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ABSTRACT

This evaluation report is concerned with Phase 3 of the Three Phase Primary Science (TPPS) course piloted in Papua, New Guinea, primary schools in 1969 and which was to be taught in all primary schools in 1973. Phase 1 is a series of activities; Phase 2, a series of simple experiments for the pupils. Phase 3 is a series of more formal experiments involving comparison, measurement, recording of data, simple graphing, voluntary sketching, and reporting. In this report, the entire course is described. Evaluation procedures, instruments employed, informal and formal procedures followed, and a note about the schools involved are presented. Overall results are presented in narrative and tabulated form. Phase 3 lesson analysis, a lesson observation form, examples of school science lessons, and data from schools taking part in the evaluation procedures can be found in the appendixes. (EB)

TPPS

THREE PHASE PRIMARY SCIENCE

PHASE THREE EVALUATION

INTERIM REPORT

by

Michael Wilson

TEACHING METHODS AND MATERIALS CENTRE

RESEARCH REPORT 24

UNIVERSITY OF PAPUA NEW GUINEA

MARCH, 1974

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SECTION A INTRODUCTION

T.P.P.S.

The Three Phase Primary Science (T.P.P.S.) course was piloted in Papua New Guinea primary schools in 1969 and was to be taught in all primary schools in 1973. The name of the course refers to the three phases or stages, each covering two years of the primary school course, into which it is divided. The three phases are described in the Teachers' Handbook as follows:

> *"Phase I is a series of activities during and after which discussions and questions should be encouraged.*
>
> *Phase II is a series of simple experiments. Pupils will be expected to observe and report what they have observed. If any child wants to make notes or drawings he should be encouraged to do so and given a notebook to keep his work in.*
>
> *Phase III is a series of more formal experiments involving comparison, measurement, recording of data, simple graphing, voluntary sketching and reporting. The sketching and reporting will be in notebooks given to all pupils for this purpose."* (Papua New Guinea 1969, p.8)

The present evaluation report is concerned with Phase III only. The aims of the course are described in the same document as follows:

> *"1. To provide the children with the opportunity to gain knowledge and understanding of the world about them in as interesting and enjoyable a way as possible through activity and inquiry.*
>
> *2. To encourage and develop the attitude of inquiry."* (Op.cit. p.4)

The T.P.P.S. course is one of pupil activity. Each weekly 45 minute science lesson in Phase III (30 minutes in Phases I and II) is described for teachers on a card contained in a ring folder. The card gives the title of the lesson, the class organisation (usually groups of 4), a list of materials required, brief instructions for the activity, a picture of children engaged in the activity and sometimes questions, further information, recording procedures and further additional activities. A kit of materials is

provided to each school while at the same time much of the material required must be collected locally by teacher and children. The scope of the lessons may be ascertained from the lesson by lesson analysis contained in the present report. (Appendix A) Further details of the T.P.P.S. course together with some sample cards may be found in Wilson (1972 pp.2-4, 148-151) or by reference to the course itself.

T.P.P.S. replaces a 'Natural Science Syllabus' which remained largely untaught in most primary schools in Papua New Guinea (Wilson 1972, p.1).

EVALUATION OF T.P.P.S.

In 1970 the Papua New Guinea Department of Education asked the Educational Materials Centre (now the Teaching Methods and Materials Centre) of the University of Papua New Guinea to undertake an evaluation of T.P.P.S. As a result of this request an evaluation of Phase I and II was undertaken in 1971/72 and a report published in 1972 (Wilson 1972). This report was concerned principally with the operation of T.P.P.S. in the classroom, rather than with the outcomes of the course. In 1972 the TMMC was asked to extend the evaluation to Phase III and the present report covers the work of the Phase III evaluation in late 1972 and during 1973.

The evaluation of Phase III involves several important changes in emphasis from the Phase I and II project. While there is a continuing interest in the use of classroom observation, and hence evaluation of the implementation of the course in the classroom, the nature of the observations has been considerably changed. There has also been an increased emphasis, as befits an evaluation of the last stage of a course, on the course outcomes. Attempts have been made to determine these outcomes through achievement (cognitive) tests for the pupils and attitudinal (affective) tests for both pupils and teachers.

The aims of T.P.P.S. as stated above provided a starting point for the evaluation. Thus Aim 1 is evaluated by observing lessons and administering cognitive tests while Aim 2 is examined, albeit inadequately, by means of the pupil attitude tests and again by lesson observations. The aims stated for T.P.P.S. are brief and in order to make a more adequate determination of

the aims and objectives of the course both the teachers' handbook and the cards themselves have been carefully examined. The teachers' handbook was particularly valuable in providing a guide for the classroom observation instrument. The cards have been analysed in terms of the skills and concepts involved. This analysis is presented in Appendix A and formed a basis for the construction of the cognitive tests. At the same time the evaluation has not been restricted to the aims explicit in the course where an extension seemed appropriate and desirable. This has been particularly so in the use of the observation data and the construction of the attitude tests.

Although the present evaluation is being undertaken after the course has been implemented and introduced into schools and may therefore be thought of as 'summative' (i.e. an evaluation which 'sums up' a completed course as a whole) it also has the characteristics of a 'formative' (on going) evaluation. It has already been decided, as noted above, that T.P.P.S. will be taught in all Papua New Guinea primary schools so there is little point in addressing the question of whether T.P.P.S. is better or worse than any other course as there is no practicable alternative for Papua New Guinea at the present time. What will happen is that the course (i.e. the cards) will be revised and developed in future editions. The primary object of the evaluation is therefore to determine the strengths and weaknesses of various aspects of the course and provide information which will be of value when this revision takes place. Hence the heavy emphasis on the lesson by lesson analysis contained in this report.

Although it was originally hoped that a final report on Phase III would be produced at this time the present report is of an interim nature. There are several reasons for this. The main one is the A and B organisation of T.P.P.S. which means that in 1973 all schools should have been teaching Phase 3B and thus it was not possible to conduct an evaluation of Phase 3A in that year.*

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* The A and B system as it applies to Phase III means that in any given year in terms 1 and 2 both Standard 5 and Standard 6 follow the same lessons - either Phase 3A (as in 1972) or Phase 3B (as in 1973). A and B years alternate so that each child completes both Phase 3A and 3B. In term 3 Standard 5 and 6 have science lessons designated for their particular Standard i.e. Standard 5 Term 3 lessons or Standard 6 Term 3 lessons. In fact some schools did teach Phase 3A in 1973 and although some data on Phase 3A was collected it has not been included in this interim report.

Another reason is that some of the evaluating instruments used in 1973 could only be piloted in that year and will need modification before being used in the final evaluation in 1974. It is hoped that the production of an interim report which indicates the methodology of the evaluation and provides some preliminary findings will stimulate feedback from those involved in T.P.P.S. and others which may be of value in the final report.

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SECTION B EVALUATION PROCEDURES

LESSON OBSERVATIONS

For the evaluation of Phases I and II a highly structured observation instrument was used by head teachers in their own schools in many parts of the country. For Phase III an attempt has been made to look more closely at what is happening in the classroom and this has resulted in a less highly structured more open ended form to be used only by those with a professional background in science education and a close knowledge of the T.P.P.S. course itself. This has meant that observational work has been restricted to the writer, the research assistant (who in fact carried out the bulk of the work) and science education lecturers in primary teachers' colleges in Papua New Guinea. Six of these latter from five colleges took part.

The observational instrument used consisted of a single quarto sheet printed on both sides. It is reproduced as Appendix B. In order to give some structure to the results and to facilitate analysis the front of the sheet asks for certain factual information concerning the lesson, school and teacher to be recorded. The observer is then asked to follow the lesson card during the lesson and to record in an open ended way under the general headings 'Instructions', 'Activities' and 'Discussion with Pupils' any deviation from the instructions and activities listed on the card. After the lesson he is asked to complete the back of the form with an overview of the lesson in terms of 'Difficulties with Activity', 'Difficulties in Understanding Science', 'Questions Children Ask' and 'Participation in Discussion'. Finally comments and suggestions are sought from both observer and teacher. With an observation instrument of this nature it is clear that the validity of the outcome depends very heavily on the professional judgment of the observers, all of whom have in fact had intimate contact with T.P.P.S. over a period of years. The number of lessons observed in each section of Phase III (excluding Phase 3A) is shown in Table I.

TABLE 1 LESSONS OBSERVED

	Phase 3B	Term 3 St.5	Term 3 St.6	Total
Number of cards (lessons) in sub-section	21	11	11	43
Number of lessons observed by research assistant	47	16	16	79
Number of lessons observed by others	25	10	11	46
Total lessons observed	72	26	27	125

THE COGNITIVE TESTS

During 1973 a group of science educators comprising the science staff of Port Moresby Teachers' College plus the writer were engaged on the construction of a series of Science Mastery Tests for the Department of Education. There are about 20 of these tests each with 10 multiple choice questions and based on the content of a small group of lessons grom T.P.P.S. These tests provided the basic material for the cognitive tests used in this evaluation. It was decided to produce a single test for each of the four sections of Phase III i.e. Phase 3A, Phase 3B, Term 3 St.6 and Term 3 St.5 (Phase 3A is omitted from this report for reasons already given) and to base these on an analysis of Phase III lessons which was carried out at the end of 1972 and reproduced here as Appendix A. The tests were constructed by selecting from the Mastery Tests a sample of questions to cover what were judged to be the most important items listed under the heading "Specific Sciencific Concepts". The results of this process are indicated in Appendix A where the numbers of the test questions corresponding to the concepts listed have been inserted in the analysis. Where necessary the Mastery Test items have been modified and occasionally completely new questions written. The test items are aimed at the general level of

knowledge, understanding and application rather than any higher abilities. A test for higher abilities is more appropriate in terms of the concepts listed under "General Scientific Concepts" and no test of this kind has yet been written for the evaluation. Neither has any attempt been made to analyse the items into precise ability categories because while the category may be clear for some questions, for most, classification depends on the details of the experience of each child which are not fully known. The test items are included in the lesson by lesson analysis (Section D).

The tests were administered initially in the schools in which the lesson observations had been carried out in the Port Moresby area. The sample of schools for observation had in its turn been chosen as a result of geographical accessibility, (see note on schools involved which follows) and timetable considerations in respect of the research assistant's programme, while avoiding atypical situations such as a demonstration school. It was hoped by using the same schools for both observation and testing to draw out some relationships between classroom activities, difficulties etc. and pupil achievement. The testing was later extended to coastal village schools up to 20 miles from Port Moresby.

ATTITUDE TESTS

There is some emphasis in the T.P.P.S. course objectives on attitudes - particularly an attitude of enquiry but also interest and enjoyment of science activities. It is also clear that in a situation of rapid change in technology and other spheres such as Papua New Guinea faces, a positive attitude towards and understanding of science - particularly its nature and application,- is of some significance. In Papua New Guinea such attitudes and understanding are likely to be developed for most people, if they are developed at all, in the primary school. For these reasons it was decided to attempt to determine the attitudes towards and understanding of science among Standard 6 children and to do this on a wider basis than that implied in the objectives of T.P.P.S. Accordingly an instrument (Science and Scientists) consisting of 29 statements relating to attitudes towards and understanding of science was constructed in

consultation with Dr John Jones of the Educational Research Unit of the University of Papua New Guinea (see Appendix C). The statements arose from considerations of the nature of the T.P.P.S. course, the significance of science in a low income country and a survey of the literature of tests of science understanding and attitudes.

For the purpose of describing the content of the instrument the statements may be broadly divided into four main areas of which the major one is the practical usefulness of science with 14 of the items relating to this area. These include four very general statements such as 'Science is good because it helps us to make useful things' and 'Some of the things which science does are bad'. There are also four statements of a less general type including 'Science can help people who live in villages' and 'The things we learn in science will help us when we leave school'. Finally within the area of the usefulness of science there is a group of six statements relating to more specific possible applications of science such as 'Science can help people to grow better crops' and 'Science can help people to become rich without working'. This aspect received considerable emphasis in the instrument for reasons alluded to above despite the fact that practical applications of science do not figure prominently in T.P.P.S.

The second area included is that of the nature and methods of science. Here the concern is simply to find out whether children understand that science is concerned with 'finding out new things' and that 'doing experiments' is the means by which this is accomplished. This aspect in particular is implicit, although never made explicit, in the T.P.P.S. course materials. Two of the four statements in this area read 'Science is good because it helps us to understand the things around us' and 'Scientists find out new things by doing experiments'.

A third area included in the instrument is concerned with the 'power' of science. This is important in that there was a suspicion in the writer's mind that children with a limited understanding of science might well see it in cargo cultist terms. This is alluded to in the statement 'Science can help people to become rich without working' which was mentioned above. There are five other statements directly related to this 'power' of science

including 'Many things happen which science cannot explain' and 'Scientists know everything now'.

Finally there are four questions relating to the difficulty of science. In this case the aim is to ascertain whether children believe that science is something which is so esoteric that it is impossible for them, or for most other people to understand it. Statements in this category include 'It is difficult to do science experiments' and 'Papua New Guinea People can learn to be good scientists like people from other countries'.

It will be noted that although this section is headed attitude tests there is a large cognitive (knowledge) component in Science and Scientists. Some statements such as 'Scientists find out new things by doing experiments' are wholly cognitive and most have a cognitive component. It is for this reason that the two words understanding and attitudes are both used when describing what the scale is attempting to assess and it is the opinion of the writer that it is impossible to separate these two in this context. To put this another way, what is being attempted is to examine these childrens' 'picture' or 'image' of science and to assess the accuracy and favourableness of this 'image'.

Pupils were asked to respond to the statements on a three point scale - Agree, Don't know, Disagree. Scoring was 3 for a 'favourable' response, 2 for Don't know and 1 for 'unfavourable' (see Table 3). The statements were carefully worded and checked by science teachers in schools to ensure that they were suited to the children for whom they were intended.

Despite efforts to make sure that the statements were clear and unambiguous and that the language is suited to the children there are considerable difficulties in a test of this type. Children may not have developed attitudes towards science or their own personal 'picture' of science. Even if they have they may not wish to make this known through the test, they may prefer to answer as they think the investigator would wish them to answer - to tell him what they think he wants to know. Finally they may not understand the statements or what they are being asked to do in a situation where it is not the right answer which is required but each child's own personal opinion or understanding.

These problems cannot be entirely overcome but there are ways of ascertaining whether the results are being severely distorted by some of them. One way is simply to examine the statements carefully to make sure they are clear and appropriate - as teachers were asked to do in this case. This process gives an indication of content (face) validity. The reader may care to do this for himself by referring to the 29 statements which are given in Appendix C. In addition there are certain statistical procedures which can assist. For example if a certain item is being answered randomly, perhaps because it is not understood, or if it does not relate to pupils' overall picture of science as measured by the instrument as a whole, then that item will not correlate positively with the total score. All items do in fact correlate positively with the total (except item 21) and the great majority at an acceptably high level (see Table 3).

A further procedure used was to carry out a factor analysis of the results from a group of pupils. This showed that pupils in their responses grouped items in a similar way to the groupings described above in the description of the construction of the test - this tends to confirm that children are able to undertake the test in a meaningful way. Lastly a statistical test of reliability of the instrument (Kuder Richardson Formula 20) showed a reasonable though not high level of internal reliability (0.53) with a sample of 792 pupils.

Taking all the above evidence into account it was judged that the instrument Science and Scientists had overcome the difficulties inherent in the situation to a degree that it was sufficiently reliable and valid to provide worthwhile, if at this stage somewhat tentative, results.

A second attitude instrument in the same form as Science and Scientists was constructed to assess pupils' attitudes to various aspects of the T.P.P.S. course. This instrument consisting of 18 statements was entitled 'School Science Lessons'. The statements were devised from the characteristics of T.P.P.S. lessons as culled from the Teachers' Handbook and the lesson cards. They fall into four loose groups. The first relates to science activities with particular emphasis on pupils finding things out for themselves. Two of the 5 items in this group are 'I like to find out things for myself in

science lessons' and 'Science lessons are BEST when the teacher does an experiment and we watch'. Secondly there are three statements about questions and discussion in science lessons. An example of this is 'During science lessons I like to talk to my friends about the experiments we are doing'. The third group of statements relates to specific areas of subject matter content. The five listed under the heading 'I like science lessons when we learn about ...' are a) plants and animals, b) electricity, c) soils and rocks, d) measuring things, e) magnets. Finally there are 5 items of a general nature which do not really form a group. These include 'The science we learn in school is hard to understand' and 'We should have MORE science lessons each week'. A complete list of the items may be found in Appendix D.

It will be noted that School Science Lessons has a much lower cognitive component than Science and Scientists - it is concerned almost exclusively with attitudes (likes and dislikes) and very little with understanding. So far as validity and reliability are concerned one would expect the problem to be less with School Science Lessons than with Science and Scientists as children are being asked directly for their opinions about something of which they have first hand experience namely their science lessons. Face validity may be assessed by comparing the statements included in the scale with the nature of T.P.P.S. lessons as described in the course materials - particularly the Teachers' Handbook. The expectation of higher reliability is borne out by the statistical evidence. A Kuder Richardson (20) reliability coefficient of 0.611 was obtained from a sample of 509 pupils and the correlation of each stem with the total score shown in Table 7 are positive in all but two cases and generally higher than those obtained from Science and Scientists.

The two 'attitude' instruments were administered by the writer and the research assistant to Standard 6 pupils in the Port Moresby and Rabaul areas - about equally in town schools and in schools in villages close to the two centres. In addition the writer had the opportunity to administer the instruments to small groups of pupils in two more remote rural areas - Namatanai in the New Ireland District and Kagua in the Southern Highlands District.

