument will prove useful in this way.

The evaluation team has also drawn up an outline of information necessary to help a science educator judge the availability and costs of materials for a given unit.*

2. Writing a teachers' guide

Once a science educator believes he has a unit based on readily available materials which can get children working on their own investigations, he tries to write a teachers' guide that will help other teachers to get children investigating. Then this written guide must be evaluated. He must try to see whether teachers he knows, who are capable of teaching some of the units well, can use this guide without further help from him and get their pupils working as well as the pilot teacher did. He visits these classes, and tries to see what has not been clear in his trial written version, or what parts do not give the teacher enough ideas of what to do, or what parts are unnecessarily detailed.

*For further information, contact your Science Centre for a copy of the Source Book for Evaluation.

The educator often does not have time to visit all the teachers consistently, so the evaluation team has helped to develop questionnaires to help him get the information he needs. They include such questions as: "Which activity did your pupils enjoy most?" "What activity was the most difficult for them?" "What was the most exciting thing that happened as you taught this unit?" "How long did your class spend on this unit?"

Questions such as these give the educator an indirect way to understand where the guide is successful and where not so successful. For instance, if many teachers say that one activity was a failure, and the writer knows from pilot classes that it can be exciting, he is likely to conclude that the written guide does not give the teacher a good enough idea of what to do. Or, if teachers say they spent four lessons on the whole unit, while he knows there are enough activities for 10 or 15 lessons, the educator can assume the guide is not giving a clear idea about ways in which a teacher might proceed.

Another way to get information from teachers has been to ask them to compare several units. Questions like these have been helpful: "Which of these was easiest to teach?" "Which took the most preparation outside class time?" "Did the children ever bring work from one unit into their work in another unit?" "Which unit would you <u>not</u> want to teach again?"

One excellent way to get information from teachers about the unit is to use questionnaires like this in combination with a meeting of a group of teachers who have taught the same units. After they have each filled out a questionnaire independently, their answers can serve as the basis for very fruitful discussions about the unit.

3. <u>Approaches to teacher training</u>

In teacher training, also, the science educators have been evaluating their own efforts as they go. Not much comparison has been made, however, among dif-

ferent kinds of approaches used by different science educators. After seeing many different approaches to teacher training, the evaluators have suggested that, in order to carry out such comparisons, information such as the following should be gathered for each approach to teacher training.

Sponsorship?

- Ministry
- Teacher Training College
- Local Education Office
- Inspectorate

Number of teachers and who they are?

- in-service
- pre-service
- specialized
- self-selected

Number of tutors and who they are?

Amount of time?

- occasionally
- over a year
- intensively
- for a week

What happens in the course?

- materials used
- availability of children
- classroom observation
- practice teaching
- discussion
- workshop for teachers to make their own equipment
- special features (resource people, films)

Types of follow-up?

- materials provided
- meetings
- written communication among the teachers

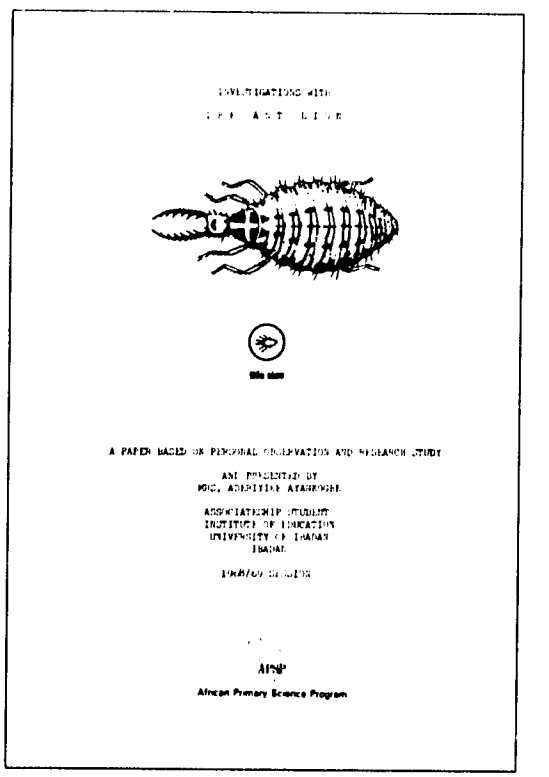
These approaches to teacher training must then be compared in terms of the results in the classrooms, along with the costs involved. How many of the teachers are teaching very well? How many still need more help? How many do not seem to have profited at all? How many are able to help other teachers

now? Which aspects of the course were the most fruitful? What units are good for beginning teachers? What is the optimal kind of follow-up to offer? How can inspectors be most helpful?

