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ABSTRACT

Science education specialists from Asian and Pacific countries convened to explore issues related to the evaluation of pupil science learning. This document contains a synthesis of the discussions and findings of the meeting. Summaries of the study group's deliberations are provided in four sections. Chapter 1 describes the participating countries' experiences concerning the nature of and problems in pupil evaluation. Common themes and issues are identified and discussed concerning instruction, the educational environment, and student attitudes. An analysis of current objectives and emphases of science education occurs in chapter 2. This chapter contains ideas on the purposes, prerequisites, influences, and constraints connected with pupil evaluation. Chapter 3 offers some possible solutions to the identified problems. Recommendations are itemized for societal, teacher, instrumentation, pupil, time, local, curriculum, facility, and language factors. Specific strategies and methodologies for evaluating pupil activities are presented in chapter 4. Descriptive tables provide examples of evaluation possibilities. The participants' names and addresses are included in an appendix. (ML)

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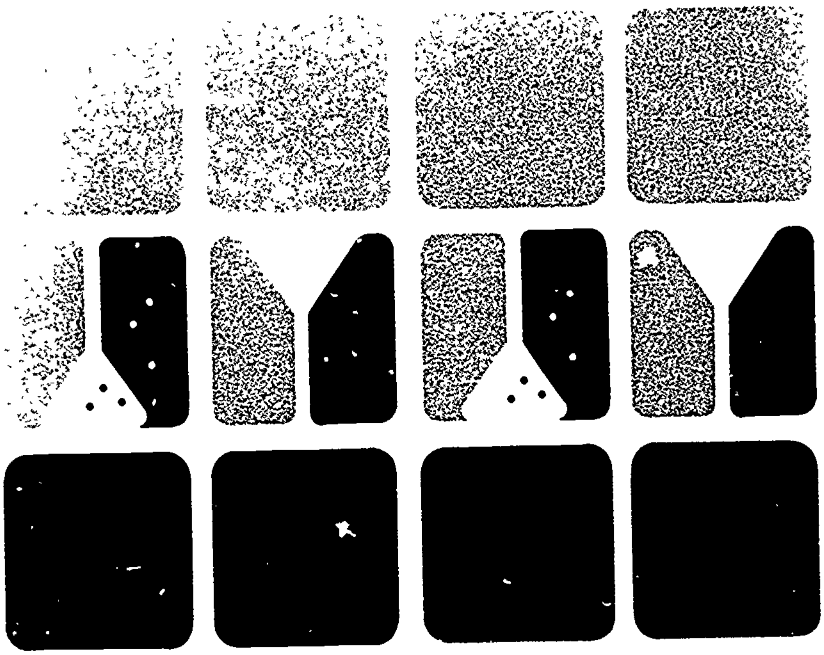

PUPIL EVALUATION IN SCIENCE

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FOR EDUCATION IN ASIA AND THE PACIFIC
Bangkok, 1985

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This is a report of a Study Group Meeting which brought together 16 science education specialists from Australia, Fiji, India, Indonesia, Japan, Malaysia, Nepal, New Zealand, Pakistan, Philippines, Republic of Korea, Sri Lanka, Thailand and the SEAMEO Regional Centre for Education in Science and Mathematics (RECSAM), to exchange information and experiences related to the evaluation of pupil science learning; to identify the common and special problems and issues in this field; work out some possible solutions to these problems and issues; and propose strategies and methodologies for developing performance evaluation in science.

The Study Group Meeting was convened at the invitation of Unesco Regional Office for Education in Asia and the Pacific (ROEAP) and was jointly organized by its Asian Centre of Educational Innovation for Development (ACEID) and RECSAM and was held at RECSAM, Glugor, Penang, Malaysia, from 9–18 January 1985.

The Group carried out its deliberations under the Chairmanship of Mr. Brandon W. Schollum (New Zealand) with Dr. N.M. Herrelia (Philippines) helping as Rapporteur.

C O N T E N T S

Chapter 1

CURRENT STATUS OF EVALUATION IN SCIENCE

Introduction

Two of the stated objectives of the Study Group Meeting were: to exchange information and experiences related to the evaluation of pupils' science learning, and to identify common and special problems and issues. Towards this end, the participan s described their countries' experiences concerning the nature of and problems in pupil evaluation. The purpose of this chapter is to provide a synthesis of these reports and to highlight common issues and problems.

It was evident from the presentations that the education systems, science curricula and pupil evaluation procedures very widely from country to country on a number of dimensions. For example, with respect to curriculum decision making, a few countries reported that for all except the upper secondary level the teachers in each school had the responsibilities for designing and implementing their own curricula. On the other hand, a majority of the countries have a very centralized curriculum in which there are few opportunities for curriculum decision-making by teachers. In terms of school resources and facilities there were wide disparities between countries. However, it is very evident that, despite these differences, the issues and problems with respect to pupil evaluation are remarkably similar.

A number of themes were identified which provide a focus for the discussion of the common issues and problems. Each of these is discussed below.

Linking Evaluation to Instruction

A decade or two ago, science education was primarily concerned with the transfer of scientific knowledge from teacher to pupil. The teaching strategies, mainly teacher centred, were designed to facilitate this process. Likewise, the evaluation procedures were designed to evaluate the extent to which this transfer of scientific knowledge of facts, rather than processes, had taken place. Pencil and paper examinations, mainly emphasizing recall of information, were successful for this purpose. In recent years however science curricula have placed more emphasis on developing a broader range of education objectives. Terms such as "process skills", "activity - oriented", "laboratory skills", "student interests and attitudes" commonly pervade the writings on science curricula.