During the period of the evaluation of T.P.P.S. it has become increasingly clear, particularly through lesson observation, that teachers' attitudes

and background are a crucial factor in T.P.P.S. The education and training of primary school teachers in Papua New Guinea in relation to science varies greatly. Recently qualified teachers may have completed four years of secondary education and then have undertaken a two year college course which included science specifically related to T.P.P.S. At the other end of the scale most teachers at present teaching in primary schools (although not most of those at present teaching science) have completed no more than primary school plus one year of teacher training with little or no science. During the evaluation every opportunity to discuss the course with teachers in their schools has been taken. But it was felt necessary to contact a wider sample of teachers than can be approached personally and for this reason an attempt is being made to gather information on teachers' attitudes towards and understanding of both the T.P.P.S. course and science itself. To this end two instruments for use with primary science teachers, which to some extent parallel the pupil instruments described above, have been constructed.

The first of these entitled 'Science - Primary Teachers' examines teachers' understanding of and attitudes towards science. The major areas covered are the nature and methods of science, the usefulness of science and interest and enjoyment of science. The second instrument 'Primary Science Teaching' is based on the methodology and philosophy of the T.P.P.S. course and covers preparation for and teacher initiative in science lessons, pupil-teacher relations and pupil activity including questions and participation in discussion.

Items for possible inclusion in both instruments were submitted for scrutiny to a panel of 13 teachers college science lecturers and others working in science education in Papua New Guinea, who also added items of their own.

An initial version of each instrument was administered in late 1973 to a group of science teachers in the field (N = 62 (P.S.T.) N = 54 (S.P.T.)) and final year teachers college students (N = 141 (P.S.T. and S.P.T.)). Following a statistical analysis of the results from these two groups a revised version of both scales has been produced for use in 1974. It is intended to use these instruments to identify differences between teachers with different types of preparation for T.P.P.S., science background and teaching experience. In

addition an investigation will be made of the relationship between teachers' attitudes towards T.P.P.S. and science on the one hand and the attitudes and achievements of their pupils on the other.

INFORMAL METHODS

In addition to the formal evaluation procedures described above, efforts were made to gather information informally wherever possible. This took the form of discussions with science teachers and head teachers during visits to schools and with teachers' college staff and officials of the Department of Education whenever the occasion arose. Insights gained in this way are incorporated into the discussion of the results whenever appropriate and identified as such.

SCHOOLS INVOLVED

Passing reference has been made above to the locations of schools involved in observational work, testing and so on. A complete list of schools taking part is given in Appendix E which shows that while some observational work and attitude testing (and also informal contact) took place in rural schools, most of the evaluation has taken place in schools in or near major centres. There are obvious geographical difficulties in making personal contact with rural schools in Papua New Guinea. It is very expensive in terms of both time and money to make even a brief visit to a remote school and virtually impossible to have the kind of extended contact which was possible in urban and semi-urban schools. This means that the sample of schools used in this evaluation is not typical of Papua New Guinea primary schools and the question of the validity of the sample must be raised.

The previous evaluation of Phases I and II of T.P.P.S. which made use of head teachers in their own schools, covered schools in all parts of Papua New Guinea - most of the schools were in fact in rural areas. However an analysis of the results of the large number of classroom observations carried out in that study failed to reveal any significant differences between the operation of T.P.P.S. in urban and in rural schools. During the course of the present study the writer has had the opportunity to observe a small number of T.P.P.S. lessons in fairly remote areas of the country and the observations have been

in line with the earlier findings - in fact if one were to draw conclusions from the very small number of these observations one would have to say that the lessons observed in the more remote areas were if anything, among the more successful. Although one might expect urban schools to have some advantages - they have easier access to materials and to outside help and are generally more attractive to teachers and therefore have a wider choice of staff, the rural schools do also have some compensating advantages. Firstly, while town children have the advantage of greater contact with and understanding of modern technological application of science, rural children have similar advantages with respect to the descriptive biological study of the immediate environment on which much of T.P.P.S. is based. Similarly there are corresponding advantages for each type of school in the provision of local materials for science lessons. In addition while urban schools are attractive to teachers, recent, much better educated and trained teachers' college graduates tend to find themselves in rural schools early in their careers. There is also evidence from analysis of various kinds of material obtained from the small number of rural schools involved in the present evaluation to support the contention that differences between urban and rural schools in respect of science education are minimal. This evidence is included in later sections of this report. Thus the contention is made that the results obtained here from mainly urban and semi-urban schools are in fact valid in general for schools in rural areas also.

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SECTION C OVERALL RESULTS

LESSON OBSERVATIONS

The bulk of the material from the 125 lesson observations is contained in Section D - which gives the results on a lesson by lesson basis (in this section lesson numbers given in brackets refer to the report on that lesson in Section D where an illustration or further material on the point being discussed may be found). It is the intention here to draw out some of the most important general points which arise from observations of Phase III lessons. In this process it will be difficulties and areas of less than complete success which will be emphasised and this may tend to give a negative impression of the working of the course in the classroom. In view of this it must be stressed at the outset that despite the difficulties discussed below the observations indicate that Phase III of T.P.P.S. like Phase I and II, although to a more limited extent, continues to provide a wide range of experiences of science activities which, with a few exceptions, arouse considerable interest among and provide real enjoyment for the primary school children who take part. This is a major aim of the course.

The first aspect of T.P.P.S. lessons to be considered - the provision of materials - illustrates the emphasis on negative aspects noted above. The observation form asked observers to record materials listed on the lesson card which were *missing*. In 57 of the 125 lessons observed it was reported that some materials were missing. In 19 of these it was judged that this had a serious effect on the lesson. Sometimes the difficulty was due to lack of supplies from the Department of Education and in conversation many teachers complained of the dearth of such supplies. Further investigation of such complaints usually showed that materials which are supplied to schools on a regular yearly basis had been received but those for which special requests were to be and had been made did not turn up. However in many of the observed cases of missing materials it was material to be collected by teacher or pupils which was not available. (It should be noted in this connection that if really vital materials were not available the lesson would be omitted or postponed by the teacher and this situation would of course not be recorded on any observation form.)

There is a considerable amount of material to be collected by teachers for Phase III lessons which is particularly significant in view of the fact that science occupies only 45 minutes out of a total teaching week of about 1500 minutes. This is recognised by the writer of the course (Papua New Guinea 1969, p.5) but is expected to ease as teachers collect many of the things they need for re-use in future years. However the rapid turn-over of primary school staff means that by the time a teacher has completed the two year T.P.P.S. A and B cycle he may well be in a different school and can hardly take his class sets of large coffee jars with him, although these should be available for his successor. Only 12 of the lessons observed were taught by teachers in their third year of experience with Phase III and although the number involved is far too small for any firm conclusion to be reached their record for missing materials appears to be worse than average.

To assist in the systematic collection of materials there is a special pink card every ten lesson cards which lists the materials which the teacher will need to collect for the next ten lessons with a recommendation that he starts to gather these items together straight away. This does not appear to exert any influence. Most teachers collect materials at best the day before the lesson. There is a problem here but the policy of utilising and getting teachers to collect locally available materials for science lessons must be the right one on grounds of expense and relevance. The solution is to ensure that teachers are motivated, preferably by enthusiasm for the course, to build up a collection of materials in the science room of each primary school.

Having obtained the materials for his lesson the first thing the teacher must do is to organise his class into groups - groups of 4 are the norm. This is a straightforward matter as the grouping is generally the same every week and at Phase I and II level no difficulty was encountered. However at Phase III level observers sometimes reported haphazard group organisation. For example in a small Standard 6 class, as many are, where children could work in 10 groups of twos and threes there may be all sizes of groups up to 8 - apparently according to how groups of friends organise themselves. This is not a point of very great importance but is indicative of the relationship between some senior primary classes and a teacher from a lower class who comes to teach them once a week.

In order to get the lesson under way the teacher gives out materials to groups and then issues simple instructions based on the 'Do this' section of the lesson card. These instructions on the card are usually in the form of numbered sentences giving the childrens' activities in sequence. Difficulties frequently arise over the issuing of these instructions so that children are not sure what they are supposed to do. Sometimes this arises because the teacher himself is not sure, sometimes because the teacher has told the children too much all at once, sometimes because what the teacher says is simply confused, sometimes because instructions are given in the wrong order, sometimes because he *talks* about things with which children are not familiar instead of *showing* them. Many lessons suffer from one or more of these difficulties. What usually happens next is that the teacher goes round and shows one group what to do and this quickly diffuses to the rest. Even where this does not happen there are usually enough clues in what the teacher has said and in the materials themselves for someone to start doing something which approximates to what they were supposed to be doing and again this quickly spreads. The writer has frequently been surprised by the extent to which the collective common sense of the pupils can overcome all sorts of deficiencies in the teacher so that by the end of even those lessons which get off to a very unpromising start most children have done most of the things they were supposed to do. (Children are similarly observed using their common sense to come up with right answers to questions which they do not understand (Standard 6, Lesson 9).) An important point relating to the issuing of instructions and teachers' understanding of what is going on is that cards which might appear quite clear and straightforward to someone with even the most meagre science background may be quite confusing and genuinely ambiguous to someone with none. (Phase 3B Lesson 3; Phase 3B Lesson 14.)

Difficulties with the activities themselves sometimes arise because the teacher has not tried the experiment beforehand and is not able to foresee difficulties merely by reading the card (Phase 3B Lesson 3; Phase 3B Lesson 15). Teachers very rarely go beyond the activities listed on the card nor encourage children to do so and initiative in modifying or substituting materials is rare (Phase 3B Lesson 6). (An outstanding example of a lesson in which a teacher *did* follow up a child's alternative suggestion occurred in Phase 3B Lesson 21.) Sometimes activities must be performed in a certain order in order to follow a logical

process of development but teachers who are unaware of this may not preserve the necessary sequence (Standard 5 Lesson 4; Phase 3B Lesson 1).

Some reference should be made here to long term activities. These may involve the teacher in preparatory work some weeks in advance of a lesson e.g. planting seeds (Standard 5 Lesson 5) or alternatively following up a lesson the following week (Standard 5 Lesson 6). No case was recorded in which the long term preparatory work had been done and similarly very few follow up lessons were observed.

There is considerable emphasis in T.P.P.S. on the encouragement of childrens' questions. The failure to do so was a major criticism of Phases I and II. In only 16 of the 125 Phase III lessons observed did observers report that children asked questions although there was a section on the observation form specifically for this purpose. Many observers noted particularly that no questions were asked and some pointed out that the teacher did not encourage questions. In only one lesson was teacher encouragement of questions noted. The discussion of this problem in the Phase I and II report seems if anything more pertinent in Phase III (Wilson 1972, pp.15, 33-34). Fundamentally teachers do not encourage questions because they are afraid (certain) they cannot answer them. Pupils don't ask because they know the teachers don't want them to ask and because they know the teachers don't know the answers. When teachers do get questions which they can't answer ('Why does the water rise?' in a capillarity experiment and 'Why is the image upside down?' in the pin hole camera) the preferred technique, at least when an observer is present, is to cover one's ignorance with a multitude of words. Cover up techniques have also been observed in dealing with a situation where the outcome of an activity is not what was expected. In this case the outcome is either ignored or contradicted (Phase 3B Lesson 17; Phase 3B Lesson 18). Hardly an example to encourage "the attitude of inquiry".

One major difference between Phase III and Phase I and II is that Phase III involves more systematic recording in various forms of the results of activities. In practice this tends to get squeezed out at the end of the lesson through lack of time. This arises from the situation in which a teacher teaching a class other than his own must adhere strictly to the 45

minute time limit. The only type of recording generally possible under this limitation is that where pupils fill in a few words on a teacher prepared duplicated answer sheet. Other important aspects of T.P.P.S. lessons which get short shrift from this system are 'Extra Activities' (almost invariably) and discussion (occasionally). The question of one science teacher per school compared with each teacher teaching science to his own class raised in the Phase I and II report remains valid as does the conclusion that there are considerable educational advantages in the latter (Wilson 1972, pp.30, 39).

One further point which was not evident in the evaluation of Phase I and II arises from the lesson observations. This is the differences, in science classes, between girls and boys. Observers report that girls tend to show less interest, participate less in the activities and apparently gain less from them. It would appear that girls have learnt, from whom is not clear, that science is a subject for boys - this is certainly the impression they give. This is a situation which, if not encouraged, is at least tolerated by science teachers who have come to expect less involvement of girls in science lessons - and so a vicious circle is established.

The considerable range of difficulties with Phase III lessons which have been noted here and are very much more apparent than in Phases I and II, are no doubt factors behind a marked reluctance to teach T.P.P.S. which has been discerned during this evaluation in 1973. It is not possible to quantify this reluctance but it is apparent in several ways. Some schools visited freely admit that they are not teaching T.P.P.S. at all at Phase III level despite a directive from the Department of Education that all schools should do so. The reasons usually given are lack of a trained science teacher and less frequently lack of a science kit - neither of which are officially acceptable reasons. Other schools are less ready to admit difficulties with Phase III but it often becomes apparent in conversation that the course is being taught at best spasmodically. Finally several schools in the Port Moresby area contacted during first term with a request to observe science lessons only began to organise the course after the request was received. The basic reason for this reluctance, which is closely related to the difficulties described above, is that teachers who have not been trained to teach Phase III believe that it requires a lot of preparation, is difficult to teach and to understand and

that they must have a course in T.P.P.S. before they can teach it. (This is just one example of a widespread course obsession among primary teachers in Papua New Guinea.) There is some evidence to support some of these beliefs in the classroom observation reported above. However there is little evidence that training - particularly a short in-service course makes much difference to this situation. Very few, about 20, of the 125 lessons observed were taught by untrained teachers and they certainly had their share of difficulties but it is not possible from this small number to say whether they had more than their share. (Some observers commented on the inadequacy of Phase III in-service courses.) What was clear was that those teachers who, for whatever reason, were interested in science and in teaching science generally made a success of the T.P.P.S. lesson. Further, if a teacher is prepared to collect the necessary materials and have a go at understanding the card and getting the activities going even if he misinterprets the instructions and doesn't understand the science, lesson observations indicate that he will generally achieve a worthwhile level of pupil interest and meaningful participation. Nevertheless many of the difficulties encountered in T.P.P.S. lessons arise directly from teacher rather than course shortcomings (although it is a shortcoming of the course that it is not able to overcome shortcomings in the teachers) and could be eased by appropriate teacher preparation - both in science and science teaching.

COGNITIVE TESTS

As described in Section B cognitive tests were prepared and administered for three of the four sub-sections of Phase III namely Phase 3B, Standard 5 Term 3, and Standard 6 Term 3. The use of these tests during 1973 showed that several of the items were unsatisfactory in some way and these items will be rewritten for use in 1974. Full details of the test items and the results are given in Section D. In this section a summary of some general points will be given.

Before attempting to interpret the results of the tests some consideration of the nature of the tests is necessary. Most cognitive tests are normative i.e. they measure achievement relative to standards or norms established by prior testing with other groups. No norms are available for primary science

in Papua New Guinea and these tests are in fact criterion referenced. This means that first a judgment is made concerning what children completing T.P.P.S. should be expected to achieve, in the absence of detailed objectives this is inferred from the written materials, the cards. Next, items are constructed which are judged to assess this expected achievement and administered to T.P.P.S. pupils. Finally, the responses to these items by the pupils are analysed. In this situation a poor result may be due to faulty judgment of expected course outcomes, faulty item construction or finally, a weakness in the course in relation to the pupils. It is because there is this large element of subjective judgment that in Section D the reader is provided with some details of the course along with the test items and the results. He will thus be able, to some extent, to assess the judgments made for himself.

An examination of the results from individual test items seems to show the following basic pattern. Items asking for simple, direct knowledge of a phenomenon included in T.P.P.S. are generally answered well by pupils. Those going beyond this and asking for an application or development of the basic idea even though this is specifically included in the T.P.P.S. course are much less well answered.

Taking into account the factors discussed above and the information from lesson observations it is concluded that the children are achieving the simplest cognitive objectives of T.P.P.S. to a large extent but those involving anything more are achieved to a much lesser extent. (To see what is meant by the 'simplest objectives' and the reasons for this situation in particular cases the reader must refer to Section D.)

It is of course possible that T.P.P.S. is making no contribution to the achievement of even these simplest objectives and that pupils who have not done the course would perform equally well on items designed to assess these. Because the items do relate directly to T.P.P.S. lessons it was not thought appropriate to administer the tests to non T.P.P.S. pupils. However data was gathered in which particular lessons each class which did the test had omitted and these omitted lessons were matched with the corresponding test items. It was thus possible to identify a, usually small, group of pupils who while they had done most of the T.P.P.S. course had not done the particular lesson on

which a particular item was based. Nearly all classes were in fact in this position for at least one lesson. For 12 items, all in the Phase 3B test, there were sufficient pupils who had not done the corresponding lesson for their results to be analysed separately and compared with those who had done the lesson. The results of this analysis (which is given in Section D) do not show large differences between those who had and had not done the lesson on which a particular item was based. Although the differences are not large they do exist. For the 12 items analysed one gave the same result for both groups, those who had NOT done the lesson performed better on 3 items and those who HAD done the lesson performed better on 8. Of all these differences only 2, in favour of those who had done the lesson, were significant (at the 0.05 level). There is evidence here then for a small increase in achievement, as measured by these tests, being produced by some T.P.P.S. lessons.

A further analysis of the scores was undertaken to examine differences between scores of boys and girls. Scores were compared question by question and differences tested for significance. Results are shown in Table 2.