At the University of Ibadan, Nigeria, Dr. Yoloye carried out a study which investigated some of the factors which might be used in the selection of teachers for such courses. ("Study of Teacher Response to a Training Procedure" by E.A. Yoloye, University of Ibadan, 1969.) In the same study he made the prediction that teachers who themselves became deeply involved in learning science on the basis of their own investigations would be better able to help children learn in the same way.

He attempted to assess his students' involvement in their learning by asking them to submit written reports of their investigations, on a voluntary basis. The reports were to describe what the students did in scheduled class laboratory sessions, as well as outside class on their own time. An independent evaluator (in the sense of not having been involved in the training) read the reports, and grouped them into four categories - excellent, good, fair, poor. The factors the evaluator used in making judgments were the following:

1. Variety of questions
2. How much time spent outside class
3. Expressions of appreciation
4. Patience required to answer one question
5. Invention of Apparatus
6. Experimental design - repetition, quantification, controls
7. Whether evidence justified conclusion
8. Intelligent speculation, in absence of ways to verify
9. Mention of possible alternative conclusions
10. Accuracy of data
11. Persistence in pursuit of one problem
12. Openness to questions raised by chance observations or 'mistakes'



Dr. Yoloye's study enabled him to relate the students' reports to other factors, such as years of teaching experience and certain kinds of abilities and aptitudes as assessed by other measures. In this particular study, however, the final step of correlating the teachers' involvement in their own learning with their ability to help children learn in this way was not carried out, due to external circumstances which made it impossible to assess their teaching in the classroom.

E. Mushi at Morogoro College of National Education in Tanzania has attempted to develop appropriate ways to assess pre-service college students who were preparing to teach science in this way. As a "final examination" each student was given some new materials he had not worked with before, and a few general questions. The students were not expected to provide "right" answers. They were required to:

1. work with materials given and explore possibilities,
2. ask good questions and formulate problems clearly,
3. work scientifically towards answering these problems,
4. show their initiative and resourcefulness in scientific investigation.

In addition to this "examination," the students were assessed in the following ways:

A. Individual and group projects throughout the course. The work and reports were judged by at least three tutors.

B. Teaching practice and reports. All students taught science and were required to keep a record of their activities, the responses of the children and developments.

C. Work and attitude throughout the course.

In all studies such as these two mentioned, observation of the teachers in their classrooms is an essential aspect in the comparisons to be made. The classroom observation system referred to earlier (page 16) is one instrument that could be used to compare various classrooms.

As well as the observation of classrooms, some work has been done with questionnaires which teachers are asked to fill out at the end of a course, or complete after some months of teaching. (See Source Book for Evaluation.)

4. Curriculum planning

Once many individual units have been written, there is the further task of deciding how they fit together. This type of curriculum planning has as yet not been done, since it is only within the last 18 months that a large number of workable units has been produced. Evaluation will be an important part of this job, too. For one thing, it will be necessary to see whether, taken together, the units provide a familiarity with a variety of aspects of the world and a variety of ways of finding out, as outlined in the Program's goals (the first assumptions). For another thing, new questionnaires will have to be developed, to be used with observation procedures, to help decide which units can be most helpful to other units, which are good ones for teachers who are just starting work in the science program, and which units gain the most by being done after the children have done a number of other units.

5. Planning for the Program

Any Ministry interested in helping teachers use this program is likely to want to know how it fits into the rest of their primary school education. As evaluators, we have been concerned with this problem as well, and have given some thought to the kinds of information that would be necessary. Some of the relevant questions are the following: What are the over-all goals for primary school education in the country, and how do they relate to the goals of this program? What is the current syllabus and how could this program fit into it? If it does not correspond, how is change effected in a syllabus? What kind of primary school leaving examinations are there and how might they affect this program? How many pupils are there? How fast is the number increasing? How many teachers are there? How fast do they change? How many inspectors are there? How many teacher training colleges are there? In the light of these numbers, how could this program be introduced on a wide scale?