These development in science curricula have not, it would appear, been matched by changes or developments in pupil evaluation procedures. There is often a disparity between the stated objectives of the science curriculum, which are often being imprecisely expressed, and the objectives that are able to be assessed by the pupil evaluation procedures employed by teachers and education systems. The disparity has created some confusion in the minds of teachers and students, both with respect to the nature of the science curriculum and evaluation of pupils learning. For example, if the science curriculum emphasizes scientific processes but the pupil evaluation procedures emphasize recall of scientific knowledge, it is likely that the former gives way to the latter.

An analysis of the science curriculum in a given school often shows that there is not one but at least three versions of the curriculum. Firstly there is the <u>intended</u> curriculum as proposed by the curriculum developers. The intended curriculum has a statement of objectives and stated or implied teaching strategies designed to achieve the objectives. Influenced by a number of factors, not least of which are the pupil evaluation procedures, teachers reinterpret this curriculum and implement it in a different manner than what was intended. This gives rise to the <u>translated</u> curriculum. Pupils are also influenced in how they react to the teaching and learning experiences presented by the teacher and science curriculum by a number of factors such as prior experiences and teacher expectations and the <u>achieved</u> curriculum is thus different from the intended or translated curriculum.

Many participants reported that the pupil evaluation procedures used were a major factor in producing this gap between intended and achieved curriculum and between instruction and evaluation. This is especially the case where external examinations are used. It was pointed out that for the most part external examinations evaluate pupil learning on a narrow range of objectives only, that is recall and comprehension of scientific information. Rarely are objectives relating to process skills, laboratory skills, and higher level cognitive skills evaluated.

At the level of formative evaluation, the evaluation procedures available to and used by teachers do not serve and support the development of a broad range of educational objectives. In most cases the school level formative evaluation procedures imitate those of summative evaluation. For a variety of reasons, teachers do not effectively use evaluation procedures for diagnosing student learning difficulties or for determining the level of concept development of the students to provide feedback for improving the teaching/ learning process.

The Educational Environment

In addition to the positive changes in science curriculum, there have also been changes in the educational environment in recent years. These changes include:

- The perception by government more than ever that their country's future prosperity is heavily determined by their development in science and technology and therefore on the quality of science education at all levels.
- The increasing proportion of students undertaking primary and secondary studies in science.
- The pressures to provide adequate education for "disadvantaged" sectors of the community.
- The pressures to provide special programmes for gifted students and for under-achieving students.
- High parental expectations of students, especially with respect to science.
- Large class sizes in many schools and inadequate or non-existent facilities including laboratories and science equipment.

These features of the education environment have a number of implications for pupil evaluation in science and have also produced some problems. Included in these are:

- The need to cater for all students and to allow students of all ability levels to undertake science studies.
- The need to develop curricula and pupil evaluation procedures in a variety of languages, especially with respect to providing equivalent versions of the same external examination.
- The problems associated with the language of instruction being other than the pupils first language.
- The need for science curricula to be seen to be fair to all language, ethnic groups and for males and females.

Teachers have improved in their ability to teach science and to evaluate outcomes of instruction but in many ways these pressures on teachers have reduced their ability to provide effective evaluation and instruction of as high a quality as they would like. They have tended to regress to the teacher-centred, knowledge-based curricula of the past.

The Purposes of Evaluation

A number of participants expressed the view that pupil evaluation procedures were being almost exclusively used for the purposes of distinguishing between, ranking, passing and failing, and selecting students. This is due, in no small way, to the importance attached to external summative examination scores by people that have significant influences on pupils' futures. Examination scores are used by schools for selecting students for promotion to higher grades, by tertiary institutions for selecting students for admission, and by employers for distinguishing between job applicants. The point was often raised that the use of pupil evaluation for comparing and distinguishing between students was over emphasized.

Rarely were pupils evaluated with the purpose of ascertaining the current status of their knowledge and understanding without comparison to other students. This information can provide valuable feedback for teachers in designing and modifying the teaching/learning processes. Recent research has shown the critical importance of determining the nature of students' understandings of a given topic prior to instructions in that topic.

Student Attitudes

An important issue raised was the very negative attitudes that some students hold toward science education. Students considered science to be too hard, requiring memorization of large amounts of information and being not relevant to their everyday lives.

The emphasis on external examinations has had a significant influence in causing these poor student attitudes. Students focus only on the goal of passing the examination and their attitudes are reflected in statements such as "tell me only what I need to know and I will learn it", "if its not going to be examined I won't learn it", and "science is remembering, not doing". It was pointed out that teachers often promote these attitudes by using the threat of failing the examinations as a motivation factor.

Chapter 2

MAJOR ISSUES AND PROBLEMS

Science education in participating countries has changed considerably in the past ten years. For many years science education was concerned primarily with facts and laws of science which were memorized by students. Laboratory work, if done, was concerned mainly with verification of stated facts and laws. Science education was provided to a relatively small number of pupils.

Science education today has different objectives and emphases. Pupils are expected to be active participants in the learning process, often doing activities and experiments with an inquiry approach, posing their own questions and seeking answers to them, discovering and solving problems, working with everyday materials and scientific equipment, in classrooms, in the field and in equipped laboratories. Science education is one of the means to reduce prejudices and obscurantism. More countries are trying to provide science education to all pupils in the formal school system.

The Concept of Evaluation

Evaluation of pupil learning in science, which now is concerned with the new objectives and emphases, can be defined as "continual measurement of pupil achievements to assist in decision-making at various stages".