TABLE 2

COGNITIVE TESTS BOYS v GIRLS

NUMBER OF ITEMS										
Test Items	Boys Superior				No Difference	Girls Superior				TOTAL
	0.01 Level	0.05 Level	Not Sign.	Total		0.01 Level	0.05 Level	Not Sign.	Total	
3B	4	1	8	13	1	0	0	0	0	14
St.6	0	1	2	3	0	0	1	6	7	10
St.5	0	1	7	8	1	0	0	3	3	12
Total	4	3	17	24	2	0	1	9	10	36

Table 2 shows that boys scores were superior on 24 of the 36 items and girls on 10. In addition boys scores were significantly (at the 0.05 level or better) better than girls on 7 items whereas girls scores were significantly better on only 1 item. No reason for the girls superior scores in the Standard 6 test can be detected. It is of interest that the boys superiority on the cognitive tests is in line with reported behaviour differences between boys and girls in science classrooms referred to above.

ATTITUDE TESTS

Science and Scientists (Appendix C) was administered to a total of 792 Standard 6 pupils at the end of 1973. Most of the schools which these children attended were in Port Moresby and Rabaul. In both towns there was a predominance of schools which had been doing the T.P.P.S. course - those which had not had done little or no science. In addition, there were small samples from two rural areas. These were from the Namatanai area of the New Ireland District (N = 44) and the Kagua area of the Southern Highlands District (N = 74). A first analysis of the data showed only a very weak relationship between the total score and any of the variables urban/rural male/female, or T.P.P.S./non T.P.P.S. so initially the sample was considered as a whole.

The overall mean score was 63.35 (the maximum possible score being 87 (3 x 29) and the minimum 29, which gives an item mean of 2.18 i.e. just on the agree side of don't know. (The method of construction of the instrument means that the total score does not have a high validity in this version - for future use the instrument will be rewritten to make the total score more meaningful.)

It is of more interest to examine the scores on individual items which are given in Table 3. An examination of the high and low scoring items gives the following broad image of science for the group as a whole. The children are generally aware of the fact that the task of science is to find out about the world about them and that this is achieved through experiments while the results of this effort are of value both because they increase our knowledge and because this knowledge is useful. On the other hand they see science as difficult to understand and are confused about the power and area of application of science tending to attribute to science greater power and a wider range of uses than is in fact the case.

TABLE 3

SCIENCE AND SCIENTISTS ANALYSIS BY ITEM

N = 792				
Item	Score 3	Mean Score	Standard Deviation	Correlation with Total Score
1.	Agree	2.42	0.763	0.335
2.	Agree	2.67	0.650	0.335
3.	Disagree	1.87	0.778	0.188
4.	Disagree	1.87	0.894	0.192
5.	Agree	1.84	0.785	0.142
6.	Agree	2.28	0.676	0.225
7.	Disagree	1.78	0.848	0.152
8/1	Agree	2.29	0.797	0.342
8/2	Disagree	2.42	0.645	0.250
8/3	Disagree	1.94	0.718	0.113
8/4	Agree	2.34	0.758	0.291
8/5	Disagree	1.82	0.733	0.021
8/6	Agree	2.21	0.733	0.283
9.	Agree	2.74	0.605	0.372
10.	Agree	2.71	0.631	0.368
11.	Disagree	2.92	0.695	0.274
12.	Agree	2.54	0.733	0.333
14.	Agree	2.19	0.804	0.349
15.	Agree	2.52	0.709	0.331
16.	Disagree	1.91	0.832	0.128
17.	Disagree	1.75	0.797	0.069
18.	Agree	2.55	0.722	0.373
19.	Agree	2.53	0.711	0.297
20.	Agree	2.22	0.768	0.246
21.	Disagree	1.52	0.709	0.063
23.	Agree	1.91	0.776	0.109
24.	Disagree	2.08	0.759	0.235
25.	Agree	2.59	0.684	0.343
26.	Disagree	1.65	0.829	0.002
Total		63.35	5.776	1.00

(Items 13 and 22 on the original instrument have been omitted from the analysis.)

Although the initial analysis showed only a very weak relationship between the total score and any of the variables sex, location or type of school and T.P.P.S./non T.P.P.S. pupils, this latter factor is of considerable interest in the present context and so an analysis of individual item scores to compare T.P.P.S. with non T.P.P.S. pupils was carried out. This was accomplished by selecting a T.P.P.S. sample (N = 274) and matching this by sex and location of school with a non T.P.P.S. sample (N = 354). The results of this analysis are given in Table 4 which shows all the items which produced a significant difference between T.P.P.S. and non T.P.P.S. pupils. There are only 3 which are significant at the generally accepted levels and one of them is in favour of non T.P.P.S. The 2 items on which T.P.P.S. pupils score higher relate to the use of science in growing crops and doing work more easily. There is in fact quite a lot in T.P.P.S. about plants and soil and a small amount about simple machines. In view of the T.P.P.S. emphasis on experiments it is disappointing to see T.P.P.S. pupils scoring significantly lower on a question which says that everything which is written in science books is true. Accordingly a check was made on the other questions relating to the 'power' of science and as the table shows T.P.P.S. pupils also scored lower on two of these items although at a low level of significance. (These were the only 2 items showing this level of significant difference.)

There is an indication here that T.P.P.S. tends to lead pupils to an exaggerated view of the infallibility of science. However it must be stressed that the differences between T.P.P.S. and non T.P.P.S. pupils are small.

TABLE 4 SCIENCE AND SCIENTISTS

ITEMS SHOWING SIGNIFICANT DIFFERENCES BETWEEN T.P.P.S. AND NON T.P.P.S. PUPILS					
Item	Mean T.P.P.S. N = 354	Mean Non T.P.P.S. N = 274	't'	Significance Level	In Favour of
8/1	2.38	2.20	2.32	0.05	T.P.P.S.
8/6	2.32	2.17	2.10	0.05	T.P.P.S.
21	1.47	1.62	2.15	0.05	Non T.P.P.S.
17	1.68	1.82	1.86	0.10	Non T.P.P.S.
23	1.85	1.99	1.89	0.10	Non T.P.P.S.

In view of the findings in respect of differences between boys and girls both in lesson observations and cognitive tests it is of interest to compare the scores of the boys (N = 432) with those of the girls (N = 360) on each item. Table 5 shows the items which produced significant differences.

TABLE 5 SCIENCE AND SCIENTISTS

ITEMS SHOWING SIGNIFICANT DIFFERENCES BETWEEN BOYS AND GIRLS					
Item	Mean Boys N = 432	Mean Girls N = 360	't'	Significance Level	In Favour of
2	2.72	2.62	2.28	0.05	Boys
3	1.93	1.79	2.51	0.05	Boys
5	1.93	1.73	3.55	0.01	Boys
6	2.33	2.22	2.17	0.05	Boys
8/5	1.77	1.68	2.12	0.05	Girls
8/6	2.27	2.14	2.28	0.05	Boys
14	2.25	2.11	2.39	0.05	Boys
Total	63.86	62.75	2.70	0.01	Boys

Table 5 shows that there is a significant though small difference between the total scores for boys and girls with the boys scoring higher. The boys also score higher on 6 of the 7 individual items which show a significant difference. The boys seem to be more certain of the usefulness of science as 3 of the 6 items on which they score higher relate to this aspect. Perhaps related to this they are also more likely to see science as something that can make people happy hence the girls' higher score on item 8/5 where agree is scored low. In addition boys more often state that they would like to be scientists and more often understand that scientists find things out by doing experiments. Finally boys also score significantly higher on item 3 (Scientists know everything now) and higher, though not significantly so, on both the similar items 17 and 23 showing that they have a slightly more realistic view of the power and limitations of science - although their lower score on item 8/5 could be seen as a contradiction of this. To sum up, boys appear to have a better understanding of and more positive attitude towards science than girls particularly in the area of the usefulness of science. This result produces a comprehensible pattern alongside the reported relative lack of interest and participation of girls in science lessons and lower achievement on the cognitive tests.

Finally a sample of Port Moresby pupils (N = 231) was compared with a sample of rural pupils from the Kagua sub-district of the Southern Highlands (N = 74). All pupils were doing T.P.P.S. The results are given in Table 6.

TABLE 6 SCIENCE AND SCIENTISTS

ITEMS SHOWING SIGNIFICANT DIFFERENCES BETWEEN URBAN AND RURAL T.P.P.S. PUPILS					
Item	Mean Urban N = 231	Mean Rural N = 74	't'	Significance Level	In Favour of
6	2.22	2.43	2.47	0.05	Rural
8/2	2.42	2.66	2.86	0.01	Rural
8/3	2.06	1.86	2.13	0.05	Urban
21	1.45	1.27	3.26	0.01	Urban
23	1.78	1.98	2.10	0.05	Rural
29	1.51	1.73	2.16	0.05	Rural

There is no significant difference between the totals for the two groups but of the 6 individual items which show a significant difference 4 are in favour of the rural group. The rural children have a slightly greater desire to become scientists but are less likely to think that science can make people rich without working (Kagua is a relatively poorly developed rural area). They are also a little more sceptical about science's ability to explain everything (perhaps being closer to traditional knowledge) and of the need to be clever to be a scientist. Urban children on the other hand are rather more sceptical of what is written in science books (although both groups incline to accept everything) and of science's ability to make people good citizens. It is difficult to discern any pattern here and it must be stressed once more that the differences are small and in this case fairly well balanced between the two groups. This tends to support the contention made when describing the total sample used to the evaluation that differences between urban and rural schools and pupils so far as science is concerned are small.

Children who completed Science and Scientists were also asked to complete the second instrument - School Science Lessons - if they were doing T.P.P.S. Phase III. The results for the whole sample of 507 pupils - again mainly from schools in or near urban centres are given in Table 7.

TABLE 7 SCHOOL SCIENCE LESSONS

ANALYSIS BY ITEM N = 507				
Item	Score 3	Mean Score	Standard Deviation	Correlation with total score
1.	D	2.15	0.899	0.331
2.	A	2.74	0.624	0.509
3.	D	1.38	0.719	-0.114
4.	A	2.56	0.745	0.541
5.	D	1.64	0.755	-0.137
6.	A	2.54	0.736	0.457
7.	A	2.46	0.795	0.484
8.	A	2.60	0.731	0.530
10/1	A	2.58	0.694	0.461
10/2	A	2.58	0.685	0.390
10/3	A	2.55	0.713	0.497
10/4	A	2.34	0.778	0.410
10/5	A	2.49	0.715	0.450
11.	A	2.24	0.854	0.389
12.	A	2.18	0.817	0.337
13.	D	2.13	0.744	0.185
14.	A	2.59	0.713	0.433
15.	A	2.42	0.835	0.416
Total		42.17	4.93	1.00

(Item 9 on the original instrument has been omitted from the analysis)

The mean total score is 42.17 giving an item mean of 2.45 which is well on the agree side of don't know (the scale could be improved for future use by including less obviously positive items and more requiring the response disagree for a score of 3). The items which score highest are those expressing general approval such as being happy when it is time for science (item 2) and wanting more science lessons (item 14), a science club (item 6) and so on. Also

included are approval of questions to and from teachers and pupils (items 4 and 8) which in the case of questions *by* pupils occur in T.P.P.S. lessons to a very limited extent. It is of more interest to examine questions which score relatively low. The two lowest (items 3 and 5) show that children have not appreciated or do not agree that they should find things out for themselves in science lessons, rather they rely on the teacher. The responses to these 2 questions may have been distorted by being among the very few requiring, for a high score, a response of disagree but the result is reinforced by the responses to items 11 and 12 which require a positive response for a high score and yet still score relatively low. Their responses to these 4 items indicate a reluctance among the children to support the idea of relying on their own efforts to 'find out' for themselves. The low score on item 1 supports the finding from Science and Scientists that pupils generally feel that science is difficult. The alternative areas of content of the course presented in item 10 tend to score uniformly high except that 'measuring things' scores well below the others. Classroom observations showed considerable practical difficulty with measurement, scales and units.

The results from School Science Lessons were analysed by sex and the outcome is shown in Table 8.

TABLE 8 SCHOOL SCIENCE LESSONS

ITEMS SHOWING SIGNIFICANT DIFFERENCES BETWEEN BOYS AND GIRLS					
Item	Mean Boys N = 286	Mean Girls N = 221	't'	Significance Level	In Favour of
3.	1.45	1.29	2.45	0.05	Boys
10/2	2.64	2.49	2.46	0.05	Boys
13.	2.05	2.24	2.76	0.01	Girls

There are only 3 items showing a significant difference in mean score, two of which are in favour of boys. Boys less often say that science lessons are best when the teacher does the experiment while the pupils watch and have a higher

opinion of lessons about electricity. Girls are more likely to disagree that boys are better at science than girls. Very little difference but again as with other aspects of this evaluation such differences as there are in favour of boys.

Finally Table 9 shows items in which there were significant differences between urban and rural children. Here a sample of Port Moresby pupils (N = 120) is compared with one from the rural areas of the Southern Highlands and New Ireland Districts (N = 118).

TABLE 9 SCHOOL SCIENCE LESSONS

ITEMS SHOWING SIGNIFICANT DIFFERENCES BETWEEN THE MEAN SCORES OF URBAN AND RURAL PUPILS

Items	Mean Urban N = 120	Mean Rural N = 118	't'	Significance Level	In Favour of
3	1.29	1.48	1.99	0.05	Rural
10/2	2.50	2.71	2.39	0.05	Rural
10/5	2.42	2.63	2.39	0.05	Rural
12	2.33	2.09	2.18	0.05	Urban
13	2.12	2.31	2.04	0.05	Rural

The differences are again small and mainly in favour of the rural pupils. Like the boys when compared with the girls, the rural children tend not to like best watching the teacher do an experiment but do like electricity lessons more than urban children (there is no relationship between sex and location of school). In addition rural pupils express a greater liking for lessons on magnetism and are less likely to think that boys are better at science than girls. Urban children on the other hand show a greater tendency to like lessons where they do not know what will happen. Again small differences and no evidence to refute the postulated similarity of science in urban and rural schools.

CONCLUSIONS

This is an interim report and the conclusions presented and discussed here are tentative. More observation work is needed particularly of Phase 3A lessons and the instruments used in the evaluation require modification. Nevertheless the writer believes it unlikely that many of the preliminary conclusions presented briefly here will be greatly altered by this further work although this is of course not impossible. One way in which the conclusions may be changed is as a result of feedback from readers of this raport concerning weaknesses in the evaluation or arising from personal experience of T.P.P.S. Such feedback is earnestly sought.

Phase III of T.P.P.S. provides experiences related to a wide range of scientific phenomena which generally arouse considerable interest and provide real enjoyment for primary school pupils. But the work reported here shows that considerably more difficulties are encountered with Phase III than was the case with Phases I and II. Lesson observations show that teachers frequently have trouble with the provision of needed materials, with coherent issuing of initial instructions, in understanding what the activity is all about and in stimulating and dealing with questions. Long term experiments and the recording of the outcomes of activities are often neglected. The result of these factors is, as shown by the results of the cognitive tests, that pupils understand only the simplest ideas involved in the activities and that there is little difference between those who have and have not done a particular T.P.P.S. lesson. Children enjoy their science lessons but have not fully understood the importance of the activities as a means of finding out for themselves. There is little evidence of any attitude of enquiry or initiative on the part of either pupils or teachers. At the same time there is evidence of differences in behaviour, attitude and achievement between boys and girls - uniformly in favour of boys. Children have a reasonably accurate and favourable image of science and scientists but tend to believe that science is difficult and wider in power and applications than is in fact the case. There is little difference in the image of science of children who have and have not done T.P.P.S.

Some concepts are introduced and developed in such a short time that it proves quite impossible for the pupils to grasp them - the teachers themselves are

sometimes not clear of the purpose of an activity and often unsure of the underlying science. There is a very big difference between the level of activity and understanding utilised in Phase II compared with Phase III. This is vividly illustrated by the very first lesson in Phase 3A. In this lesson children are required to perform an experiment and record the results involving the manipulation of two independent variables. They must then induce a generalisation from these results and by deductions predict the outcome of unseen cases! This is an extreme example but does indicate the sort of difficulties faced by both pupils and teachers. Other examples are pointed out in Section D.

Some of these difficulties with Phase III arise from the fact that science teachers may have to teach science to classes other than their own in a strictly limited time. This would be eased by having each teacher teach science to his own class. Most, however, stem from the over ambitious nature of parts of Phase III of the T.P.P.S. course in relation to the educational background - both professional and academic - of the teachers.

In view of the success of T.P.P.S. in achieving some of its basic aims described earlier it would not be wise, nor is it practicable, to change the basic form of T.P.P.S. and measures to tackle the problems which have arisen could be taken within the established framework of the course. Examples of appropriate measures would be the elimination of some of the more difficult concepts from the course, the provision of more time and activities in order to approach new ideas more slowly and the provision of more background information and practical teaching ideas for teachers. This would encourage teachers to have the confidence to promote a freer atmosphere of genuine enquiry in their classes and thus move towards the achievement of the major expressed aim of the course.

Finally some reference must be made to evaluation of the appropriateness of the content of the course. Here the concern is not, as in the rest of this report, with what has been achieved but with whether what is attempted is worth aiming for. There are several large questions involved here which it would not be appropriate to treat at length in this report. The first is whether science should be taught at all in primary schools in Papua New Guinea. While most of the questions to which this report is addressed assume a positive answer to this question, it may be worth mentioning that in the writers' opinion a positive

answer may be justified in terms of the importance of science in the external culture which is inevitably and increasingly influencing Papua New Guinea and of the primary school as the only opportunity for most children to build up an understanding of science. Next there is the question of whether the emphasis on activity and inquiry in T.P.P.S. is appropriate. Activity can be justified in terms of the increased achievement which, there is considerable evidence to show, stems from active involvement in the learning process. An attitude of inquiry is important for people who will in all probability have to be able to cope with far reaching changes in their daily lives.