As evaluators, we have also attempted to answer one or two of these questions. For instance, in one country where there was no science included in the ministry's curriculum for the lower grades, some people were worried that the time spent on science activities in these lower grades might mean that language and arithmetic learning would suffer as a result. To check this, we compared the accomplishment in arithmetic and English of children who had been involved in this program for at least a year with other children who had not been involved in it. We found that the classes which had been engaged in science activities were not behind the other classes in arithmetic and English. The averages of the two groups were just about the same. The introduction of science activities at this level, therefore, does not seem to jeopardize work in arithmetic and English.

As another example, an effort has been made to see whether it is possible to help teachers teach in this way without having to spend very large investments in training and follow-up by skilled science educators. The initial indications from these attempts are that good teachers who have had experience themselves in teaching this way can help other teachers teach in the same way at very little cost to the Ministry. In some cases, a good teacher has been released from his classroom teaching in order to be free to help other teachers in his area to start teaching in this way. In other cases, teachers have remained in their own classes but have helped other interested teachers in the same school. In both these cases, independent evaluation of the work of these teachers has shown that training of this sort can be very effective.

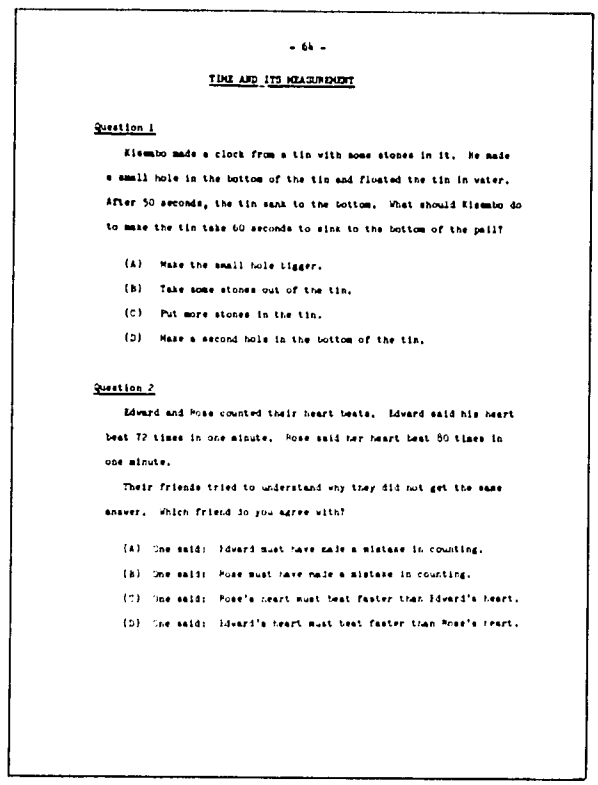
6. Examinations

It can be seen from what precedes that most people involved in this program feel that conventional pencil and paper tests are inadequate to evaluate

much of the progress the children may be making.

Many people feel that it is very important in a program like this not to have any examinations. They feel that whenever there are examinations, teachers put their greatest effort into preparing children to answer examination questions, even though they realize that in doing so, they are neglecting other important aspects of their pupils' development.

Other people feel that since most ministries do have examinations in science, this program could be helpful in developing some multiple choice questions that are as good as they can be. The evaluators have, in fact, collaborated with some of the science educators in making up some questions of this sort, which can be found in the revised Source Book for Evaluation



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TIME AND ITS MEASUREMENT

Question 1

Kiembo made a clock from a tin with some stones in it. He made a small hole in the bottom of the tin and floated the tin in water. After 50 seconds, the tin sank to the bottom. What should Kiembo do to make the tin take 60 seconds to sink to the bottom of the pail?

(A) Make the small hole bigger.

(B) Take some stones out of the tin.

(C) Put more stones in the tin.

(D) Make a second hole in the bottom of the tin.

Question 2

Edward and Rose counted their heart beats. Edward said his heart beat 72 times in one minute. Rose said her heart beat 80 times in one minute.

Their friends tried to understand why they did not get the same answer. Which friend do you agree with?

(A) One said: Edward must have made a mistake in counting.

(B) One said: Rose must have made a mistake in counting.

(C) One said: Rose's heart must beat faster than Edward's heart.