Both instructional and curriculum objectives should be evaluated, in the following categories:

- cognitive: including both low and higher level objectives relating to the content of the curriculum;
- affective: including interests, attitudes, values and cognitive preferences used in decision-making;
- psychomotor: including manipulative and laboratory skills;
- processes of science: which incorporate aspects of cognitive and psychomotor categories in particular.

Evaluation of pupil learning can be carried out in many ways including daily observations of pupils and their records, discussions between teacher and pupils, written tests, performance tests, teacher questioning, peer evaluation and pupil self-evaluation.

Evaluation may have several purposes:

(a) to meet a social need such as to provide a certificate on completion of a stage of schooling, to provide information to employers, or to indicate readiness for higher study;

(b) for grading or selection of pupils. This purpose is often referred to as summative and usually takes place at the end of a unit of study or at end of term or end of a year of study; and

(c) for provision of feedback to teachers for the diagnosis of learning difficulties of pupils. This purpose is referred to as formative and usually takes place part way through a unit or course. It requires follow-up to assist pupils who are having learning difficulties in order to improve instruction.

The main purpose of pupil evaluation in science should be to improve instruction. While it is necessary to recognize the need of pupil ranking and selection, evaluation should be formative, to diagnose learning difficulties and follow up in order to improve instruction.

Pre-requisites for Effective Evaluation

In order to use pupil evaluation in this way, teachers must understand and value the importance of this purpose of pupil evaluation and they must have the knowledge and skills to carry out pupil evaluation and do the important follow-up. They must have valid and reliable instruments in order to evaluate effectively.

Teachers must have time to plan, write and administer tests and to analyse and interpret the results and use them in order to improve instruction.

Teachers must have the facilities (laboratories or science activity rooms, for example), equipment and resources for evaluation of manipulative and laboratory skills.

They must be able to assist students individually to overcome learning difficulties and improve their learning.

The curriculum materials (teachers guides, textbooks) must state the objectives of science teaching clearly, including higher level cognitive, affective, psychomotor and process objectives. These materials should contain science that is relevant to all students to assist them to live in and understand their environment. There must be effective communication between teacher and pupils.

Pupils should be interested in learning science and should work together co-operatively during learning activities. Provision should be made for pupils from disadvantaged groups.

Influences on Pupil Evaluation in Science

The strongest influence on science education in the participating countries is the status given to the external examinations and the pressure from parents and from society as a whole for pupils to obtain good results. The attitude of many governments, ministries, teachers, parents and communities is that the main purpose of pupil evaluation is to rank pupils for selection to higher levels of study. This attitude and concept of evaluation have led to domination of science teaching by external examinations, influencing both instructional and evaluation procedures. Society tends to be reluctant to accept changes in education, particularly changes in the purpose of pupil evaluation.

The high status of external examinations is associated with examination bodies consisting largely of university and ministry staff with little involvement, if any, of competent teachers or parents.

In general, teachers are not provided with sufficient experience or training in using evaluation for improvement of instruction. They often do not understand the new curriculum approaches and their skills to evaluate all curriculum objectives are not adequate for the task.

Teachers are not provided with a sufficient range of exemplars of items and instruments for evaluation of higher level cognitive abilities, attitudes, processes and performance. They tend to evaluate achievement of lower cognitive objectives only and neglect higher cognitive, affective, psychomotor and process objectives.

Because of problems experienced by teachers, many of which are due to factors beyond their control, pupils lose interest in school and many dislike learning science. Pupils from disadvantaged groups often do not receive special attention. Pupils often develop strongly competitive attitudes.

Constraints on Teachers

There are many constraints on teachers which limit their ability to conduct pupil evaluation effectively.

Teachers are often unable to complete the curriculum. They feel that they must do so in order to prepare pupils adequately for the demands imposed by external examinations.

The level of resources available does not always enable provision of laboratories and sufficient equipment. As a result, it is not always possible for teachers to evaluate pupils activity and laboratory skills.

The language of science instruction in some cases is not the mother tongue of the students, resulting in difficulties of communication between pupils and teachers. This creates problems in evaluation which are aggravated when there is inadequate standardization of science terminology in some languages. Differences in language are associated with different cultural backgrounds of pupils who live in different geographical locations. Different forms of evaluation instruments are often necessary to provide for these differences in pupils.

Teaching loads are often very heavy and classes are large, making it difficult for teachers to carry out evaluation and use the results in order to improve pupil learning.

Most of the present day curriculum materials (teacher guides, textbooks) do not contain higher level cognitive, affective, psychomotor and process objectives that the teachers are expected to evaluate.

The discrepancy between the needs of teachers for effective evaluation of science learning and the present situation in schools is due to societal (attitudes of society to evaluation) and economic (financial) pressures. The pressures and constraints on science teachers have resulted in a number of major issues and problems concerned with pupil evaluation in science.

The problems are identified and described in more detail in the following chapter.

Chapter 3

DESIRABLE NEW DIRECTIONS

The second task of the Meeting was to identify and work out some possible solutions to the problems and issues identified.

In the following pages, besides stating each problem, there is a brief description of the premise which is the main, but not the only, factor in determining each problem.

For most of the problems stated, there is a range of possible solutions given, and each country could implement or adapt those that are appropriate, according to its particular needs and available resources.

1. Societal Factor	The Problem
Selection processes for jobs and for further study dominate the entire teaching/learning process.	a) Examination results are used as the predominant or only factor for selection to further study, or to jobs. b) The external examination has an undue influence on the teaching/learning process.