At a more immediate level the appropriateness of the particular content of the T.P.P.S. course must be considered. This has been attempted in the summaries following the report in each small group of lessons in Section D. Criteria employed in assessing the scientific content are 1) relevance to the pupils' environment and 2) the degree to which the science involves a fundamental principle i.e. one which has wide applicability in assisting understanding of the material world. Activities are assessed in terms of 1) their practicability 2) the interest and enjoyment engendered among pupils and 3) their ability to illuminate the underlying science. In general most of the content can be justified on one or other of these criteria. Topics about which doubts are raised in this context are the lessons on capillarity (Phase 3B Cards 12-14), the starch test (Standard 5 Card 10) and the single lesson involving the use of the pendulum (Standard 5 Card 11). An important general criticism of the content is that it makes very little reference to the everyday practical applications of science through technology.

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SECTION D RESULTS LESSON BY LESSON

This section contains the results of the lesson observations and test results organised by lesson (lesson card). The lessons are dealt with in small subject matter groups as they are organised in the course except that the groupings have been altered slightly where this seemed appropriate.

After the lesson numbers and the subject matter title of the group of lessons there follows the title of the individual lesson card and a short description of the activities included in that lesson. This is followed by a report of the lesson observations (the number of times each lesson was observed is given in brackets). This report begins under the sub-heading 'Materials' with a listing of any materials which were observed to be missing and where possible the reason for this. The next sub-section deals with the activities of the lesson and the third with the science involved - either explicitly or where appropriate implicitly - in the activities. Under these two sub-sections it is *difficulties* and deviations from the card which are emphasised so that if a particular aspect of the lesson as it appears on the card is not mentioned it may be assumed that the observers were not aware of any particular difficulty with that aspect.

After the report of the lesson observations there follows the test question(s) relevant to that particular lesson. The test question is first given, (any diagrams have been described rather than re-drawn), including the four alternative responses. Next is presented a table showing the results for that particular question showing the percentage giving each response by boys and girls. In addition where possible, the results have been analysed for those children who did and who did not do the particular lesson on which the question is based. It should be remembered that those who have not done a particular lesson have done most of the rest of the course and this can in some cases have some influence on their scores. After the table of results some comments on significant aspects of these results are included.

Finally at the end of the report on each group of lessons a few tentative comments are offered relating to the general suitability of the lessons in terms of content and approach (see Section C Conclusions).

PHASE 3B

PHASE 3B CARDS 1-4 VOLUME

CARD 1 LET'S FIND OUT WHAT THE MARKS ON A SYRINGE MEAN

Children press out a 1 cm^3 cubic hole in a piece of plasticine, fill it with water, pour the water into a marked syringe and read the scale.

Lesson Observations (3 lessons)

THE MATERIALS

Cuisinaire rods were not always available. It was assumed that these would be available in all schools for use in maths but this is not the case.

THE ACTIVITIES

The only difficulty observed with the activity was in making sure the hole was exactly one centimetre deep. This is crucial in convincing the children that the marks on the syringe are cubic centimetres but was not stressed by teachers. In addition few schools have cuisinaire rods available and teachers who attempt to make their own rods may not be aware of the importance of an accurate cross-section of one square centimetre.

THE SCIENCE

Many children had difficulty understanding what is meant to say that the volume of the hole was one cubic centimetre.

Examples of misunderstandings are evident from answers to a question about the size of the hole e.g. "3cm" (i.e. 1cm x 1cm x 1cm)
"1 inch"
"1 square".

The misunderstandings persisted although in some cases children learnt to give an answer in terms of cubic centimetres in a mechanical way. On the other hand children did not appear to have any difficulty with the basic conservation task

i.e. that the volume of water when poured from the hole to the syringe is conserved.

The card should include an instruction for the children to put 1cc. into the syringe several times. This appears to be implied but is not stated. Some teachers appear not to understand the *logical development* of the lesson and so reversed the order of some of the activities.

TEST QUESTION

(A diagram showed 2 tins Y "This tin holds 10ml of water" and X (marked in 5ml to 30ml) "This tin holds 30ml of water").

1. How many times will it take tin Y to fill tin X?

A. 4 times B. 3 times
C. 10 times D. 30 times.

RESULTS

	No Resp.	A	*B	C	D	N
Boys	1%	16%	*58%	9%	16%	262
Girls	2%	23%	*42%	13%	20%	176
Total	1%	18%	*52%	11%	18%	438

* correct response.

This Question is based on the process carried out in Card I and is answered correctly by more than half of the students.

This appears to confirm observations that mechanical processes involving volume cause little difficulty to most children. However the questions could be answered correctly without the concept of volume i.e. simply by mechanical arithmetic.

CARD 2 LET'S MAKE A SOLID CUBIC CENTIMETRE

Lesson Observations (5 lessons)

THE MATERIALS

Cuisinaire rods are not readily available even in urban schools.

THE ACTIVITIES

Making the solid cubic centimetre was generally well understood and enjoyed. The steps involved in the process of measurement of volume by displacement were carried out unsatisfactorily in three of the five lessons observed.

THE SCIENCE

Most children did not follow the steps in the measurement of volume by displacement and again reversal of the order of some of the steps by teachers indicated a lack of understanding on their part also. Children are also confused by the linear scale on the syringe measuring a volume and for example often talk about volumes in centimetres.

TEST QUESTION

(A diagram A shows a syringe with water to the 10ml mark. B shows the same syringe, now containing a stone, and the water at the 13ml mark).

2. A syringe is filled with water to the mark shown in diagram A. In diagram B a stone has been put into the same syringe. The water rises. What is the volume of the stone?

A. 3ml
B. 10ml
C. 13ml
D. 23ml.

RESULTS

	No Resp.	*A	B	C	D	N
Boys	2%	*35%	15%	43%	5%	262
Girls	3%	*34%	20%	40%	3%	176
Total	2%	*35%	17%	42%	4%	438

*correct response.

The proportion giving the correct response 35% is not much better than the chance value (25%) (i.e. if no pupil knew the answer and all guessed about 25% would probably get the right answer by chance). Most chose the reading on the syringe containing the stone. This tends to confirm lesson observations which indicate a lack of understanding of measurement of volume by displacement (a similar activity occurs in the next lesson - card 3).

CARD 3 LET'S MARK VOLUMES ON A GLASS JAR

Children use 20ml syringes to calibrate a glass jar in 100ml divisions. These jars are then used to measure volume by displacement again (see card 2). The unit ml. replaces the unit cc.

Lesson Observations (3 lessons)

THE MATERIALS

Sufficiently large jars were not provided.

THE ACTIVITIES

The provision by teachers of quite inadequate jars illustrates the fact that the great majority of teachers do not, whether for lack of time or other reasons, try out the activities before the lesson.

In none of the lessons observed did the teachers have large enough jars. Larger coffee jars than those people normally buy are essential for this activity but this is not stressed on the card.

Two of the four teachers "overcame" the difficulty of getting a volume of 500ml when the jar only held 200ml by calibrating the jar three times over. Some groups calibrated the jars by measuring equal distances on the jar after the first measurement using the syringe in spite of the jars being of non-uniform cross-section. Again there was general misunderstanding of measurement of volume by displacement (see previous card and test results).

THE SCIENCE

The change from cc. to mls. is abrupt and unexplained on the card. In an attempt to understand this one teacher read the second part of the card (which contains several references to 5 lots of 20mls), came to the conclusion that 20cc equals 100mls and attempted to teach the lesson on the basis of converting cc. to ml. by multiplying by 5.

TEST QUESTION (see card 2)

CARD 4 LET'S RECORD THE VOLUME OF AIR IN OUR LUNGS

The children fill their graduated bottles with water, invert them in a container of water then blow into them to displace the water with air from their lungs.

Lesson Observations (2 lessons)

THE MATERIALS

None of the teachers had bamboo mouthpieces which, in any case, were not necessary. The very large jars needed were not available.

THE ACTIVITIES

The experiment described on the card is complicated and many difficulties can arise e.g. some air in the jar before the children began to blow; children not

taking a deep breath to fill their lungs; children stop blowing when one jar is full of air (no child was ever observed filling more than one jar with air as the card suggests as he would have to hold half a breath while the jar was refilled).

THE SCIENCE

There is continuing confusion about the units of volume on the part of both teachers and pupils. See above.

TEST QUESTION

Question 1 and 2 are related to the work of this card.

OVERVIEW CARDS 1-4

These cards contain a valuable series of activities on volume and there is some subjective evidence from the lesson observations that children do progress in their development of the concept of volume. This is of particular importance in view of the results of work on conservation tasks with primary school children in Papua New Guinea which shows a comparatively late development of this essential concept. However, much of the work, that on displacement is the prime example, is beyond the children partly because it is not well understood by the teachers. Another area of considerable confusion is that of units of volume - even at the end of the sequence of lessons both pupils and teachers were frequently observed to quote volumes in units of length.

PHASE 3B CARDS 5-8 WATER

CARD 5 LET'S SEE WHAT SUBSTANCES DISSOLVE IN WATER

Sugar, salt, chalkdust, sand, copper sulphate and potassium permanganate are classified as soluble or insoluble by attempting to make them dissolve in water in a syringe.

Lesson Observations (2 lessons)

THE MATERIALS

Copper sulphate and potassium permanganate were not available in either lesson.

THE ACTIVITIES

In one of the lessons observed the same water was used in an attempt to dissolve each solid in turn which made the activity very confusing and led the class and teacher to conclude that chalk dust dissolves in water.

In the other lesson there was a tendency to add too much solid so that there was always some left. Despite these difficulties children were at general able to distinguish between soluble and insoluble substances by the end of the lesson (they may well have been able to do so at the beginning - see test results).

In one of the lessons observed the teacher suggested that children attempt to dissolve other things which they found at home. This kind of suggestion and in fact any attempt to relate T.P.P.S. lessons to everyday life was rarely observed.

Teachers are expected to recover copper sulphate from solutions after use by leaving them in the sun.

The extra activity was not attempted in any of the lessons observed.

THE SCIENCE

The word 'dissolved' is not explained on the card so there is no indication as to how pupils and teachers are to know whether something is soluble or not.

One teacher attempted to explain the word 'dissolve', saying that it meant to 'disappear' or to 'change into water'.

TEST QUESTION

3. Which of these will dissolve (is soluble) in water?

A. salt and sand
B. sugar and salt
C. sugar and sand
D. salt and clay.

RESULTS

		No Resp.	A	*B	C	D	N
Children who have done cards 5 and/or 6.	Boys	3%	9%	*71%	7%	9%	232
	Girls	1%	14%	*66%	6%	12%	166
	Total	2%	12%	*69%	7%	11%	398
Children who have NOT done cards 5 and 6.	Boys	0%	23%	*57%	3%	17%	30
	Girls	0%	0%	*70%	0%	30%	10
	Total	0%	18%	*60%	3%	20%	40
All Children.	Boys	3%	11%	*67%	7%	10%	262
	Girls	1%	14%	*66%	6%	13%	176
	Total	2%	12%	*68%	6%	11%	438

*correct response.

The result shows a large majority of children able to distinguish examples of soluble from insoluble substances. Although the children who have done a lesson on solubility performed better than those who have not, there is no significant difference between their scores. Similarly there is no significant difference between the scores for boys and girls.

CARD 6 LET'S COMPARE HOW SULUBLE DIFFERENT THINGS ARE

The children add measured amounts of different substances to water in a syringe.

Lesson Observations (1 lesson)

THE MATERIALS

No copper sulphate was available.

THE ACTIVITIES

There was no difficulty in measuring 15mls of water. The children added such large quantities of each substance initially that there was always some solid left undissolved, thus no comparison of solubility was possible. Inevitably in view of the above no recording was attempted.

The lesson ended with a discussion as to how they could make the undissolved part dissolve. Some children suggested adding more water and eventually after the teacher referred them to making tea, they suggested heating the water.

THE SCIENCE

The teacher realized the children should add small quantities of the substances from burner tops but these were not available and he didn't attempt to find any suitable alternative measure.

The children in the class observed had no idea about how to find how much of something will dissolve or the different solubilities of different substances.

TEST QUESTION (see card 5)

CARD 7 LET'S GET PURE WATER FROM SALTY WATER

The children boil salt water to dryness allowing steam to condense on a cold surface (bottle). Meanwhile the teacher sets up a simple water still made from a tin can and a straw.

Lesson Observations (2 lessons)

THE MATERIALS

Neither teacher made the still.

THE ACTIVITIES

In neither of the lessons observed was any salt obtained because a) too much liquid was used b) the burners are inefficient (the burners are also dangerous - in one of the lessons observed a desk caught fire). In one lesson wet bottles were used which meant the children were not able to see the formation of condensed water.

In neither lesson did the teacher attempt to make the still although one teacher claimed to have made one in a previous lesson but had had no success with it. This same teacher had taught the lesson several times before and claimed that his pupils had never obtained salt.

THE SCIENCE

At the end of the lesson the children were told that they should have obtained salt in the tin lid and in one of the lessons only did they taste pure water from the side of the bottle.

TEST QUESTION

4. If we boil salt water in a tin until it is dry, what do we find left in the tin?

A. Water
B. Salt
C. Nothing
D. Ashes.

RESULTS

		No Resp.	A	B*	C	D	N
Children who have done card 7.	Boys	3%	15%	*43%	21%	18%	230
	Girls	1%	14%	*38%	29%	19%	160
	Total	2%	14%	*41%	24%	18%	390
Children who have NOT done card 7.	Boys	0%	9%	*41%	34%	16%	32
	Girls	0%	6%	*44%	38%	13%	16
	Total	0%	8%	*42%	35%	15%	48
All Children.	Boys	2%	14%	*43%	23%	18%	262
	Girls	1%	13%	*38%	30%	18%	176
	Total	2%	14%	*41%	26%	18%	438

*correct response.

Only about 40% made the correct response. 'Nothing' was the most popular distractor especially amongst those who had not done the lesson. More who had done the lesson said that water would be left which may reflect the sort of experiences described above. In this question those who had not done the lesson scored very slightly higher although the difference was not significant, neither was the higher score of the boys.

CARD 8 LET'S MIX COPPER SULPHATE AND SAND AND SEPARATE THEM AGAIN

Children make a mixture of sand and copper sulphate, are asked how to separate it, then dissolve and filter.

Lesson Observations (2 lessons)

THE MATERIALS

All were available.

THE ACTIVITIES

In neither lesson were the children asked for ideas about separating the mixture, rather, they were simply told what to do step by step.

Children have no difficulty with the activity itself.

THE SCIENCE

No difficulties.

TEST QUESTION

(Simple diagrams showing evaporating and filtration).

5. If sand and copper sulphate are mixed together they could be separated again:

   A. by using a magnet
   B. by making a solution and evaporating the water
   C. by dissolving the copper sulphate in water and filtering out sand
   D. by dissolving the sand in water and filtering out the copper sulphate.

RESULTS

		No Resp.	A	B	*C	D	N
Children who have done card 8.	Boys	2%	23%	16%	*35%	25%	223
	Girls	3%	34%	17%	*28%	19%	151
	Total	2%	27%	16%	*32%	22%	374
Children who have NOT done card 8.	Boys	0%	49%	15%	*15%	21%	39
	Girls	0%	4%	20%	*40%	36%	25
	Total	0%	31%	17%	*25%	31%	64
All Children.	Boys	2%	27%	16%	*32%	24%	262
	Girls	2%	30%	18%	*30%	21%	176
	Total	2%	28%	16%	*31%	23%	438

*correct response.

Those who had done this card scored better than those who had not although the difference is not significant and the scores are not much better than chance. Again the boys score better but not significantly so. (The difference between girls and boys for those who had not done the lesson must be disregarded in view of the small numbers involved.) It is possible that the wording of this question is too complicated which may help to explain the popularity of response A which has the simplest wording as well as being a method of separating mixtures used elsewhere in Phase 3B.

OVERVIEW CARDS 5-8

Water as a solvent is an important topic with wide applications. The sequence of activities provides a meaningful progression from the simplest ideas to two useful applications of the ideas and techniques. However a number of difficulties over details in the activities frequently arise as the above lesson observations

indicate. This is reflected in the test results which show a grasp of the simple concept of solubility but considerable difficulty with the later ideas.

PHASE 3B CARDS 9-11 BURNING

(These cards are headed Air - Card 9 and General - Cards 10 and 11 but clearly form a short sequence on burning and so are grouped under that heading here.)

CARD 9 LET'S DO SOME EXPERIMENTS ON BURNING

A group of experiments included burning paper folded and buried partly in sand and burning a candle under a jar, all designed to show the importance of air for burning.

Lesson Observations (2 lessons)

THE MATERIALS

In one lesson no recording tables were provided.

THE ACTIVITIES

All activities in both lessons successful and enjoyed by children. In both cases burning the candle under the jar was omitted presumably because it appears on the card less prominently than the other activities.

THE SCIENCE

No difficulties. Children understood that air was necessary for burning.

TEST QUESTION

(2 diagrams 1. showing a small candle in a large jar, 2. showing a large candle in a small jar.)

6. Which candle will burn for a longer time?

A. They will both burn for the same time.
B. Number 2 because it will get hotter.
C. Number 1 because it has more air.
D. Number 2 because it is bigger.

RESULTS

		No Resp.	A	B	*C	D	N
Children who have done card 9.	Boys	1%	10%	12%	*44%	33%	174
	Girls	1%	12%	6%	*43%	38%	136
	Total	1%	11%	9%	*44%	35%	310
Children who have NOT done card 9.	Boys	0%	11%	11%	*49%	28%	88
	Girls	0%	10%	13%	*45%	33%	40
	Total	0%	11%	12%	*48%	30%	128
All Children.	Boys	1%	10%	12%	*46%	31%	262
	Girls	1%	11%	7%	*44%	36%	176
	Total	1%	11%	10%	*45%	33%	438

*correct response.