(D) One said: Edward's heart must beat faster than Rose's heart.

Still other people feel that a different kind of examination might be possible - a more open-ended examination where a child has the chance to reveal whatever he has learned, rather than being expected to answer precise questions.

But in principle, the evaluators agree that teachers need all the help they can get in realizing that many of the goals of this program cannot be tested by examination techniques. If they are free to put their effort into helping the children progress in the areas we have discussed, if they can be encouraged to look for indications of children's progress every day as they teach, they they are most likely to do a good job every day.

IN THE LONG RUN

The long range objective of this program is to develop certain characteristics in children. Is there any evidence that teaching as it is done in this program does help in this development?

This question really can be answered only over a long period of time. The real result, of course, must be sought in the adult lives that these children will lead. Are they more productive, do they do things for themselves, are they interested in continuing their learning, are they able to think about decisions that will affect them and their communities? We would like to think about a study of this sort, to be carried out over many years, and the chairman of the group, Dr. Yoloye, includes such a possibility in his view of what might be done in evaluation in the long run.

We felt, however, that it would be interesting to try to do something sooner, as well. The single largest contribution of the evaluation team so far has been to develop an instrument to examine classes of children who have been in the Program for some time, to see to what extent they have made progress toward these goals. (For a more detailed report than the summary that follows, see "A Comparison Study for Evaluating Primary School Science in Africa.")

We decided to compare some of those children who have been taught by teachers in the Program for one to three years with children who had not been taught by teachers in the Program. The first group of teachers had the use of written guides, and training from science educators or from experienced teachers (see page 23). In the judgement of the local science educators, they were doing a good job. The second group did not even know about the Program.

Teachers have often remarked that as children continue learning in this program, they get better and better at suggesting ideas and at doing things for themselves. We wanted to see if this was generally true.

We decided to see what a class of children who had had this experience for a year or more would do with materials when they were left to their own resources, without any teacher at all. Our idea was that if children really were learning how to do things for themselves, and learning to trust their own ideas, and learning about the material world, they would act differently from other children who, in school, were still doing only what they were told to do, and learning other people's ideas.

We chose materials that children in the Program had not been studying. That certainly would have put them at an advantage over the children with whom we were comparing them. Instead, we chose some materials which none of the children had ever seen - plastic colour filters, geometric pattern blocks, folding mirrors, commercial building sets, for example. We also chose some materials that are familiar to children whether or not they have been in the Program - cigarette foil, match boxes, rubber rings from inner tubes, scraps of wire and wood and metal, empty cotton spools, and so forth.

We could not watch a whole class of children at a time; so we chose a dozen from one class, having each child write his name on a piece of paper, and pulling out 12 names by chance.

We laid out the materials in a room in the school and then told the 12 children, in their own vernacular, to go into the room, and do whatever they wanted to do with the materials which were there. We told them that they could move around the room, and that they could talk to each other, and that they could work with their friends.

We did this in classes from Standards I through V which had been in the Program, and Standards I through VII which had not been in the Program. Since there were several classes at each of the grade levels, this meant that we studied about 40 classes.

We found that the children who had been in the Program did indeed have many ideas about how to work with these materials. They usually moved into the room quite directly, looked at the various tables to see what was there, tried a few things, and then started to work at something with involvement and concentration. Children sometimes worked alone and sometimes collaborated.

Every child had ideas of what he might do. A great variety of different things were done in one class. Materials were used in combinations that the adults had never thought of before. They were used not only on their original tables, but were carried about the room to be used in combinations with other materials. By the end of the 40 minutes, children were producing more and more ideas, and were always sorry to have to stop.

In contrast to this, classes which had not been in this program had a much smaller range of ideas. These children tended to do simple things, and to copy one another. There were often several children who simply never did anything constructive. They spent the whole time timidly watching others, touching things from time to time, but never committing themselves to anything. In some of these classes, after 25 or 30 minutes, all the children had run out of ideas, and had nothing left to do. There were very few instances of elaborate work where a child spent a lot of time and effort to overcome difficulties in what he was trying to do.