Possible Solutions

While the external examinations remain, there is much scope for improvement of the examinations themselves:

(a) the range of mental processes evaluated could be broadened using better constructed questions;

(b) examination setters could be given help in working from a table of specifications of objectives and contents;

(c) examination setters should have practical experience of the range of learning problems of pupils; and

(d) teachers should be involved in examination setting process.

Pupil evaluation in science

It is high time that there should be moves towards partial and then ultimately total internal assessment with responsibility given to schools to carry out the assessment of pupils' learning. Expert advice and moderation procedures, coupled with other procedures described below, should ensure that standards of teaching and learning will improve. The need for at least partial internal assessment is seen as highly desirable, for in this form of assessment the school can focus on objectives and techniques that cannot be adequately assessed by paper and pencil examinations, e.g.:

- seminar presentations
- discussion involvement
- participation in debates on science-sc , issues e.g. conservation; creation-evolution
- project work
- laboratory work, particularly manipulative skills

Some countries have external practical examinations which have an internally assessed component. For internal assessment pupils can be provided with practice in the skills to be assessed, and given the criteria of assessment. The pupils are given a novel problem to solve and report, or are asked to replicate a particular experiment already done. The mastery of manipulative skills used in the right context is critical, e.g. operation of a burette, pipette, etc., in volumetric analysis.

It is noted that, while the possible solutions above require some moderation, the experience of several countries shows there are logistic problems with external practical examinations.

A mark obtained in the school assessed section of the course can be portrayed separately or as part of the final mark incorporating the examination mark.

Any external examination results should be reported in conjunction with a student profile which could include information on:

- aptitude in laboratory work
- participation in school and class activities
- responsibility, punctuality ......
- communication skills - oral, written
- decision making skills

There should be an active programme to inform employers how to use such a profile in job selection.

Once in place, there must be evaluation procedures to check the usefulness of such a profile.

The groups that should be involved in the construction and monitoring of the student profile are teachers, employers, parents and regional administrative personnel.

2. Teacher Factor

The emphasis given to 'evaluation' and to science education itself in many pre-service teacher training programmes is inadequate, e.g. 0-100 hours of science education in many primary teachers colleges. This reduces the ability of teachers to understand and work confidently with the variety of evaluation procedures available for use in the classroom. The opportunities for continual in-service training are limited.

The Problem

a) Inadequate understanding and perceptions of new goals of science education.

b) Many teachers lack competence, confidence, positive attitudes, and support to cope with the new emphasis on "doing" science and the processes of science.

c) There is an emphasis on summative evaluation of achievement/ performance rather than on formative evaluation to improve teaching and learning.

d) In practice, teachers emphasize lower level cognitive objectives rather than higher level mental processes, including the systematic practice and development of process skills.

Possible Solutions

1. To provide pre and in-service training for teachers of science in:

   (a) the value and use of diagnostic testing to improve teaching and learning;

   (b) the skills and processes used in construction and administration of tests and interpretation, especially for tests covering the full range of educational objectives;

   (c) participating in development and analysis of a range of appropriate evaluation procedures, using expert advice, e.g. through such groups as Science Teacher Associations, school clusters, resource centres, etc.; and

(d) remedial procedures for improving students' learning.

2. Model teaching and learning packages can be developed and disseminated to teachers. These would show teachers how to use formative evaluation effectively in their teaching. Such packages could illustrate the range, strength and persistence of children's existing ideas before and during teaching in specific topics, and the mismatch between the students' achieved curriculum and the teachers' intended curriculum in a particular topics.

3. School clusters could be set up to work on tasks of common interest and share information on pupil evaluation. These clusters should build on existing structures.

4. Existing and new Resource Centres should be established to provide materials for pupil evaluation.

5. Teachers could be encouraged to form Science Teacher Associations to provide assistance to teachers.

Existing educational bodies, school groups, resource centres and teachers should work together to enable these solutions to be achieved.

3. Instrumentation Factor	Problem
There are not sufficient appropriate evaluation instruments available for teachers.	There is a lack of valid, reliable evaluation tests and other instruments (particularly in the affective and psychomotor domains).

Possible Solutions

There is much scope for the development of a large bank of pretrialled items and instruments within each country. Such a bank should include:

(a) culture free or culture fair items covering the full range of education objectives;

(b) a range of different types of item (multichoice, short answer, essay) and instruments with guidelines on how these can be used effectively in formative evaluation as well as in summative evaluation; and

(c) detailed descriptions and specifications of all items.

These items should be made available to classroom teachers and information about them should be widely disseminated.

Efforts should be made to identify item banks already in use, and to share these between countries. Expert item writers could be asked to contribute items.

School clusters, regions, national centres and international centres should be involved in establishment of item banks.

4. Pupil Factor	Problem
There is evidence that current evaluation are having a negative effect on students interest in and attitude to science education. Particular groups of students are being disadvantaged.	a) Pupils lose interest, develop competitive attitudes, and may not take science subjects. b) Current evaluation procedures disadvantage some groups, e.g. girls; ethnic minorities; those pupils with physical, mental or social disabilities.

Possible Solutions

Evaluation procedures should be appropriate for the ability levels of different groups of students.

Measures should be developed to ensure that the procedures do not disadvantage any group, e.g. pretrialling items.

Evaluation procedures should account for alternative teaching strategies which are aimed at promoting student interest in science.

- participation in science clubs, fairs and visits to places of interest in science
- give co-operative exercises such as model making and use group evaluation
- use criterion reference testing more often
- relate teaching and learning to the pupils prior and everyday experiences

5. Time Factor

The demands on teacher preparation time and the nature of the overloaded curriculum do not allow for well prepared and conducted evaluation procedures.