About half of all groups get the right answer. Those who have not done the lesson score slightly (not significantly) higher as do the boys. It may be that most teachers miss out the part of the lesson on which this particular experiment is based as occurred in the two lessons observed. Another reason for the uniformity of the results may be that a similar activity occurs in an earlier phase of T.P.P.S.

CARD 10 LET'S GET CARBON BY BURNING THINGS

The teacher shows carbon and then children burn various materials to find which contain carbon.

Lesson Observations (4 lessons)

THE MATERIALS

Many of the suggested materials were missing - mainly the foodstuffs.

THE ACTIVITIES

Little difficulty with activity except that no teacher had any animal materials to burn. One teacher launched straight into the activities without any mention of carbon.

THE SCIENCE

Only one teacher brought out the fact that plants and animals contain a lot of carbon. There was considerable confusion over the difference between carbon and ash.

TEST QUESTION

7. A boy was asked to find out if a piece of lapiap had carbon in it. The best way to do this is to:

   A. boil it in water
   B. test it with iodine and look for a black colour
   C. test it with copper sulphate
   D. burn it and look for black stuff.

RESULTS

		No Resp.	A	B	C	*D	N
Children who had done card 10.	Boys	3%	38%	16%	12%	*31%	125
	Girls	6%	31%	22%	8%	*33%	110
	Total	5%	34%	19%	10%	*32%	235
Children who had NOT done card 10.	Boys	2%	36%	20%	9%	*32%	137
	Girls	2%	36%	24%	11%	*27%	66
	Total	2%	36%	22%	10%	*31%	203
All Children.	Boys	3%	37%	18%	11%	*32%	262
	Girls	5%	33%	23%	9%	*31%	176
	Total	3%	35%	20%	10%	*31%	438

*correct response.

About one third got the right answer. Again there was no significant difference between those who had and had not done the card or between boys and girls. The most popular alternative is A, perhaps because this seems a reasonable thing to do to a laplap. Questions asked during the testing at some schools indicated that children had forgotten the word 'carbon'.

CARD 11 LET'S GET SALT FROM ASH

Children mix water and ash, filter and evaporate to get a salty substance.

Lesson Observations (3 lessons)

THE MATERIALS

In one lesson candles were used as the teacher regarded the burners as dangerous. One teacher had not made heating stands.

THE ACTIVITIES

No difficulties. All successful in obtaining salt.

THE SCIENCE

No difficulties. All the teachers clearly brought out the origin of the salty substance.

TEST QUESTION

None.

OVERVIEW CARDS 9-11

Important ideas about burning and about some of the constituents of living things are brought out in these lessons. The activities are generally successful and enjoyed by the children. The apparent high level of understanding observed during lessons is not confirmed by the test results. Possible reasons for this have been pointed out in the comments on the test questions.

PHASE 3B CARDS 12-14 CAPILLARITY

These cards are headed General - Card 12-13, Water - Card 14, but clearly form a sequence on capillarity and so are grouped under that heading here.

CARD 12 LET'S MEASURE HOW FAR DIFFERENT LIQUIDS CLIMB UP PAPER STRIPS

Children observe water and kerosene climbing up strips of paper and record the heights at 5 minute intervals.

Lesson Observations (1 lesson)

THE MATERIALS

All necessary available.

THE ACTIVITIES

Some difficulty with the mechanics of measuring the length of the wet strip at different times e.g. some children took the strip out to measure it; some were confused by millimetres on their rulers; some measured from the wrong end of the ruler etc. However, these difficulties were generally overcome and the activity was successful and enjoyed by the children. There was no time to find the average.

THE SCIENCE

No difficulties - the children are expected to do no more than observe the phenomenon. They asked no questions about it.

TEST QUESTION

None.

CARD 13 LET'S MEASURE HOW FAR WATER CLIMBS UP DIFFERENT STRIPS

In a similar activity to card 12 the children observe and measure water climbing up different kinds of material.

Lesson Observations (5 lessons)

THE MATERIALS

In only one lesson was string used.

THE ACTIVITIES

Many reports of practical difficulties reported similar to those listed under card 12. In particular in making several measurements at a given time. Again

not enough time to finish the lesson properly.

THE SCIENCE

No difficulties reported.

TEST QUESTION

None.

CARD 14 LET'S FIND HOW FAR WATER CLIMBS IN SOIL

Children make a plastic tube, fill it with sand and allow water to climb up it. This is repeated with soil.

Lesson Observations (3 lessons)

THE MATERIALS

All available.

THE ACTIVITIES

Many of the difficulties already reported persist even into this third lesson of the series, in addition there is some difficulty in making the plastic tubes (neither the instructions nor the photograph which illustrate this are clear on the card) and one class observed used wet soil.

THE SCIENCE

One teacher was asked why the water rose up the tube. He stressed the need to make certain there is no air at the top of the sealed tube "If there is air in the tube it will push down on the water and not allow it to rise up. When there is no air in the tube the atmospheric pressure forces the water to rise."

TEST QUESTION

None.

OVERVIEW CARDS 12-14

Capillarity is an important phenomenon with applications in childrens' everyday life as examples given on the cards show.

The activities also give children further practise in measurement. However the teachers appear to do little to help improve childrens' measurement skills presumably because they have many other things to think about in these lessons. In addition one must ask whether children could be made aware of this phenomenon in one lesson rather than three. Three weeks on this topic seems rather excessive.

PHASE 3B CARDS 15-17 EARTH

CARD 15 LET'S SEE HOW MUCH WATER STAYS IN DIFFERENT SOILS

Children watch measured amounts of water percolating through sand and then through soil. They determine the amount of water retained by each.

Lesson Observations (5 lessons)

THE MATERIALS

All available.

THE ACTIVITIES

A considerable amount of time can be spent by children doing nothing but watching water drip through the funnel. This varies considerably with the type of soil used and means that it is essential for the teacher to try the experiment out beforehand. Few realise the necessity to do this.

THE SCIENCE

Children measure the amount of water which percolates through the soil but do not understand how to use this to calculate the amount of water remaining in the soil. In most of the lessons observed children simply copied the teachers' results from the board. Generally the subjective judgment of observers was that children did not achieve the apparent objective of the activity i.e. an understanding that some soils retain more water than others.

TEST QUESTIONS

(4 labelled diagrams each show a funnel containing soil in the neck of a bottle. The 4 bottles contain different amounts of water, A most and D least).

The same amount of water was poured on to each soil then left to stand.

8. Which soil holds the most water? A B C D

9. Which is most likely to be clay? A B C D

RESULTS

Question 8.

		No Resp.	A	B	C	*D	N
Children who have done card 15.	Boys	2%	74%	2%	4%	*17%	218
	Girls	2%	86%	3%	2%	*7%	152
	Total	2%	79%	3%	3%	*13%	370
Children who have NOT done card 15.	Boys	2%	68%	11%	0%	*18%	44
	Girls	0%	88%	4%	4%	*4%	24
	Total	1%	75%	9%	1%	*13%	68
All Children.	Boys	2%	73%	4%	3%	*17%	262
	Girls	2%	86%	3%	2%	*7%	176
	Total	2%	78%	4%	3%	*13%	438

*correct response.

Question 9.

		No Resp.	A	B	C	*D	N
Children who have done card 15.	Boys	5%	25%	14%	20%	*37%	218
	Girls	3%	16%	14%	28%	*40%	142
	Total	4%	21%	14%	23%	*38%	370
Children who have NOT done card 15.	Boys	2%	25%	16%	11%	*45%	44
	Girls	0%	25%	38%	8%	*29%	24
	Total	1%	25%	24%	10%	*40%	68
All Children.	Boys	4%	24%	15%	19%	*39%	262
	Girls	2%	17%	17%	25%	*39%	176
	Total	3%	21%	16%	21%	*39%	438

*correct response.

Results of question 8 very strongly confirm the lesson observations which indicated that children did not understand how to find the amount of water retained. When asked which soil holds the most water the great majority opt for the case in which they can see most water in the bottle. Although very few children get the correct answer, the boys did significantly better than the girls (significant at the 0.01 level). There is no significant difference between those who have and have not done the lesson.

In view of the results on question 8 it is difficult to understand the rather better (though still not good) result on question 9, because a correct answer to question 9 logically requires a correct answer to question 8 as a pre-requisite i.e. you cannot deduce that D is likely to be clay unless you know that D has retained most water. It may be that in answering question 8 pupils just relied on the immediate visual impression (most water) but in question 9 they may have remembered that it is hard for water to pass through clay - either from the experiment or in the case of those who had not done the experiment (and these did slightly though not significantly better) from

everyday experience. However these results remain puzzling.

CARD 16 LET'S STUDY WASTE MATTER IN SOILS

Children collect samples of waste material in different stages of decay and examine them. They heat a sample of garden soil.

Lesson Observations (4 lessons)

THE MATERIALS

Generally all available.

THE ACTIVITIES

There is little difficulty in finding the required waste materials. Careful guidance is required from the teacher if children are to gain anything from examining the material. One class didn't have time to heat the soil after finding it and thoroughly examining the waste matter. Those who did heat the soil were interested to see water driven off and the burning waste material.

THE SCIENCE

Waste matter in soil appears to be a new idea to the children but it generally became clear as the lesson progressed. Two of the teachers observed were unsure of the concept of waste matter in soil themselves.

TEST QUESTION

(A diagram shows a sample of soil being heated by a flame)

10. What happens when soil containing plant matter is heated?

A. the soil burns away
B. the plant waste matter burns
C. the soil melts
D. none of these.

RESULTS

		No Resp.	A	*B	C	D	N
Children who have done card 16.	Boys	2%	11%	*41%	23%	23%	149
	Girls	0%	15%	*33%	26%	26%	105
	Total	1%	13%	*38%	24%	24%	254
Children who have NOT done card 16.	Boys	5%	12%	*41%	22%	20%	113
	Girls	3%	11%	*31%	28%	27%	71
	Total	4%	11%	*37%	24%	23%	184
All Children.	Boys	3%	11%	*41%	23%	22%	262
	Girls	1%	14%	*32%	27%	26%	176
	Total	3%	12%	*37%	24%	24%	438

*correct response.

About a third of all groups chose the correct response. There was no significant difference between those who had and had not done card 16.

One reason for the poor response may be that while the question asks what happened when soil is heated the possible answers do not include what is in fact most obvious in the experimental situation i.e. water is driven off.

Boys scored significantly better than girls on this question (significant at the 0.01 level).

CARD 17 LET'S FIND OUT HOW MUCH AIR THERE IS IN DIFFERENT SOILS

Children fill one jar with soil and another with water. The one filled with water is then inverted over the other so that air from the soil bubbles into the water. This is repeated for a second sample of soil.

Lesson Observations (5 lessons)

THE MATERIALS

All available.

THE ACTIVITIES

The card warns teachers to try this experiment out beforehand as many things can go wrong - which they did e.g. water leaking from inverted jars; top of jars falling off and breaking; soil jar not full of soil; soil falling into water; measuring volume of water instead of air. Children were reluctant to turn the water jar upside down especially if the teacher was obviously uncertain also. However when the activity did work, and it was usually successful eventually, the children were quite impressed to see the air bubbling out of the soil.

In none of the lessons observed was the extra activity (*measurement* of the volume of air) attempted.

THE SCIENCE

The teacher did not always understand that to make the comparison required, conditions in the two experiments must be the same e.g. jars of the same size; both jars FULL of soil.

One teacher used light garden soil rather than clay and so got more air from the soil than from the sand. He still felt it necessary to convince the children that the sand contained more air as he knew this was the expected answer.

TEST QUESTION

(A small diagram shows bubbles rising from a lump of soil in a beaker of water.)

11. Into a beaker of water I drop a lump of soil. I watched it and saw some bubbles coming out of the water. This shows that:

A. there was some air in the soil

B. there is some plant matter in the soil

C. the soil dissolved in the water

D. the water was boiling.

RESULTS

		No Resp.	*A	B	C	D	N
Children who have done card 17.	Boys	3%	*28%	27%	31%	10%	172
	Girls	0%	*26%	31%	32%	10%	127
	Total	2%	*27%	29%	32%	10%	299
Children who have NOT done card 17.	Boys	2%	*17%	34%	37%	10%	90
	Girls	0%	*16%	29%	39%	16%	49
	Total	1%	*17%	32%	37%	12%	139
All Children.	Boys	3%	*24%	29%	33%	10%	262
	Girls	0%	*23%	31%	34%	12%	176
	Total	2%	*24%	30%	34%	11%	438

*correct response.

The most popular alternative is C. This may perhaps be partly explained by the fact that there is quite a lot of work on dissolving in Phase 3B. It is also true of course that some part of the soil will dissolve in the water. Perhaps the question is slightly ambiguous and may be improved by making the stem "The bubbles show that ...". However those who had done this lesson did perform significantly better than those who had not (significant at the 0.05 level).

OVERVIEW CARDS 15-17

This series of activities on Earth is particularly relevant in the Papua New Guinea situation and the activities themselves lead to important results on water retention, waste material and air content. However, there are difficulties with some of the activities described above which distract attention from the basic concepts involved. This is illustrated both by the observations and the test results recorded. At first sight some of the activities may appear to lack interest but in fact a high level of pupil involvement and enjoyment was observed in most of these lessons.

PHASE 3B CARDS 18-21 MAGNETISM

CARD 18 LET'S MAKE A MAGNET

Children test different kinds of metals to see whether they are magnets then attempt to magnetise them by stroking with a magnet and then retest. They list things which can and cannot be magnetised.

Lesson Observations (7 lessons)

THE MATERIALS

Generally all available.

THE ACTIVITIES

Some teachers did not know the word 'stroke' and had the children hit the metal. In some lessons residual magnetism in the pieces of metal or the pins confused the first part of the lesson. When this happened it was ignored by the teachers. Some of the original issue magnets are now not strong enough for this activity. However if and when these difficulties were overcome the activities were successful and enjoyed by the children.

THE SCIENCE

The only difficulty was over the process of magnetisation by stroking described above. The approach here is unusual for T.P.P.S. as in this lesson the teacher demonstrates the main activity (making a magnet) and *the result* of stroking before the children have a chance to try it and find out for themselves what happens.

TEST QUESTION

12. Which is the best way to find out if a piece of steel is a magnet?

A. See if it picks up a pencil.
B. See if it picks up a nail or pins.
C. See if it picks up plastic.
D. See if it picks up pieces of glass.

RESULTS

		No Resp.	A	*B	C	D	N
Children who have done card 18.	Boys	2%	3%	*84%	7%	5%	191
	Girls	2%	3%	*74%	11%	10%	125
	Total	2%	3%	*80%	9%	7%	316
Children who have NOT done card 18.	Boys	1%	7%	*73%	7%	11%	71
	Girls	4%	6%	*76%	6%	8%	51
	Total	2%	7%	*75%	7%	10%	122
All Children.	Boys	2%	4%	*81%	7%	6%	262
	Girls	2%	4%	*75%	10%	9%	176
	Total	2%	4%	*79%	8%	8%	438

*correct response.

RESULTS

The answer to this question is clearly well known to all the children and only slightly but not significantly better known to those who have done this lesson than to those who have not. However, quite a lot of the children who had not done this lesson had done one or both of the other two lessons on magnetism which follow this one. Although a test for magnetism does not specifically occur in these lessons, children inevitably do many things with the magnets which are not on the cards and so could well discover the answer to this question themselves.

CARD 19 LET'S MAKE A COMPASS

Children float a magnet on a tin lid in water to make a compass. They then magnetize a piece of metal to make another compass.

Lesson Observations (4 lessons)

THE MATERIALS

All available.

THE ACTIVITIES

The first part of the lesson is very quickly completed and most teachers do not go on to the second part in which the children make their own magnet and compass. Again some of the magnets are not powerful enough. Teachers do not instruct the children to mark the end of the magnet pointing North.

THE SCIENCE

Although children can do the activity quite easily teachers do not generally bring out the fact that the magnet points in one direction or the use of the compass which is, in fact, very briefly dealt with on the card and is quite foreign to the childrens' experience.

TEST QUESTION

(Diagram showing a magnet suspended by string.)

13. Magu let the magnet in the picture turn round; what will happen to the magnet?

A. One end will point north.
B. It will point in any direction.
C. It will keep turning round and round.
D. One end will point west.

RESULTS

		No Resp.	*A	B	C	D	N
Children who have done card 19.	Boys	3%	*28%	27%	31%	10%	172
	Girls	0%	*26%	31%	32%	10%	127
	Total	2%	*27%	29%	32%	10%	299
Children who have NOT done card 19.	Boys	2%	*17%	34%	37%	10%	90
	Girls	0%	*16%	29%	39%	16%	49
	Total	1%	*17%	32%	37%	12%	139
All Children.	Boys	3%	*24%	29%	33%	10%	262
	Girls	0%	*23%	31%	34%	12%	176
	Total	2%	*24%	30%	34%	11%	438

*correct response.

Most children have chosen the straight-forward common sense answers (B and C). (Assuming one knows nothing about magnets). Although only a quarter of those who had done the lesson got the answer right their score was significantly better (significant at the 0.05 level) than those who had not.

CARD 20 LET'S FIND OUT MORE ABOUT TWO MAGNETS

Children push and pull a magnet floating in a tin lid on water using a second magnet. Similar activities follow using 2 magnets on the bench. A magnet is stood on end and the greatest distance at which another magnet can make it fall is measured.

Lesson Observations (6 lessons)

THE MATERIALS

All available.

THE ACTIVITIES

Activities successful and enjoyed by the children. However several teachers mentioned that the activities were too short so that there would seem to be an opportunity to develop the ideas of N and S poles which occurred in the previous lesson. The new recently issued stronger magnets are of rectangular cross-section which makes the activity in which magnets are rolled on the bench impossible.