There was one another aspect to this evaluation. The 40 minutes of free time told us about the resourcefulness, the concentration, and the self confidence of children in these different classes - how readily they were able to find out about new things, and what ideas they had about using familiar things. We undertook another aspect, to see how they compared in their ability to think through and solve a problem that we gave them to do. The problems were ones that children of certain ages find difficult to solve, but that adults on the whole do not find difficult. We knew that children usually develop very slowly in their ability to solve problems like these, and that almost no special "training" can help them to do better. But we thought that children who had been in the Program for two or three years and had been thinking through problems on their own during the science activities might, over that long period of time, develop better ways than others.

There was only one class which had been doing science activities in the Program for three full years. This class did very much better on these problems than any other class of that level. Furthermore, we compared their results with three different classes of children one year older, and they did better than these older classes. Of course, we cannot draw final conclusions from one class, but this is a very encouraging indication of long range effects.

Children who had been in the Program for one or two years did slightly better, on the average, than other children the same age who had not been in the Program, although the difference was much less striking.

CONCLUSION

There are two major aspects to a complex job. One is the inventive aspect - having ideas about possible ways to do it. The other is the evaluative aspect - being able to tell how these ideas are working, which ones to keep, which ones to discard, and which ones to change.

Teaching is always a complex job. A good teacher must constantly be inventive - thinking of different ways to help different children, thinking of ways to use new books or equipment which become available, thinking of ways to overcome difficulties he has met previously. Good tutors, education officers, inspectors and advisors must be inventive in the courses they offer, the books they write, the suggestions they make when they visit. Responsible ministry officials must be inventive in the programs they recommend, in the ways they think of for teachers to help each other, in the ways they plan for change, and in the ways they relate education to the overall needs of their nation.

The goals of all these people are exceedingly long range - affecting the lives the children may lead in the future, what these children may do for their communities and their fellow citizens. No educators can afford to wait until the children grow up before judging the effectiveness of their ideas. They must have indications they can use as they go, which will show that, in the long run, they are progressing toward their goals.

Good examinations can serve to give indications about the amount of information children have gained. But even the best examinations cannot reveal the way children are developing in other important areas. There must be different ways to judge the progress.

As evaluators, we have sought to provide indicators that people can use to help them judge their progress as they go. For teachers, whose work

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with their pupils is the most central influence in the educational process, we have tried to suggest indicators that they can use in their classrooms day by day. For those whose job is to help teachers, we have tried to provide ways for them to judge the effectiveness of the courses, the writing, and the suggestions they offer to teachers. For ministry officials, we have tried to provide ways of judging how well this program as a whole can help large numbers of teachers to help children become competent, confident, resourceful individuals.

Since the Program is very long range - can never, in fact, come to an "end" - it is important to have questions all along the way that people can ask themselves, to judge whether the project is making progress toward what it is trying to do.

Asking those questions, and figuring out ways to answer them, has been the main job of this evaluation team.

Eleanor Duckworth
August 1970

APPENDIX

WHAT YOU CAN LOOK FOR

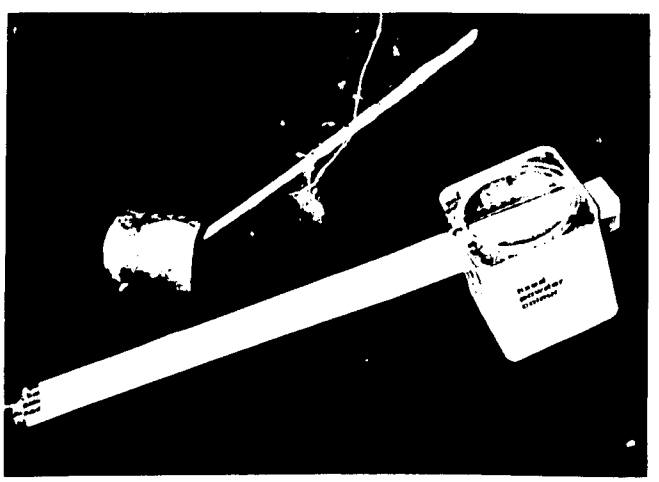
If there is no list of facts to be attained, how can a teacher or a visitor tell whether children are gaining from their science activities?

These notes are for both teachers and visitors. The first few pages are mainly for visitors. The last two pages are mainly for teachers.

First of all, if the children are engaged in these activities, there will be real things in the room to learn from, and they will look as if they are being cared for and used. Here are some examples.