The Problem

Teachers use time that could be given to formative evaluation for drilling for external examinations. Other teachers are unable to complete the stated curriculum effectively.

Possible Solutions

There should be on-going evaluation of the current curriculum concerning:

(a) quantity of material in terms of content

(b) resources available as opposed to those required to properly implement the curriculum

(c) how teachers could be assisted to select curricular materials wisely

(d) mismatch between achieved curriculum and intended curriculum

Such an evaluation must involve cooperation among teachers, curriculum developers, and educational researchers.

6. Local Factor

In many countries in this part of the world, classrooms are often overcrowded. Teachers are unable to carry heavy workloads and give individual attention and assistance to students.

The Problem

It is virtually impossible for teacher to cope with the difficulties faced by students in a large calss and to evaluate effectively the performance of these students.

Possible Solutions

The effective use of oral evaluation, peer assessment and self-assessment could be looked into carefully to overcome the stated difficulty. Eventually, the class-size would have to be reduced to its optimum size.

Teachers should have access to pre-prepared and tried evaluation items which can be used and interpreted with minimal effort.

7. Curriculum Objectives Factor

One of the main concerns of current innovation in science education is to encourage student attainment of higher level cognitive, affective and psychomotor objectives.

The Problem

Existing science curricular materials (be it teacher guides or student texts) do not always adequately indicate higher level cognitive, affective and psychomotor objectives or how to evaluate them.

Possible Solution

Such objectives should be clearly stated for teachers to use. Also, where possible, relative emphases for cognitive, affective, psychomotor and process objectives at different levels of schooling should be made explicit to teachers.

National Centres for curriculum should review their curriculum materials in view of theses requirements.

Guidelines and exemplars on how these objectives can be evaluated should be provided.

8. Facility and Resource Factor

To teach science and hence to evaluate the learning outcomes meaningfully requires proper facilities, suitable equipment in sufficient quantity, and adequate resources.

The Problem

To a large extent, schools in many countries in this region are not well equipped with facilities and equipment. This poses great difficulty for teachers in their efforts to find an appropriate way to develop and evaluate the full range of science education objectives.

Possible Solution

One possible way is to establish or expand resource centres to provide the necessary equipment, hardware and software. Teacher should be encouraged to improvise and use readily available and low cost materials wherever possible. Ultimately, sufficient laboratories and adequate equipment should be provided.

9. Language Factor

Good communication between teacher and pupils (students) is always essential for effective evaluation. Good command of the language of instruction by teacher and pupils is a strong asset.

The Problem

In a good number of countries in this region, the mother tongue is often not the language of science instruction. The problem is then one of determining what is actually being measured - science understanding or language ability. This situation is more acute when equivalent examinations have to be set in different languages. Insufficient standardization of science terminology increases the problem of communication.

Possible Solution

It is important that some kind of standardization of science terminology be made. This would certainly overcome the difficulty of using inappropriate terms for describing concepts in science. To improve student and teacher command of the language in which science is taught would equally be important. Where possible, having parallel forms of examinations in different languages could be an advantage. Cooperation between linguists, teachers and scientists is necessary to enable these tasks to be done.

In translation of materials from one language to another, proper care should be taken in order to maintain uniformity among various language versions of test items.

Chapter 4

SOME STRATEGIES AND METHODOLOGIES FOR EVALUATING PUPIL ACTIVITIES

Despite the efforts made by the participating countries to improve their science education programmes, there are still problems in the area of pupil evaluation. Some of these problems can be resolved in the short term, others require longer term solutions. There is an urgent need for immediate action to be taken.

With the stress on processes and methods of science and the need to evaluate higher cognitive, affective and psychomotor objectives, science teachers have a very difficult but vital and significant role. The success of science education and pupil evaluation in science is dependent upon the ability of teachers to carry out their central role effectively.

Teachers have heavy demands on their time and abilities and many are under pressure to change their approach to concentrate on fundamental science skills and processes. There is an increasing need to develop their abilities and to provide them with the opportunity to use strategies and methodologies that will assist them to improve pupil evaluation.

The following strategies and methodologies relate to pupil performance evaluation, an area of pupil evaluation that has been relatively neglected because there are many difficulties, in carrying out such evaluation effectively in the present situation.

The concept of performance evaluation used here relates to understanding what is actually occurring when students are 'doing' science, and how both the process of science as well as the products of such experiences of students can be evaluated. Thus pupil performance evaluation is not restricted to measuring whether or not pupils can carry out or perform specific actions, such as to measure length within given specifications but includes knowledge and attitudes used to find the answers to problems posed.

Strategies

Training in task analysis

Science teachers often do not understand that pupil activities and laboratory tasks require pupils to use knowledge and attitudes in addition to manipulative and laboratory skills. Since their understanding is essential for good teaching and pupil evaluation, steps should be taken to help them to see the different processes and skills involved in pupil activities.

Teachers can be trained to analyse each activity or laboratory task into its components. When they realize the whole spectrum of what a pupil evaluation activity will cover, evaluation will no longer be such a difficult task.

An illustration of a task analysis is provided in Table 1 on the following page.

Pupil peer evaluation and self-evaluation

With large class sizes it is impossible for teachers to evaluate pupils actions individually. However, pupils can be trained to work in groups using a combination of peer evaluation and self-evaluation to evaluate their own activities, and the activity itself.

Training can include use of a set of guide questions for pupils to use. Pupils can discuss the contributions of each group member and should be encouraged to think carefully about what they are doing and why they are doing it.