THE SCIENCE

There is nothing on the card about attraction, repulsion, like and unlike poles. But in most of the lessons teachers work out their own rules. e.g. One teacher said "... the same colours have the same powers and do not like to face the same".

TEST QUESTION

(Each of four diagrams, A, B, C, D, show 2 magnets arranged in different positions relative to one another.)

14. Which of the 2 magnets above will attract each other? A B C D.

RESULTS

		No Resp.	A	B	*C	D	N
Children who have done card 20.	Boys	2%	10%	27%	*32%	29%	248
	Girls	1%	10%	37%	*21%	31%	161
	Total	2%	10%	31%	*28%	30%	409
Children who have NOT done card 20.	Boys	0%	0%	29%	*21%	50%	14
	Girls	0%	13%	40%	*0%	47%	15
	Total	0%	7%	34%	*10%	48%	29
All Children.	Boys	2%	9%	27%	*32%	30%	262
	Girls	0%	10%	38%	*19%	32%	176
	Total	2%	10%	31%	*27%	31%	438

*correct response.

Those who did the lesson chose alternative B, C and D, equally frequently but for some reason neglected A. The small number of children who had not done the lesson tended to choose D which looked different from the others. It is likely that children did not know the word attract. The number of children who had not done the lesson is too small for any conclusion to be drawn.

CARD 21 LET'S FIND OUT WHERE A MAGNET IS STRONGEST

1. Children are asked how to separate a mixture of sand and iron filings. Magnets used. 2. Children sprinkle iron filings on a magnet to find out where it is strongest.

Lesson Observations (3 lessons)

THE MATERIALS

One class had no iron filings.

THE ACTIVITIES

One teacher attempted this lesson without iron filings! Sent the class out to gather iron filings. Eventually gave up. Lesson aborted!

One class suggested using a sieve to separate the sand and iron filings. The sand turned out to be much coarser than the filings so this method worked better than the magnet. Nevertheless the teacher was to be congratulated on following up the childrens' suggestion. This does not often happen in T.P.P.S. lessons. In the third lesson observed the teacher got the magnets out at the beginning rather than getting the children to think of a solution for themselves.

In activity 2 there is considerable difficulty in removing the iron filings from the magnet.

THE SCIENCE

In activity 2 one teacher insisted that the children decide which pole was the stronger.

TEST QUESTION

None.

OVERVIEW CARDS 18-21

If the criterion for the selection of topics in science is relevant to the childrens' environment it is hard to justify the inclusion of magnetism as most children, particularly in the village situation, will never see another magnet in their lives. On the other hand magnetism is an important phenomenon both in itself and because it illustrates the fundamental concept of action at a distance. Children invariably enjoy playing with and learning about magnets.

PHASE III STANDARD 5 TERM 3

PHASE III ST.5 TERM 3 CARDS 1-4 ANIMAL REPRODUCTION

CARD 1 ANIMAL REPRODUCTION 1

Children make model egg and sperms from plasticine. Teacher talks about male, female, egg, sperm, fertilization, cell division, inheritance of characteristics.

Lesson Observations (3 lessons)

THE MATERIALS

All available.

THE ACTIVITIES

Very little activity. Teachers' explanations of the points listed above aroused considerable interest and many questions to some of which the children obviously knew the answers but most of which were genuine. Teachers avoided the former and made a reasonable attempt at the latter although one teacher in a mission school when in a corner fell back on references to God's Plan.

THE SCIENCE

Little difficulty except with the idea of the cell.

TEST QUESTION

Four diagrams show various combinations of egg and sperm.

1. Look at these diagrams. Which of these diagrams best shows a male sperm cell joining with a female egg cell? A B C D

RESULTS

	No Resp.	A	B	*C	D	N
Boys	0%	31%	7%	*36%	25%	96
Girls	0%	48%	7%	*25%	20%	81
Total	0%	39%	7%	*31%	23%	177

*correct response.

Alternative A shows 2 eggs together. It is surprising that this is the most popular choice as this is specifically covered in the activity and although pupils were observed to make mistakes in placing their model sperm and egg together, it was impossible to place 2 eggs together as each group had only one model egg.

31% got the correct answer and the boys performed significantly (at the 0.05 level) better than the girls.

CARD 2 ANIMAL REPRODUCTION 2

Teacher talks about 1) Fish reproduction (sperms, eggs, fertilization, many eggs and few survive) 2) Frog reproduction. Similar to fish plus life cycle of frog.

Lesson Observations (3 lessons)

THE MATERIALS

In two of the lessons observed no frog chart was available although the teachers said they were in the school. The teachers had not planned the lesson beforehand or found the chart.

THE ACTIVITIES

No activities as such.

Two of the three teachers didn't mention fish reproduction nor explain the significance of the large numbers of eggs produced. None of the teachers collected frogs' eggs as suggested on the card so that children could watch the life cycle.

THE SCIENCE

In this lesson and the following two teachers had not picked up from the cards the importance of the number of eggs produced in relation to maternal care.

TEST QUESTION

2. The female frog lays many eggs at a time which change into tadpoles. What happens to all these tadpoles?

   A. They ALL grow into frogs.
   B. All are eaten by fish.
   C. The mother frog looks after them.
   D. Many are eaten and only a few grow into frogs.

RESULTS

	No Resp.	A	B	C	*D	N
Boys	1%	39%	3%	27%	*30%	96
Girls	0%	48%	2%	20%	*30%	81
Total	1%	43%	3%	24%	*30%	177

*correct response.

The most popular response was A, presumably because if one ignores the word ALL (the word was in fact emphasised) it is the most obviously true. This result is explicable in terms of the observations described above. However about a third did choose the correct response.

CARD 3 ANIMAL REPRODUCTION 3

Teacher talks about reproduction in chickens; mating; sperm; egg; egg fertilization internally; egg as food; few eggs; maternal care.

Lesson Observations (4 lessons)

THE MATERIALS

In every lesson the chart issued by the Department was not available but one teacher made his own. In two lessons observed the teacher did not provide a hen's egg.

THE ACTIVITIES

No activities as such. The lesson provoked many questions from the children.

THE SCIENCE

Many small difficulties and misunderstandings e.g. yolk as egg; white as food.

Some giggling over mating. Teachers tended to use ingeneous euphemisms. As noted in the previous lesson, lack of emphasis on maternal care.

TEST QUESTION

None.

CARD 4 ANIMAL REPRODUCTION 4

Pig reproduction; development in uterus, gestation period; birth; maternal feeding; discussion of other animals.

Lesson Observations (3 lessons)

THE MATERIALS

All available.

THE ACTIVITIES

Some factual errors noted in teachers' expositions, mainly unimportant. To illustrate the range and number of questions provoked by these lessons on reproduction, the following list is given. All questions are taken from a single lesson.

When a small pig is born what will the mother do?
Why do pigs have many teats?
Do pigs give birth to the eggs or just small pigs?
Are the baby pigs born in twos or what?
What is the difference between people and pigs?
How do the pigs fertilize?
Do the pigs give birth to the small pigs in one day or two days?
When pigs are born do they drink the mother's milk?
How long does a pig live?
If a mother pig is killed will we find the baby pigs alive?
When dogs go on top of pigs do the pigs get sperm?
If the male pig doesn't put its penis in the mother can it get babies?

THE SCIENCE

Some minor misunderstandings as noted above.

TEST QUESTIONS

3. Which of these statements is NOT true about reproduction in pigs?

   A. The baby pig feeds on the mother's milk.
   B. The egg is fertilized outside the female pig's body.
   C. The fertilized egg grows inside the female pig's body.
   D. The female pig looks after the baby pigs.

RESULTS

	No Resp.	A	*B	C	D	N
Boys	2%	15%	*50%	17%	17%	96
Girls	1%	15%	*41%	20%	23%	81
Total	2%	15%	*46%	18%	20%	177

*correct response.

About half the children selected the correct response with the others fairly evenly spread over the other three responses.

One might expect that most children would be familiar with the information of this question through knowledge of pigs in the village situation, however classroom observations do not support this expectation (see questions above). Boys did better than girls but not significantly so.

4. Which group of animals feed their young by giving them milk from their breasts?

A. Hens, Lizards, Snakes.
B. Cows, Pigs, Rats.
C. Fish, Turtles, Seagulls.
D. Bees, Wasps, Spiders.

RESULTS

	No Resp.	A	*B	C	D	N
Boys	2%	6%	*85%	7%	7%	96
Girls	0%	4%	*91%	1%	4%	81
Total	1%	5%	*88%	2%	3%	177

*correct response.

Obviously very well known to the children. Girls slightly better than boys.

OVERVIEW CARDS 1-4

There has been considerable controversy over the inclusion of these lessons in the science course. Eventually it was decided that the local community through the Board of Management of each school could decide whether these lessons were taught to their children. The main educational argument in favour is that there are many misunderstandings among children and even adults in this area (for example there is a widely held belief that conception cannot occur until intercourse has taken place several times). As most children leave school after Standard 6 the formal school system has no further opportunity to provide education on these matters.

Personal observations show that childrens' reactions to these lessons are generally good and a high level of genuine interest is apparent. In addition there is a good level of achievement as far as grasp of the basic ideas is concerned and this is supported by the results of the test questions although there is no evidence concerning how much of this understanding is due to the course.

One aspect which does not come across although it is a major theme running through the four lessons, is the relationship between the number of offspring produced and the need for maternal care.

PHASE III ST.5 TERM 3 CARDS 5-9 SEED TO SEED

CARD 5 LET'S FIND OUT ABOUT GROWTH

CARD 6 LET'S RECORD OUR RESULTS ON GROWTH

ACTIVITY I

Children find the 'sleeping plant' in a seed. Children 'plant' four seeds in different positions in a jar with water but no soil. The teacher does the same experiment without water. The results are observed the following week.

ACTIVITY 2

Children mark a plant stem every 10cm and the following week check for growth.

Lesson Observations (5 lessons)

THE MATERIALS

In none of the lessons observed had teachers followed the instructions on card 1 and planted maize seeds in preparation for this lesson. Some teachers used plants growing in the school gardens for measuring. In all cases the instruction to provide 'plenty of soil' caused confusion to both teachers and pupils. Soil appears to be quite unnecessary, indeed one apparent aim of the lesson is for children to understand that soil is NOT necessary for germination.

THE ACTIVITIES

Activity 1. Apart from not knowing what to do with the soil, no difficulty was observed with activity 1.

Activity 2. In two of the lessons observed activity 2 was not attempted apparently because the teachers did not understand what to do. In a third lesson the children were told to plant sticks. The observer reported "Children will have little hope of finding where growth takes place".

Lesson 6, which is a follow-up to Lesson 5, was never observed. This appears to be because children examine the germinating seeds during the following week rather than in the regular science lessons while activity 2 as reported above is generally not attempted.

THE SCIENCE

As the science emerges from the follow-up activities and these were not observed it is impossible to comment on the level of understanding achieved. However it seems clear that teachers did not understand the ideas behind the growth experiment.

TEST QUESTION

5. Which seed will begin to grow?

A. A seed on dry soil.
B. A seed with water.
C. A seed with no water in the sun.
D. A dry seed in a dark room.

RESULTS

	No Resp.	A	*B	C	D	N
Boys	1%	5%	*74%	13%	7%	96
Girls	0%	6%	*65%	17%	11%	81
Total	1%	6%	*70%	15%	9%	177

*correct response.

Despite confusion over the soil noted above children clearly have a good grasp of the main idea behind cards 5 and 6. Boys perform better than girls but not significantly so.

CARD 7 LET'S LOOK AT THE PARTS OF PLANTS

Children label with parts of an actual plant and discuss the functions of these parts with the teacher. They place planted seeds in 1) a dark place 2) a box with a hole at one end. They examine these in the following week's lesson.

Lesson Observations (5 lessons)

THE MATERIALS

Many children failed to bring a plant or brought large plants so that in two lessons observed there were insufficient plants to allow each child to stick one in a book.

THE ACTIVITIES

The first activity including writing about the parts of the plant takes a very long time. This prevented one teacher observed from attempting the second part of the activities. The second part requires a lot of instructions which, as often occurs in T.P.P.S. lessons, are given in a confused way by the teachers. However again, as often happens, pupils manage to sort out for themselves what they are supposed to do - without understanding why.

There is only one report of follow-up to this lesson which states that the children were able to answer adequately questions arising from the activity.

THE SCIENCE

Again understanding arises from the follow-up which was not adequately observed.

TEST QUESTIONS

(A large diagram of a plant with parts labelled A (flowers), B (leaves, C (stem), D (roots).)

Look at the picture. Use this picture for questions 6 and 7.

6. Which part gets substances from the soil? A B C D

7. Which part makes food for the plant? A B C D

RESULTS

Question 6

	No Resp.	A	B	C	*D	N
Boys	1%	9%	2%	17%	*71%	96
Girls	1%	6%	4%	15%	*74%	81
Total	1%	8%	3%	16%	*72%	177

*correct response.

There is clearly little difficulty with this question.

Question 7

	No Resp.	A	*B	C	D	N
Boys	1%	27%	*20%	7%	45%	96
Girls	0%	30%	*19%	7%	44%	81
Total	1%	28%	*19%	7%	45%	177

*correct response.

The choice of D shows considerable confusion between making food and obtaining nutrients from the soil. This despite the fact that making food and the need for sunlight is emphasised in relation to the activities of the lesson.

(Four diagrams show boxes with an opening to the light. Three diagrams show different directions of growth of the plant and one, C, shows very little growth).

8. Agemake leaves his plant in this box. He leaves it one week. Which picture shows how the plant will grow? A B C D

RESULTS

	No Resp.	A	B	C	*D	N
Boys	2%	16%	26%	26%	*30%	96
Girls	0%	19%	28%	33%	*20%	81
Total	1%	17%	27%	29%	*25%	177

*correct response.

The distribution of responses is similar to that which would be expected by chance. One would expect that if children had seen the results of this experiment the question would cause no difficulty. This probably indicates that this, like other experiments in T.P.P.S. which extend over a period of time, are largely neglected by the teacher.

CARD 8 LET'S LOOK AT THE PARTS OF A FLOWER

Children examine the parts of a flower - petals, male, female parts.

Lesson Observations (1 lesson)

THE MATERIALS

All available in the lesson observed.

THE ACTIVITIES

No difficulties observed.

THE SCIENCE

The observer reported that the teacher didn't understand the diagram of the parts of the flower.

TEST QUESTION

See next card.

CARD 9 LET'S SEE HOW FLOWERS CHANGE INTO FRUITS

Children examine flowers and discuss pollination, fertilization, ovary, fruit, seed and hence complete the cycle.

Lesson Observations (1 lesson)

THE MATERIALS

All available in the lesson.

THE ACTIVITIES

No difficulties except there is not much for the children to do. The lesson is largely exposition on the teacher's part. The observer suggested that children could be involved in more recording to reinforce the activities.

THE SCIENCE

No difficulties.

TEST QUESTIONS

9. How is a flower fertilized?

A. By sperm from an insect.
B. By pollen from the male part of the flower.
C. By pollen from the female part of the flower.
D. By ovaries carried by the wind.

RESULTS

	No Resp.	A	*B	C	D	N
Boys	4%	24%	*24%	29%	19%	96
Girls	1%	21%	*22%	36%	20%	81
Total	3%	23%	*23%	32%	19%	177

*correct response.

The small difference in wording of alternatives B and C and the correct interpretation of the important word 'from' in these alternatives may have caused confusion.

Question 10. (Diagram of a flower the same as on Card 8 but labelled A B C D.)

10. Which part will grow into the fruit?

RESULTS

	No Resp.	A	B	C	*D	N
Boys	2%	9%	26%	19%	*44%	96
Girls	0%	16%	37%	17%	*30%	81
Total	1%	12%	31%	18%	*37%	177

*correct response.

A more straightforward question than question 9 - directly related to what children have actually seen in the activity - provided the children can interpret the diagram in terms of the actual flowers they have examined. However the overall correct response of 37% is somewhat disappointing. Boys score significantly better than girls (at the 0.05 level).

OVERVIEW CARDS 5-9

An important and relevant topic for a predominantly rural country which uses a series of worthwhile activities to illustrate the complete life cycle of plants. However some of the activities, particularly those involving an extended period of observation, are ignored by many teachers. In addition the overall view, i.e. the cycle seed to seed of the title, is only very briefly referred to at the very end of the last card and it must be doubted whether the children, or even the teachers are aware of this basic theme.

The results of the test questions show the very simplest ideas generally well understood but others, e.g. growth towards the light and fertilization, which were probably not part of childrens' knowledge before doing the T.P.P.S. course, much less well understood.

CARD 10 LET'S FIND OUT WHAT FOODS CONTAIN STARCH

The teacher shows the children the iodine test for starch. Children test various substances for starch.

Lesson Observations (0 lessons)

None observed mainly due to disruption of school timetable which occurs at the end of Term III.

TEST QUESTION

11. When we put iodine on bread it turns black. This shows us that the bread contains:

A. carbon B. salt
C. water D. starch.

RESULTS

	No Resp.	A	B	C	*D	N
Boys	1%	40%	5%	21%	*34%	96
Girls	2%	43%	7%	12%	*35%	81
Total	2%	41%	6%	17%	*34%	177

*correct response.

The choice of alternative A is clearly due to the linking of the word 'black' in the stem with word 'carbon'. However two of the five classes tested had not done this lesson and an examination of the results of those who have show that they responded slightly but not significantly better with 40% choosing the correct response.

OVERVIEW CARD 10

Although there is some connection between this card and card 7 in which children are told that plants make food in their leaves, no explicit link between these two lessons is made on the cards so that Card 10 does stand very largely on its own. In addition the activity is very much of the cookery book type requiring little or no understanding although it could perhaps be defended as illustrating the important idea of a scientific test cf. test for a magnet. However the value of a simple test for starch on its own without relating this to such topics as nutrition must be questioned.