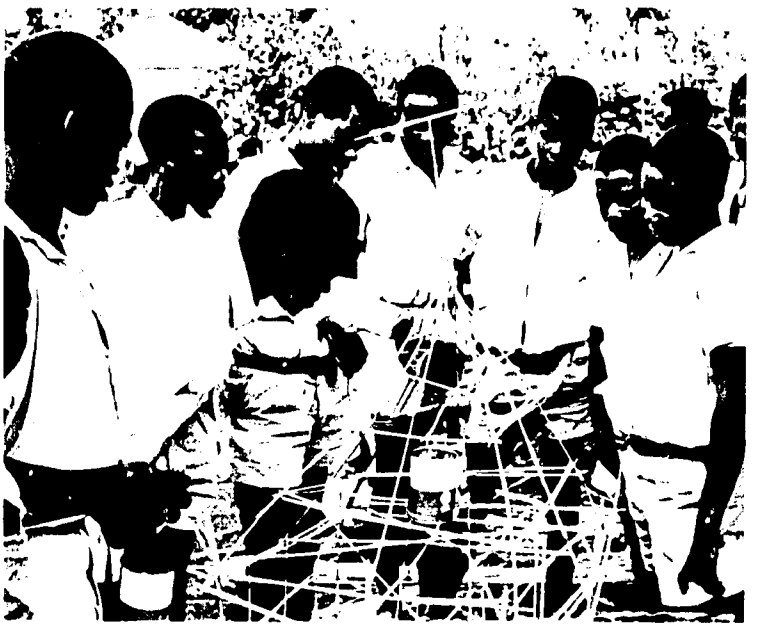
One class might have 20 or 30 or 40 or 50 tins and containers of various sizes, with plants growing in them. This class might also have some planted outdoors.

Or one class might have some hand-made musical instruments hanging from the walls or from the roof. In this class there would probably also be some materials for making musical instruments - bamboo, wood, wires, reeds, tins.



A class might have boxes of sand, with insects living in them, being cared for.

There might be some hand-made scales, with different things to weigh - bottle tops, stones, used torch batteries, palm nuts, soil.



There might be materials to build with - cigarette boxes, reeds, clay, wood, tins, sand. There might also be some weights to hang on the constructions, to test their strength.

In classes where the teacher has been teaching this way for one or two years, and has developed some experience and confidence, there may be materials for several different kinds of activity all at once.

Second, during the science periods, the children will be working with these materials - and not just listening to the teacher talk about them, or watching someone demonstrate with them, or writing down what someone tells them to write down. While they are working, the children will be free to talk to each other, to walk about, to go outdoors, to get materials that they need. Some may be making something; some may be using what they have made; some may be trying to do a specific thing - like making an ant lion go forward, or filling a tin until it sinks; some may be watching something very closely; some may be trying to 'see what happens if'; some may be setting up experiments; some may be arguing about different things they have found; some may be showing each other what they have done; some may be planning what to do next.

In some classes all the children will be trying to do more or less the same thing; in others, children will be doing many different things. Neither of these approaches is necessarily better than the other. It depends on the teacher, and it depends on the interests of the class. The important thing is whether the children are busy, know what they are trying to do, and have ideas about how to go about doing it.

If the teacher constantly interrupts and addresses the whole class, to give them further instructions, that is probably because he is requiring the children to do something in his way, instead of encouraging them to try ways that they have thought of. Similarly, if the children wait to get the teacher's approval of what they have done, that is probably because they are working for the teacher, and not for themselves. Or if a lot of children spend their time watching what a few children are doing, that is probably because they do not quite know what to do themselves.

Third, during the times when the teacher and children are discussing what they have done, the children will be talking more than the teacher. They will be listening to each other, and responding to each other, and asking each other questions, and giving their opinions.

Now the more children work in this way, the better they get at it. During the very first lesson of this sort, even the very best teacher will probably have difficulty, because the children probably will not have very many ideas of things to do; and they probably will not really believe that the teacher wants them to think of their own things to do; and they probably will not think that they should say when they disagree with something that has been said. At first, therefore, they will probably wait to be told what to do, not make suggestions of their own, not talk to their friends about what they are doing, try to guess what the teacher wants them to say. But

as children get used to this way of working, and really believe that the teacher wants them to try things in their way, they will take more and more of the initiative themselves.