An example of a guide for pupil evaluation is provided in Table 2 on page 20.

TABLE 1

Example of a task analysis

Task: Identify a sample block of metal (copper)

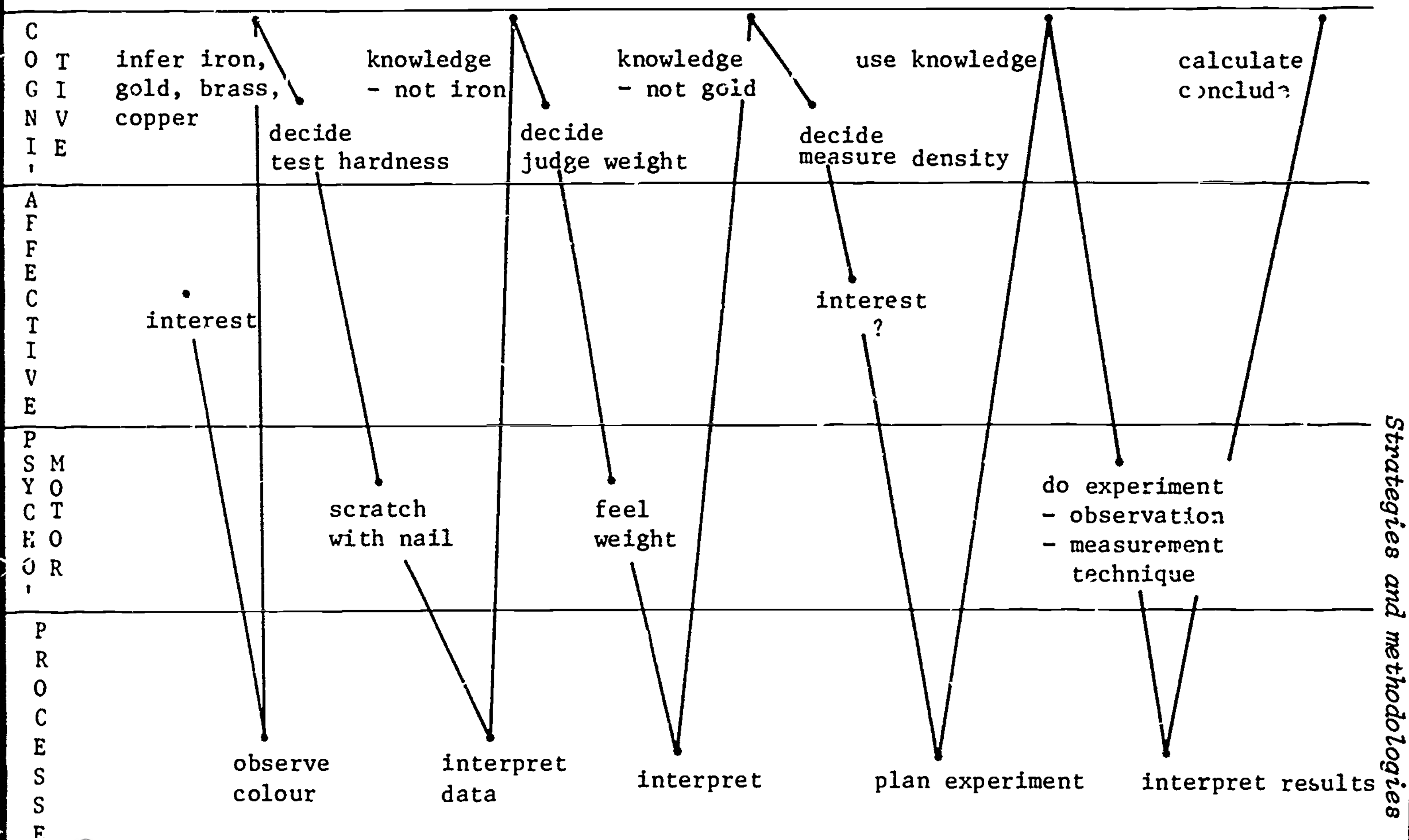


TABLE 2

A checklist of questions suitable for science activity evaluation and self evaluation

1. What were you trying to find out or show?
2. Were the instructions easy to follow?
3. What words did you find hard?
4. Did you know exactly what to do?
5. Was anything hard to do or understand?
6. If you asked for help, who did you ask?
7. Why that person?
8. When you did each part of the activity, did you really know what you were doing?
9. If you talked to other students about the activity, which did you talk about?
10. What were the results you got from the activity? What did your results mean to you?
11. When you got a result, did you think it was what the teacher expected you to find out?
12. What did you do with your results?
13. What have the results to do with what you were trying to find out, show, or prove?
14. Did you really understand what you were doing during the activity?
15. Is everyone getting an opportunity helping to get the work done?
16. Is everyone willing to work?
17. Did you enjoy the work? Why?

Use of worksheets

Worksheets are a useful alternative to observation of pupil actions. They may be structured, unstructured or a combination of both types. Examples of these different types of worksheets are given in Table 3.

A structured worksheet provides directions for pupils to follow and questions that evaluate their progress through an activity.

An unstructured worksheet may pose a problem in the form of an open-ended question, leaving pupils to work out their own procedures. A guide to the type of report required may not be present or may be in general form: for example, asking pupils to record what they did, why they did it, what they saw (heard, or smelled) and what they concluded.

TABLE 3

Examples of Worksheets

A. Structured

1. Look at the sample. What colour is it?

2. How many petals do you see?

3. What is the length of the biggest petal?

B. Unstructured

Outline the procedure you would use to identify the unknown substance A.