CARD 11 LET'S FIND OUT HOW LONG IT TAKES HEAT TO GO ALONG A ROD

The teacher sets up a metre pendulum to count seconds. Pins are stuck to a metal rod with wax, one end of the rod is heated and the time for heat to travel along the rod measured by observing the fall of the pins as the wax melts and timing with the pendulum.

Lesson Observations (1 lesson)

THE MATERIALS

No difficulty obtaining the materials on the card.

THE ACTIVITIES

Several small technical difficulties largely arising from inadequate instructions. These were overcome. The teacher extended the lesson by using rods of different metals and comparing the times for heat to travel along them.

THE SCIENCE

No difficulties.

TEST QUESTION

(A diagram shows the arrangement for heating a metal rod as used on Card 11.)

12. This equipment shows us that:

A. the metal rod is a magnet
B. heat from the flame travels along the metal rod
C. the metal rod can burn
D. the metal rod does not get hot.

RESULTS

	No Resp.	A	*B	C	D	N
Boys	1%	10%	*48%	27%	13%	96
Girls	2%	15%	*30%	30%	23%	81
Total	2%	12%	*40%	28%	18%	177

*correct response.

Of the five classes tested three had not done this lesson which should make answering the question impossible as it is based directly on the specific situation of the lesson. However a further analysis of the results showed that those who had not done the lesson were selecting the correct response as frequently as those who had.

On inspecting the alternative responses it seems clear that all three distractors can be eliminated by the use of common sense and at the same time the correct response obviously relates most closely to the diagram.

A poor question.

OVERVIEW CARD 11

Like the previous card this one stands very much on its own, both in dealing with heat (although there are similar simpler activities in earlier phases) but more particularly in its inclusion of the pendulum. The Western scientific concept of time is one which it is particularly difficult for students in apua New Guinea to grasp. Work with the pendulum can certainly do something to aid the development of this concept so it seems particularly unfortunate that only a part and a subsidiary part of one T.P.P.S. lesson is devoted to it.

PHASE III STANDARD 6 TERM 3

PHASE III ST.6 TERM 3 CARDS 1-4 LIGHT - IMAGES

CARD 1 LET'S MAKE PICTURES WITHOUT A LENS

Children make a pin-hole camera from a tin can, tracing paper and newspaper.

Lesson Observations (3 lessons)

THE MATERIALS

In none of the lessons observed was black paint available.

THE ACTIVITIES

In one of the lessons observed the teacher had no idea how to do the activity and in fact showed the children how to make the camera wrongly. In the other two lessons the teachers' instructions were judged to be inadequate. When the cameras were finally made they aroused considerable interest.

THE SCIENCE

This lesson provokes a considerable number of childrens' questions, in particular about why the image is upside down. The teachers observed did not understand the principle of the pin-hole camera and so were quite unable to answer these questions.

TEST QUESTION

(Four diagrams labelled A B C D show images of trees in different orientations.)

1. Which image of a tree is correct using a pin-hole camera?

RESULTS

	No Resp.	*A	B	C	D	N
Boys	4%	*22%	6%	67%	1%	79
Girls	0%	*32%	2%	66%	0%	41
Total	3%	*25%	5%	67%	1%	120

*correct response.

As children enjoy and are impressed by the pin-hole camera it is difficult to understand why so few choose the inverted tree in A and so many choose the upright tree of C. A misprint in the question whereby the word 'camera' was omitted may have confused some pupils.

CARD 2 LET'S MAKE A PICTURE WITH A LENS

Children use a lens to produce an inverted image of a candle flame on a screen. The lesson emphasises that two different kinds of image (magnified and diminished) can be formed.

Lesson Observations (3 lessons)

THE MATERIALS

No candles in one lesson observed. They used burners which could be very dangerous.

THE ACTIVITIES

The main difficulty arises from the fact that classrooms are generally too bright for an image of the candle to be seen. In two lessons the children worked under the desk but in one of them still could not see an image except of bright objects outside. One teacher aroused interest by mentioning the image seen on a cinema screen.

THE SCIENCE

Children were able to observe the different images but there was no attempt or intention of explanation.

The relation between this situation and the camera is not mentioned on the card.

TEST QUESTION

(A diagram shows a lens, candle and screen.)

2. To get an image on the screen that is small and upside down the lens has to be put:

   A. close to the candle
   B. half-way between the candle and the screen
   C. close to the screen
   D. at the screen.

RESULTS

	No Resp.	A	B	*C	D	N
Boys	1%	19%	70%	*10%	0%	79
Girls	0%	10%	56%	*27%	7%	41
Total	1%	16%	65%	*16%	3%	120

*correct response.

Most children opted for the simple response B, perhaps because there is no emphasis on the word small in the question, although there is emphasis on the card on the different images formed by placing the lens in different positions. Girls performed significantly better than boys on this question (significant at the 0.01 level).

CARD 3 LET'S FIND OUT ABOUT OUR EYES

Teacher talks about the eye and children observe the change in diameter of the pupil. Children form an image with a lens on a screen and this is related to the working of the eye.

Lesson Observations (4 lessons)

THE MATERIALS

In two of the four lessons no torch was available and the teachers had no idea how to manage without. In these two lessons no chart was available.

THE ACTIVITIES

The main activity apart from the formation of an image with a lens which has been done before, is to use a torch to cause a contraction of the pupil. However in all lessons observed it was noted that this was unsatisfactory with only one torch for the whole class. Simpler methods such as having the child cover his eyes for a period could be used. Many children had difficulty in differentiating the black pupil from the dark brown iris.

THE SCIENCE

Children and teachers did not generally understand the connexion between the experiment with the lens and the eye. In two of the lessons it was reported that teachers did not understand the lesson at all i.e. the parts of the eye and their functions.

TEST QUESTIONS

3. Which is the best way to describe the eye?

   A. It is like a pin-hole camera.
   B. It is like a torch.
   C. It is like a mirror.
   D. It is like a lens and a screen.

RESULTS

	No Resp.	A	B	C	*D	N
Boys	1%	25%	19%	20%	*34%	79
Girls	0%	39%	27%	7%	*27%	41
Total	1%	30%	22%	16%	*32%	120

*correct response.

The rather poor result probably reflects the lack of understanding of the relation between the lens and screen experiment and the eye noted above. However alternative A is also a reasonable response and if this is combined with D it may be deduced that the majority of the children have grasped the idea of image formation in the eye.

(Four diagrams, A B C D each show an eye with different pupil apertures)

4. Which of these eyes shows that the person was standing in bright sunshine?

A B C D

RESULTS

	No Resp.	*A	B	C	D	N
Boys	3%	*32%	20%	24%	22%	79
Girls	2%	*22%	24%	27%	24%	41
Total	3%	*28%	22%	25%	23%	120

*correct response.

The results are fairly evenly spread over the four alternatives. This may be a result of the difficulty in seeing the pupil which was noted above.

CARD 4 LET'S FIND OUT MORE ABOUT OUR EYES

Children investigate the eye's ability to focus near and distant objects.

Lesson Observations (3 lessons)

THE MATERIALS

Generally no recording sheets were available. In one lesson there were no metre tapes.

THE ACTIVITIES

Further difficulty in obtaining an image of a candle in bright and windy conditions. Children do not feel the changes in their eyes when looking at near and far objects.

THE SCIENCE

The development of scientific ideas that occurs within this lesson is (a) complex and (b) misleading. There is quite a long sequence of ideas involving the lens and ideas of focussing at different distances. The final result implies that while the eye can focus over a range of distances it cannot focus on an object closer than a certain distance (which is correct) and neither can it focus further than a certain distance (which is incorrect). However all this was far beyond the children (and the teacher) who simply went through the mechanics of the activity.

TEST QUESTION

See previous Card 3.

OVERVIEW CARDS 1-4

The topic of this sequence of lessons is important scientifically as an introduction to the behaviour of light and the formation of images and in its

everyday applications e.g. the camera, the cinema projector and most importantly, the eye.

Children enjoy immensely the lessons involving the formation of images and those involving the study of their own bodies, in this case their eyes. However most of the ideas tested by the questions have been grasped by only a minority of the pupils.

PHASE III ST.6 TERM 3 CARDS 5-6 LIVING THINGS

CARDS 5-6 LET'S DISSECT A FROG OR TOAD

Children dissect a frog or toad and examine muscle, lungs, heart, intestines and tongue.

Lesson Observations (6 lessons)

THE MATERIALS

In two lessons no chart was available and no pins.

THE ACTIVITIES

Teachers do not take a double lesson as suggested so the activity must be rather hurried. A diagram of the internal organs of the frog would help guide dissection and identification. Children are generally afraid to start this activity but once they have made the first cut interest and enthusiasm are generally very high.

THE SCIENCE

There is some difficulty over identification of internal organs.

TEST QUESTION

(Diagram of a frog showing lungs, stomach, intestine and anus.)

Look at the picture of the frog. Which part is a lung? A B C D

RESULTS

	No Resp.	*A	B	C	D	N
Boys	4%	*71%	16%	6%	3%	79
Girls	2%	*76%	19%	2%	0%	41
Total	3%	*73%	18%	5%	2%	120

*correct response.

Althouth numbers were small an analysis of the responses of children who had not done this lesson was undertaken. This showed a slightly though not significantly better result for those who had not done the lesson. It appears that children can identify a lung whether they have dissected a frog or not.

OVERVIEW CARDS 5-6

Lesson observation appears to indicate that children gain much of value from this lesson although this is not apparent from the results of the test question.

PHASE III ST.6 TERM 3 CARDS 7-8 LIGHT - REFLECTION

CARD 7 LET'S FIND OUT HOW LIGHT IS REFLECTED

Children arrange for a beam of sunlight to be reflected from a mirror and mark the positions of several incident and reflected rays.

Lesson Observations (1 lesson)

THE MATERIALS

All available.

THE ACTIVITIES

The lesson looks complex and in the only lesson observed the teacher did not know what to do and had to ask the observer for help. After this the children carried out all the activities successfully. The observer (a teachers' college head of science) points out that the one week in-service course which this teacher had undertaken to cover 63 Phase III lessons was clearly insufficient. This comment was repeated several times in the context of observation of other lessons.

THE SCIENCE

No difficulties observed.

TEST QUESTION

(Four ray diagrams showing light incident on a mirror reflected at different angles.)

6. Which diagram correctly shows how light hits a mirror? A B C D

RESULTS

	No Resp.	*A	B	C	D	N
Boys	3%	*35%	9%	5%	48%	79
Girls	0%	*17%	10%	17%	56%	41
Total	2%	*29%	9%	9%	51%	120

*correct response.

D shows an incident ray reflected along the normal. This option may have been chosen because diagram D is clearly different from the other three which are, in fact, quite similar, alternatives B and C simply showing unequal angles of

incidence and reflection without any normal drawn in. In addition alternative D which shows a normal may have confused children because a normal is the first line drawn in the activity and appears on all the ray diagrams on the card. It is however of some significance and comfort that alternative A showing equal angles of incidence and reflection is chosen three times as frequently as B or C.

Boys score significantly better than girls on this question (at the 0.01 level).

CARD 8 LET'S MAKE A PERISCOPE

Children make and use a periscope.

Lesson Observations (2 lessons)

THE MATERIALS

Cardboard in one lesson was missing.

THE ACTIVITIES

Although the method described for making a periscope is a simple one and apparently clearly described on the card, teachers find it difficult to follow. This is because the periscope described is not the usual box structure but has two sides only. In one of the lessons observed the teacher attempted to have children make periscopes from plywood but this was unsuccessful. In the other, despite some difficulties the periscopes worked and the children enjoyed the lesson.

THE SCIENCE

The card does not relate this lesson to the previous one.

TEST QUESTION

7. A small boy is at a football match. He cannot see the game because big people are standing in front of him. Which instrument would help him to see over the big people?

A. A microscope.
B. A telescope.
C. A periscope.
D. A telegram.

RESULTS

	No Resp.	A	B	*C	D	N
Boys	3%	10%	46%	*35%	6%	79
Girls	0%	22%	27%	*39%	12%	41
Total	2%	14%	39%	*37%	8%	120

*correct response.

Alternative B, the telescope, which was very popular with the boys, probably arises from a careless reading of the question in terms of distance rather than seeing *over* an obstruction. The question relies on the children remembering the word 'periscope'.

OVERVIEW CARDS 7-8

More useful material on the basic behaviour of light with a practical application which the children enjoy.

The two lessons are very closely related but this is not mentioned on the cards.

PHASE III ST.6 TERM 3 CARD 9 AIR

CARD 9 LET'S FIND OUT WHICH WAY THE AIR PRESSES

Three experiments on air pressure:

1) Breaking a stick under paper.
2) Inverted jar of water with cardboard cover.
3) Collapsing can experiment.

Lesson Observations (2 lessons)

THE MATERIALS

Large can was missing in one lesson.

THE ACTIVITIES

Experiment 1. The card surprisingly suggests the use of rulers for the breaking stick experiment. In one of the lessons observed the teacher showed the children how to hold the stick down with their hands while they hit it! In the other the teacher told the children to wet the paper so that it stuck to the desk. Both experiments produced the 'correct' result!

Experiment 2. Worked well and provoked considerable interest.

Experiment 3. The relation between the experiments and air pressure was not clearly brought out in either lesson. It is in fact a very difficult concept. The following illustrates the level at which one lesson was taught:

On first attempting experiment 1 the paper tore in almost every case.

Teacher: *I think you have already felt something pressing down?*
Class: *Yes.*
Teacher: *What is it?*
Class: *Air.*

The class had not felt anything pressing down and certainly had no reason to believe that the air had anything to do with the paper tearing. However, as often happens when children don't understand, they are able to provide the answer the teacher wants by intelligent use of appropriate clues - in this case the lesson title.

TEST QUESTIONS

8. A small amount of water inside the tin was put on a fire and heated. When the water boiled it was taken off the fire and the lid put on tightly. The tin crushed because:

   A. it was hot
   B. there was no air inside, the air outside crushed it
   C. the air inside the tin crushed it
   D. the steam inside crushed it.

RESULTS

	No Resp.	A	*B	C	D	N
Boys	0%	29%	*22%	24%	25%	79
Girls	0%	27%	*24%	24%	24%	41
Total	0%	28%	*23%	24%	25%	120

*correct response.

9. Which statement is true?

   The air presses:

   A. only sideways
   B. only downwards
   C. only upwards
   D. in all directions.

RESULTS

	No Resp.	A	B	C	*D	N
Boys	1%	10%	5%	10%	*73%	79
Girls	2%	10%	10%	5%	*73%	41
Total	2%	10%	7%	8%	*73%	120

*correct response.

These results strongly reinforce the lesson observations i.e. Question 9 which requires only the mechanical answer 'air presses in all directions' gets a high percentage correct whereas Question 8 which required an understanding of what is happening in the collapsing can experiment, produces a chance distribution or responses.

OVERVIEW CARD 9

These are the good old traditional experiments on air pressure and the children certainly enjoy them. However although in this lesson, unlike many in T.P.P.S., the science is specifically drawn out on the card one could hardly expect a single lesson to have much impact on the development of a difficult concept such as air pressure, and this appears to be the case.

PHASE III ST.6 TERM 3 CARDS 10-11 MAGNETISM AND ELECTRICITY

CARD 10 LET'S MAKE AN ELECTRIC MAGNET

Children make and test an electromagnet with a dry cell, nail and covered wire. As an extra activity the children investigate the effect of using a) fewer turns of wire; b) two cells instead of one.

Lesson Observations (2 lessons)

THE MATERIALS

All available.

THE ACTIVITIES

Two contrasting lessons observed. In one the teacher issued all the apparatus, and the children were left to their own devices. Most deduced from the answer sheet (which showed a diagram of an electromagnet) how to do the activity. However the logical development of the lesson which involves testing the nail, nail plus wire and finally nail plus wire plus battery was completely lost.

In the second lesson the teacher obviously fully understood the logical development of the sequence of activities and took the children carefully through these. He even added an activity at the beginning with a permanent magnet to revise the test for magnetism.

However the end result in terms of success with the activity and level of understanding was not, on a subjective judgment, much different in the two lessons.

THE SCIENCE

No difficulties apparent.

TEST QUESTION

(Four diagrams show electromagnets made with a) 2 batteries/many turns of wire; b) 1 battery/many turns of wire; c) 2 batteries/few turns of wire; d) 1 battery/few turns of wire.

10. Look at the diagrams. Which is the strongest electric magnet?
    A B C D

RESULTS

	No Resp.	*A	B	C	D	N
Boys	1%	*63%	13%	19%	4%	79
Girls	2%	*71%	5%	22%	0%	41
Total	2%	*66%	10%	20%	3%	120

*correct response.

Apparently a good result. However a check of the two classes which did not do the lesson shows that they performed equally well. One is forced to the conclusion that children are using their common sense. One can imagine them eliminating B and D fairly readily because these can obviously not be so strong with only one battery (the results support this conjecture). Next C with two batteries but only two turns is eliminated and one is left with A which has two batteries and lots of turns of wire and is obviously strong.

CARD 11 LET'S MAKE AN ELECTRIC BUZZER

After seeing the teacher's buzzer children make and use an electric buzzer made from a home-made electromagnet, a paperclip, a strip of 'tin' and other odds and ends.

Lesson Observations (1 lesson)

THE MATERAILS

All available.

THE ACTIVITIES

This is an optional activity and probably the most difficult in T.P.P.S. However in the one lesson observed the teacher and the boys in the class succeeded in making the buzzers work. Girls had much less success due to lack

of interest.

THE SCIENCE

This is a pure construction. No relation to the previous lesson is shown on the card or is any sort of explanation attempted.