So far, you may have noticed that I have not mentioned talking to the children. That is mainly for two reasons. First, because you can see the most important things just by watching - children are more likely to reveal what they know by doing, rather than by talking. But I confess that there is another reason, too. When I am visiting classes in Africa, I cannot understand what anybody is saying! So I have been forced to develop ways of looking that do not depend on words.

Other visitors, who do know the language, may want to talk to the children. Perhaps when you visit a class, the children will be learning something else - reading, or English, or social studies - and will not be engaged in science activities. How can you let them show you what they have learned?

Not all children will have done the same thing, or will have paid attention to the same thing, so it is impossible to make up a list of questions and expect all the children to give the same answer to them. Also, some

children will have learned things that they cannot say very well. They may have learned how to do something, for example, and the only way they can express that is by doing it.

Somehow, you want to give the children a chance to show you what it is that they have learned. The best way to do this, of course, is to start from the materials which they have been working with. You can ask some volunteers to tell you about the materials. If they are growing seeds, they may be able to tell you where the seeds came from and where the soil came from, and when they planted them. They may have planted them in some special way, in order to find out what happens (upside down, for instance!). They may have noticed something special as the plant grew, or they may wonder what is going to happen as it continues to grow.

If they have been studying time, and how to measure it, they may be able to show you some time-measurers they have made, and how to use them, and why they made them that way, and what difficulties they encountered, and who thought of a way to solve the difficulty. (We hope that children think of ways around the difficulties - and not only the teacher!)

Some children will surely be too shy to show you very much of what they have been doing. You can probably learn most by asking those children who want to show you. As time goes on, and you visit more classes, see more things they have been doing, and talk to more children, it gets much easier to know what to ask, in order to get the children to show you what they know. You will also be able to recognize when some children have done something unusual - something you never would have thought of doing yourself.

You can also find out from the teacher some other aspects of the work. You can ask the teacher what has happened that he has found exciting, and what has happened that he did not expect. You can ask him what he has done to interest the children, when their interest started to decrease. You can ask him if he has ever asked other people in the community for some ideas - people like a potter or a fisherman or a builder. You can ask him whether other teachers in the school have taken an interest in what he is doing. You can ask him whether he has any reactions from parents.

So much for the visitor. What about the teacher? Even the teacher, who is with his class every day, sometimes feels uncertain of the value of the work. Or sometimes he may feel confident that the class as a whole is benefiting, but he would like to know more about some individual child. How can he tell whether a certain child is benefiting?

I find it helpful to remember, first of all, the different kinds of aims we have. Some children may have made more progress in one than in another. The teacher should look not only for what a child knows, but for what he does, how much interest he shows, how much initiative he takes, how much he communicates with the other children.

Here are some questions a teacher can ask himself as he watches a child's work from day to day:

1. Does he make suggestions about things to do and how to do them?
2. Can he show somebody else what he has done so they can understand him?
3. Does he puzzle over a problem and keep trying to find an answer, even when it is difficult?
4. Does he have his own ideas about what to do, so he does not keep asking you for help?
5. Does he give his opinion when he does not agree with something that has been said?
6. Is he willing to change his mind about something, in view of new evide e?
7. Does he compare what he found with what other children have found?
8. Does he make things?

9. Does he have ideas about what to do with new material you present to him?
10. Does he write down or draw some of the things he does, so he does not forget what happened?
11. Does he sometimes know ahead of time what will happen if he does a certain thing?
12. Does he like to think of variations of ways of doing something?
13. Does he ever decide to do something over again, more carefully?
14. Does he feel free to say he doesn't know an answer?
15. Does he co-operate with other children in trying to solve a problem?
16. Does he ever continue this work outside school time?
17. Does he ever bring materials to school, to investigate in the same way?
18. Does he talk about this work at other times of the day?
19. Does he make comparisons between things that at first seem to be very different?
20. Does he start noticing new things?
21. Does he start raising questions about common occurrences?
22. Does he ever repeat one experiment several times, to see if it always turns out the same?
23. Does he ever watch something patiently for a long time?
24. Does he ever say, "That's beautiful"?

I think you will agree that if a child does even five or six of these things, he is benefiting.

One day I mixed all this liquids In one bottle and I put it Somewhere for three days. The next day I found only two liquids because some liquids Evaporated