Carry out these procedures and record all observations.

C. Combination of structured and unstructured

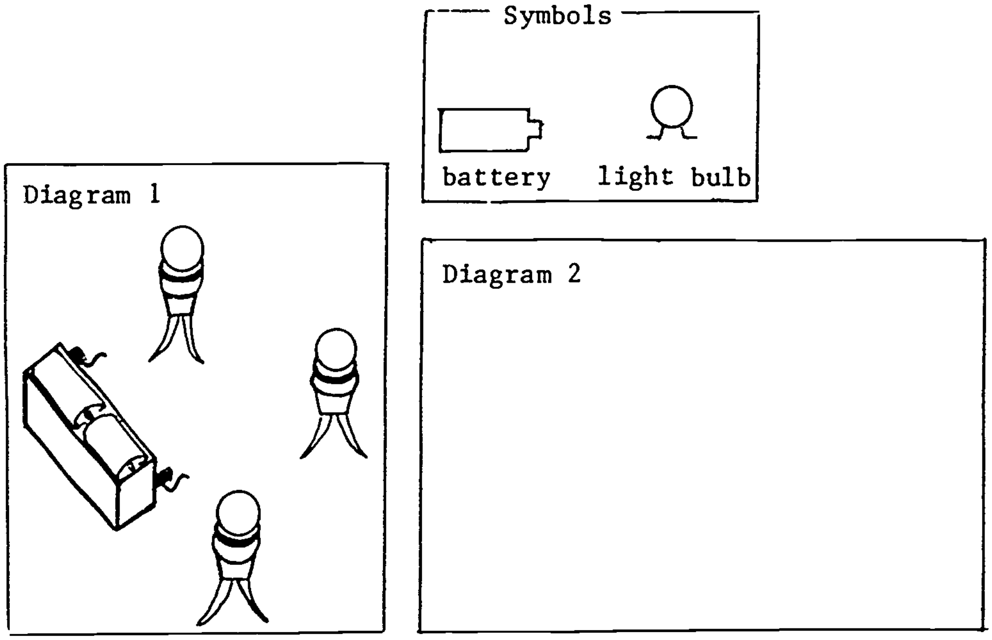
Problem: Of the three miniature light bulbs on the desk (A, B, C) only one is a flashing light.

1. After investigating, write in the space below which is the flashing bulb.

Answer: ____________

2. How can the three bulbs be wired up so that two of them flash and one emits a steady light?

When you have carried out the experiment, first complete diagram 1. Next, using the symbols below, show how the bulbs should be wired up (diagram 2).



A Guide to Expectations of Pupil Ability at Different Levels

Teachers have difficulty in understanding at what year or grade level different processes are appropriate. Some processes can be evaluated at all levels but at different degrees. For example, primary pupils may measure length with handspans or with a ruler using large units, while senior secondary pupils would be expected to use vernier scales to a high degree of accuracy.

Other processes may not be appropriate for junior pupils.

Teachers need detailed guidance on which processes are appropriate for which levels and to what degree.

Guide to Frequency of Evaluation of Each Process

Teachers could be assisted by an indication of the relative importance of each process at each age or year level and a guide to the desirable frequency of evaluation of each process. In this guide, frequency of evaluation needs to be stated for each method of evaluation, such as observation of pupil actions by the teacher, pupil group self-evaluation, use of worksheets, and teacher questioning.

The guide should provide flexibility for teacher use and should indicate possible frequencies for different objectives and different groups of pupils.

Methodologies of pupil performance evaluation

Observation of pupils doing science

One way to evaluate effectiveness of teaching is to observe the behaviour of pupils and to record the observations. Observations can direct whether or not students are interested in or are enjoying the task and how well they use the materials and equipment provided.

Observations can be carried out by pupils or teachers. Checklists may be used to provide a structure for the observations.

An example of a checklist for teacher observation of pupil activity is provided in the Table 4.

TABLE 4: Example of checklist to help teacher observations of pupils

A. OBSERVING	Keith C.	John B.	Aaron C.	Joanne G.	Shelley K.	Marion N.	Shelley B.
Will spend time observing items which interest him/her.	✓	✓	✓	✓	✓	✓	✓
Make use of the different senses to observe accurately.		✓	✓		✓	✓	
Can focus on a specific item in a mass of information.	✓	✓		✓	✓		
Notice changes in the environment.	✓	✓		✓	✓		

Questioning

Questioning of pupils during the progress or at the end of an activity can provide information on pupil attitudes, knowledge and difficulties experienced in the use of equipment.

Such questions can be asked by the teacher or can be part of the pupil group self-evaluation. They can be unstructured, such as "How are you doing?", or very specific, such as "What did you see when you did that?". They can be incorporated into a worksheet or checklist or left open to teacher or pupil initiative.

Analysis of pupils reports

Pupils can be asked to report orally or in written form, individually or as a group. Oral reports are useful to evaluate pupils ability to explain orally and to use appropriate language and terminology. Written reports can achieve the same purposes but, in addition, can be used to evaluate ability to present information in an organized fashion, to make drawings, to draw graphs, and in general, to present in visual form.

Worksheets can be used to structure reports.

Test sheets

Evaluation questions can be used in conjunction with instructions on how to carry out an activity or on separate sheets from the instructions.

Test sheets can be structured in such a way that pupils will succeed only after carrying out a certain activity in the right way. For example, pupil can be asked to identify an object and must use a hand lens successfully in order to do so. Alternatively, pupils can be asked to bore a hole in a cork and can only do so if they can use or cork borer. Example of a test sheet is presented in Table 3 (item C).