TEST QUESTION

None.

OVERVIEW CARD 10-11

The inclusion of these lessons cannot be justified in terms of their relevance to the environment in which most of the children find themselves. However they are worthwhile in that they demonstrate the inter-relation of the two important phenomenon electricity and magnetism and are a source of fascination and enjoyment to the children.

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APPENDIX A

PHASE III LESSON ANALYSIS

In order to assess the effects of T.P.P.S. it is necessary first to ascertain what the course is trying to achieve. This is set out in general terms in the Teachers' Handbook which formed the starting point for much of the evaluation of Phases I and II.

However, in order to ascertain the aims of Phase III in more detail it was decided to analyse the content of the Phase III lesson cards, lesson by lesson. This was done in terms of the two main areas of concepts and skills as they are expected or required of the children. In considering the concepts involved it was found useful to divide them into two groups, namely, general scientific concepts and specific concepts. General scientific concepts are those which are required in many if not all areas of science including those which relate to the nature and methods of science. Examples of these are the use of scales and units, and the idea and use of the controlled experiment. Specific concepts are those which relate to the content of particular areas of science e g. magnetism, weight and magnification. These specific concepts vary considerably in their specificity from those with wide application such as volume, to those with a much more restricted application such as pollination. In view of this it might be argued that some of the specific concepts which have a very wide application should be included under general concepts and in fact the dividing line is not easy to draw, however, what has been attempted is to include under general concepts only those which appear to form a necessary basis for a broad understanding of science and its methods.

The analysis shows that Phase III includes a wide range of specific scientific concepts. These raise two major questions so far as the evaluation is concerned. The first is whether it is desirable that primary school children in Papua New Guinea should develop these concepts rather than others, in other words, whether these particular concepts are the most relevant and appropriate for Papua New Guinea. The second is to what extent the T.P.P.S. course enables children to achieve an understanding of these concepts.

The general scientific concepts included in the analysis would be considered by many to be of the greatest importance. These are concepts which by their very generality can form a basis for understanding not only the more specific concepts included in the course but also the nature of science, and its impact on a changing society. An understanding of these general concepts may in fact determine a person's ability to deal meaningfully with matters relating to science, or claiming to relate to science, which he may encounter throughout his life. In view of this it is significant that several of these basic scientific ideas occur frequently both explicitly and implicitly throughout Phase III. Among them are generalizations based on specific experiments or observations, investigation of phenomena by varying a single factor in an experimental situation, the use of units in the construction of scales and measuring instruments and the application of specific concepts to useful devices. Again questions of relevance and effectiveness of the course must be considered and in particular in this context what sort of grasp of such concepts, if any, children at this stage are able to achieve.

In the present report an attempt to evaluate pupils' level of achievement of some of the *specific* concepts listed was made through three cognitive tests. The results are discussed in Section C and recorded in detail in Section D. The numbers included in brackets in the analysis which follows indicate the number of the test question which relates to the preceeding concept.

T.P.P.S. LESSON ANALYSIS

PHASE 3B

LESSON	GENERAL SCIENTIFIC CONCEPTS	SPECIFIC SCIENTIFIC CONCEPTS	SKILLS
3B 1 Syringe marks	Units - Construction of a scale using units	Volume (1), Cubic centimetres c.c. scale	Measurement of length in cm. (1 cm. only)
3B 2 Solid c.c.	Conservation Indirect measurement	As 3B No.1 Displacement of water by object to measure volume of object in c.c. (2)	Measurement of length (1 cm. only) Scale reading (c.c.) Recording (1 quantity)
3B 3 Volume jar	Scale construction using units (multiple units) Approximation	The millilitre (1) Displacement used to measure volume in mls.	Construction of volume scale using given units Recording in given table (one quantity) Scale reading recorded as between two unit marks
3B 4 Lungs volume	Units and subunits Indirect measurement		Measuring volume using calibrated vessels (including subunits) Recording (one quantity) Identification of greatest volume by comparing number values

LESSON	GENERAL SCIENTIFIC CONCEPTS	SPECIFIC SCIENTIFIC CONCEPTS	SKILLS
3B 5 Sub-stances dissolve		Soluble/Insoluble (3) Dissolving	* Problem Recording in a given table (lists of substances in 2 groups according to observations)
3B 6 Compare soluble		Degree of solubility Quantity dissolving - most/least	* Problem Recording in a given table (list of substances and one quantity) Measuring 15 mls. using graduation on syringe Identification of largest/smallest volume by comparing number values
3B 7 Pure water	Application of science concepts to useful device	Solution consists of 2 parts (4) Separating solute and solvent by boiling (4) Vaporisation Condensation	
3B 8 Separate sand/ copper sulphate	Application of science concepts to a practical problem (including a sequence of operations)	Soluble, Insoluble Separation of soluble and insoluble substances from a mixture (5) Evaporation Filtration	* Problem Filtration Measurement of volume using syringe

LESSON	GENERAL SCIENTIFIC CONCEPTS	SPECIFIC SCIENTIFIC CONCEPTS	SKILLS
3B 9 Burning	Investigation by varying one factor in a situation Induction of general rule from observations of specific cases	Burning - need for air (6)	Recording in a given table (observations)
3B 10 Carbon by burning	Induction of general rule from observation of particular cases	Vegetable matter and animal matter contain carbon Burning animal/veg. matter produces carbon (7)	* Problem
3B 11 Salt from ash		As 3B No.8 Plants contain salty stuff (Roots take in salt from soil)	Filtration
3B 12 Liquids climb strips	Capillarity Investigation by varying one factor in a situation	Capillarity for different liquids Average	Timing in minutes Measuring length in cm. Recording in a given table (1 quantity) Comparison of heights in table to identify greatest/least

LESSON	GENERAL SCIENTIFIC CONCEPTS	SPECIFIC SCIENTIFIC CONCEPTS	SKILLS
3B 13 Water - different strips	As 3B No.12	Capillarity using different materials	As 3B No.12
3B 14 Water climbs soil	As 3B No.12	Capillarity using different soils	* Construction As 3B No.12
3B 15 Water stays in soils	Investigation by varying one factor in a situation	Water retention by soils (8,9)	Recording in a given table (1 quantity) Measuring out given volume using syringe Measurement of volume using syringe Use of difference between 2 measurements (volumes) to give required measurement Identification of greatest/least volume by comparing number values
3B 16 Waste in soils.		Decay of plant materials Decayed plant matter is present in soil (10)	Observation of small detail using hand lens Recording (observations)

LESSON	GENERAL SCIENTIFIC CONCEPTS	SPECIFIC SCIENTIFIC CONCEPTS	SKILLS
3B 17 Air in soils	Investigation by varying one factor in a situation	Measurement of volume of air above water Soils contain air (11)	Recording (1 quantity) Comparison of volumes to identify larger Measurement of volume indirectly using syringe
3B 18 Make a magnet	Use of standard test procedure	Some materials can be made into magnets others cannot Testing for magnetism (12) Magnets may be of different strength	Recording (2 lists of substances in two groups according to observations) Making a magnet by stroking Testing and comparing strength of magnets by picking up pins
3B 19 Compass	Application of science concepts to useful device	Magnets free to move settle in definite directions (13) Direction of North North/South poles of magnets Application of direction seeking properties of magnets to compass	Recording of observation by completing a given statement Making a magnet by stroking

LESSON	GENERAL SCIENTIFIC CONCEPTS	SPECIFIC SCIENTIFIC CONCEPTS	SKILLS
3B 20 Two magnets		Attraction and repulsion of magnets acting at a distance (14) Magnetic force varies with distance	Measuring distances
3B 21 Magnet strength	Application of science concepts to a practical problem	Some materials are attracted by magnets Magnets strongest at the ends	* Problem Recording of interpretation of observations by completing given sentence

T.P.P.S. LESSON ANALYSIS

PHASE 3 ST.5 TERM 3

LESSON	GENERAL SCIENTIFIC CONCEPTS	SPECIFIC SCIENTIFIC CONCEPTS	SKILLS
1. Reproduction (1)		Male - sperm) relative Female - egg) sizes and numbers Fertilization by one sperm (1) Cell Cell division Inheritance of characteristics	
2. Reproduction (2)		As Phase 3 St.5 Term 3 No.1 (Revision) Fish reproduction sperm near eggs (Very many eggs, few fertilized, few survive hence very many necessary) Frog reproduction (many eggs sperm on eggs, many fertilized, few survive, hence many eggs necessary (2) Life cycle of the frog	

LESSON	GENERAL SCIENTIFIC CONCEPTS	SPECIFIC SCIENTIFIC CONCEPTS	SKILLS
3. Reproduction (3)		Chicken reproduction Mating - male places sperm inside female's body One sperm fertilises each egg inside female's body Shell formed and egg laid Egg laid is mostly food - small fertilized egg is inside Incubation Chicken cares for young (frogs and fish do not) hence need only few eggs	
4. Reproduction (4)		As Phase 3 St.5 Term 3 No.3 Pig reproduction - development of young in uterus (3) Gestation period Birth Maternal feeding and care (3, 4) Other animals similar	

LESSON	GENERAL SCIENTIFIC CONCEPTS	SPECIFIC SCIENTIFIC CONCEPTS	SKILLS
5 and 6 Seed to seed 1 and 2	Investigation by varying one factor in an experiment	Seed contains sleeping plant Germination - requires water (5) - initial direction of growth independent of orientation of seed - soil not necessary (5) Plant growth - areas of growth i.e. tips of plants	Marking off 10cm. lengths Measurement of lengths in cm. Answering given questions - recording by completion of diagram from observations
7 and 8 Seed to seed 3 and 4	Investigation by varying one factor in an experiment Induction of general rule from observation of specific cases Application of rule to new situation (Deduction)	Parts of a plant and functions Root (anchorage, water, nutrients) (6) Stem (support, carries water, nutrients) Leaves (breathing, food manufacture) (7) Flowers (make fruit and seeds) Parts of a flower - Petals male/female parts Need for sunlight for plant growth Growth occurs towards light (8)	Answering given questions on given answer sheet from observations Labelling a given diagram

LESSON	GENERAL SCIENTIFIC CONCEPTS	SPECIFIC SCIENTIFIC CONCEPTS	SKILLS
9. Seed to seed (5)		Pollination (9) (by insects and wind) Fertilization Ovary becomes fruit (10) (different types) Seeds germinate - hence complete cycle	
10. Foods contain starch	Use of standard test procedure	Plants make food (starch/sugar iodine test for starch) (11) Some foods contain starch	Test for starch Recording in given table (observation)
11. Heat along a rod		Heat conduction (12) Rate of conduction Pendulum as instrument for measuring time intervals	Recording measurement of time by completing a given sentence Recording (one quantity) Measuring out given lengths in cm. Timing using a 'seconds' pendulum

T.P.P.S. LESSON ANALYSIS

PHASE 3 ST.6 TERM 3

LESSON	GENERAL SCIENTIFIC CONCEPTS	SPECIFIC SCIENTIFIC CONCEPTS	SKILLS
1. Pictures without a lens		Image formation (1)	* Construction Recording of observations in sentence form
2. Lens pictures	Investigation by varying one factor in an experiment	Image formation and focussing with lens Nature of image (size, inversion) (2)	Recording observations by completing given sentences Forming images on a screen using lens
3. Eye (structure)	Application of science concepts to understanding of new situation	The eye - pupil (adjustable window)(4) - lens forms image (retina) (3) Simple structure Brain receives messages from eye	* Construction Recording observations in books by completing given sentences Image formation using lens
4. More about eyes		Image focussing (unclear image) Accommodation of eye to produce clear pictures Effects of distance on clarity of vision	Measurement of distance with metric tape measure Recording measurements of length on given sheet by completing given sentences

LESSON	GENERAL SCIENTIFIC CONCEPTS	SPECIFIC SCIENTIFIC CONCEPTS	SKILLS
5 and 6 Frog dissection		Anatomy of frog Skin, tongue, muscle, stomach, ribs, liver, lungs (5), heart, anus	Measurement of length Dissection of frog
7. Reflection	Application of previous experience to solve a problem in a new but related situation	Reflection of light Equal angle reflection (6)	Recording observations by drawing pattern obtained
8. Periscope	Application of science concepts to a useful device	Application of reflection to periscope (7)	* Construction Measure length Mark out distance
9. Air presses	Induction of general rule from observation of specific cases	Air presses (8) Air pressure acts in every direction (9)	Recording in a given table (observations)
10. Electric magnet	Investigation by varying one factor in an experiment	Electro-magnetic effect Variation in strength of electro-magnets depends on number of 1. batteries 2. turns of wire (10)	Recording observations (Yes/No) on given sheet

LESSON	GENERAL SCIENTIFIC CONCEPTS	SPECIFIC SCIENTIFIC CONCEPTS	SKILLS
11. Electric buzzer	Application of science concepts to a useful device	Application of electro-magnetic effect	* Construction

* Construction

In these lessons pupils are required to make the apparatus needed. Several steps are involved. Instructions are given by the teacher demonstrating his own model.

* Problem

In these lessons, without any initial help from the teacher, pupils are asked to solve a practical problem using materials issued to them.

APPENDIX B

T.P.P.S. PHASE THREE EVALUATION LESSON OBSERVATION FORM

PHASE ____ STANDARD ____ LESSON ____ TITLE _____

OBSERVER _____ TEACHER'S EXPERIENCE: PHASE I & II ___ YEAR (1st, 2nd etc.) PHASE III ___ YEAR

SCHOOL _____ T.P.P.S. COURSES: PHASE I & II ☐ INSERVICE ☐ PRESERVICE PHASE III ☐ INSERVICE ☐ PRESERVICE

ADMINISTRATION ☐ MISSION ☐

URBAN ☐ RURAL ☐ CHILDREN IN CLASS ____ NO. OF GROUPS ____

DATE _____ TEACHER HAS TAUGHT THIS LESSON ____ TIMES BEFORE

MATERIALS MISSING (Were any listed on the card missing? Why?)

THE LESSON (Please follow the lesson on the card and use the numbers on the card to record any deviation from it at any point.)

Instructions:

Activities:

Discussion with pupils:

OVERVIEW OF THE LESSON

CHILDREN

Difficulty with activity:

Difficulties in understanding science:

Questions children ask:

Participation in Discussion:

TEACHER Difficulties with activities or science concepts

OBSERVER'S COMMENTS/SUGGESTIONS (Refer to T.P.P.S. Lesson Analysis for this lesson)

TEACHER'S COMMENTS/SUGGESTIONS

APPENDIX C

SCIENCE AND SCIENTISTS

1. Science can help Papua New Guinea people to have a better life.

2. Scientists find out new things by doing experiments.

3. Scientists know everything now.

4. It is better to find out things from books than by doing experiments.

5. Science can help people who live in towns.

6. I would like to be a scientist.

7. Science is very difficult to understand.

8. Science can help people to:

   1) grow better crops
   2) become rich without working
   3) be good citizens
   4) be healthy
   5) be happy
   6) do their work more easily.

9. Scientists are always trying to find out new things.

10. Science is good because it helps us to understand more about the things around us.

11. Some of the things which science does are bad.

12. The things we learn in science will help us when we leave school.

14. Science can help people who live in villages.

15. Papua New Guinea people can learn to be good scientists like people from other countries.

16. It is difficult to do science experiments.

17. Scientists can tell us the answer to any question.

18. We need more scientists in Papua New Guinea.

19. Science is good because it helps people to make useful things.

20. Scientists know more about medicine than sorcerers.

21. Everything which is written in science books is true.

23. Many things happen which science cannot explain.

24. Science is not useful for ordinary people.

25. Many good things have come from science.

26. Only very clever people can be scientists.

APPENDIX D

SCHOOL SCIENCE LESSONS

1. The science we learn at school is hard to understand.

2. I am happy when it is time for our science lesson.

3. Science lessons are BEST when the teacher does an experiment and we watch.

4. I like to ask our science teacher questions during our science lessons.

5. I like to know what will happen BEFORE we do our science experiment.

6. It would be good to have a science club at school where we could do more science experiments after our lessons.

7. I like science lessons BEST when we do experiments OURSELVES.

8. I like our science teacher to ask us questions during science lessons.

10. I like science lessons when we learn about:

    a) plants and animals
    b) electricity
    c) soils and rocks
    d) measuring things
    e) magnets.

11. I like to find things out for myself in science lessons.

12. The experiments we do in science lessons are good when we *do not know what will happen.*

13. Boys are better at science than girls.

14. We should have MORE science lessons each week.

15. During science lessons I like to talk to my friends about the experiments we are doing.

APPENDIX E

SCHOOLS TAKING PART IN THE EVALUATION

SCHOOL	LESSON OBS.	COGNITIVE TESTS			'ATTITUDES'	
		3B	ST.6	ST.5	S&S.	SSL
PORT MORESBY						
Hagara					x	
Kila Kila	x				x	x
Koke	x	x	x	x	x	x
St. Michaels Hanuabada	x	x	x	x	x	x
Tokarara	x	x	x	x		
OTHER CENTRAL DISTRICT						
Baruni	x	x			x	x
Tubusereia		x		x	x	x
Porebada		x		x		
Moitaka	x	x	x			
Gaire					x	x
Pari					x	
EAST NEW BRITAIN						
Kalamanagunan	x				x	
Nodup					x	x
Tavui					x	
Talwat					x	
Pila Pila					x	x
Lunga Lunga					x	
Vunairoto					x	
Vunalir					x	
Malaguna	x					
St. Joseph's Kabaleo	x					
NEW IRELAND						
St. Martins Namatanai	x				x	x
Halis	x				x	x
SOUTHERN HIGHLANDS						
Kagua	x				x	x
Karia	x				x	x
Wabi	x				x	x
Daulı	x					
MADANG						
Sagalau	x					