Pencil and paper tests

Construction of good pencil and paper test items to evaluate pupil performance is difficult and time consuming. Such items need to be combined with other methods of evaluation to cover all performance objectives.

Some sample pencil and paper test items are shown in Table 5.

TABLE 5: Examples of different types of Multichoice Items

1. is Cognitive: Recall/Comprehension
2. is Performance: Measurement
3. is Process: Control of Variables
4. is Affective/Cognitive: Withholding judgement.

A. Which of the following particles are gained, lost or shared during chemical changes?

   a) electrons furthest from the nucleus of the atom

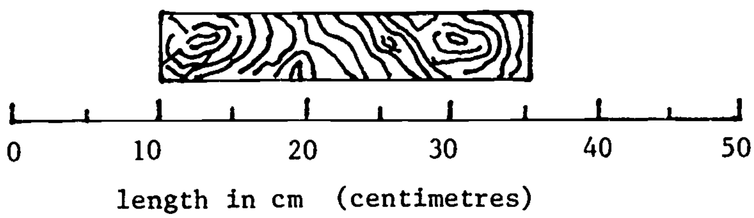
   b) electrons closest to the nucleus of the atom

   c) electrons from the nucleus of the atom

   d) protons from the nucleus of the atom

   e) neutrons from the nucleus of the atom

B. How long is the block of wood shown in the diagram?



   a) 10 cm

   b) 20 cm

   c) 25 cm

   d) 30 cm

   e) 35 cm

C. Mary and Jane each bought the same kind of rubber ball. Mary said "My ball bounces better than yours." Jane replied, "I'd like to see you prove that." What should Mary do?

   a) Drop both balls from the same height and notice which bounces higher.

b) Throw both balls against a wall and see how far each ball bounces off the wall.

c) Drop the two balls from different heights and notice which bounces higher.

d) Throw the balls down against the floor and see how high they bounce.

e) Feel the balls by hand to find which is the harder.

D. Which statement is true about an organism seen on a plant?

a) It is a parasite

b) It has sucking mouth parts

c) It is impossible to tell

d) It feeds on plants

Home involvement

Traditionally, the resources available at the homes of pupils have not been used effectively by teachers. Considering the fact that home background of pupils is a large factor influencing pupil achievement at school, home involvement in the evaluation of science processes and skills can be very beneficial.

In the Science-For-All context, the home can provide enrichment for the science learning and evaluation task.

Parents can be assisted to work with their children to evaluate progress in science learning. They can be assisted by worksheets or checklists on which feedback can be provided to pupils or to the teacher. Pupils can train their parents to work with them in a group self-evaluation activity. Parents can observe pupils activities, ask them questions and discuss what the pupil is doing and thinking. Questionnaires and opinionnaires can also be used.

Model making

Models can vary from simple constructions to complex working models. The degree of detail in construction, accuracy of representation or results and time taken to construct can vary considerably. Care must be taken to specify the purpose of the model and to limit the task to what pupils can reasonably achieve.

Model making can evaluate the highest forms of creativity in pupils. Models can be constructed from knowledge gained by reading, by experience, and imagination and creativity can be expressed.

Science fairs can be used to motivate students and stimulate their creativity.

The strategies for assisting teachers and methodologies of pupil performance evaluation outlined above can be used effectively to improve pupil evaluation by teachers.

Research projects

In order to provide additional support to teachers, two research projects are proposed.

1. Empirical investigations of pupils concepts of scientific phenomena: Such investigations should be conducted at two levels - at a research level, in research institutions, and at an action-research level, in the form of action-research by teachers in classrooms.

2. Development of a standard list of science processes related to doing science: At present there is lack of uniformity between countries on the specification and application of science process. Reference to a standard list would facilitate communication between countries.

Other follow-up activities that could be undertaken to improve pupil evaluation in science are outlined in the previous chapters.

Annex 1

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SELECTED APEID PUBLICATIONS
RELATING TO SCIENCE AND TECHNOLOGY EDUCATION

* *Physics curriculum development in Asia. 1978.*

* *Selection, maintenance and repair of school science equipment. 1978.*

* *Self-learning and instructional modules in science (a series of eight modules). 1979-1982.*

* *Universalizing education strategies for development and use of instructional materials. 1979.*

* *Designing instructional materials for general education and teacher training. a portfolio of experiences in Asia and Oceania. 1980.*

* *Linking science education to the rural environment – some experiences. 1980.*

* *Linking science education to real-life experiences and related productive skills. 1980.*

* *Linking science education to real-life: curriculum design, development and implementation. 1980.*

Biology education in Asia. 1980.

Curriculum development: linking science education to life. 1981.

Developing materials for biology teaching. 1982.

* *Mathematics education at school level – experiences in Asian region. 1982.*

Towards a better science education. 1982.

* *Some trends in the evolution of science curriculum centres in Asia, by M.N. Maddock (APEID Occasional Paper No. 12, November 1982).*

Integrating science and mathematics teaching with vocational and technical subjects. 1982.

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Report of a Workshop for Key Personnel Concerned with Out-of-School Scientific Activities by Young People. 1983.

Laboratory techniques for secondary school science education. 1984.

Training of science teachers and teacher educators. 1985.

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* Out of stock

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5. Educational technology with stress on mass media and low-cost instructional materials;
6. Professional support services and training of educational personnel;
7. Co-operative studies and innovative projects of research and research-based experimentation related to educational development.