AN INVESTIGATION OF THE SCIENCE PROCESS SKILLS IN THE INTENDED AND IMPLEMENTED PSP OF SINGAPORE

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DECLARATION

This work is original and has not been previously submitted in support of a degree qualification or other course.

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ABSTRACT

This study investigated the science process skills in the intended and implemented Primary Science Project (PSP) of Singapore. The science process skills were the focus of the investigation since the national primary science syllabus set out as one of its four aims the need for schools to help each pupil to acquire the ability to use the science process skills. An eclectic evaluation methodology was adopted, collecting and using both qualitative and quantitative data.

The study does not claim to have worked in a judgement free context; it is recognised that information presented cannot be considered to be 'objective'. Inevitably the selection of what data to collect, the method of analysis and its reporting, have been based on the researcher's own values and possible biases. In particular, though focussing on the process-based elements of the project, it has ignored its contribution to the aspects of learning and the interaction of processes and content. The study used a systematic classroom observation schedule coupled with observer notes of the lesson, teacher interviews which partly included the use of a videotape of children working with process skills as a focus and a teacher questionnaire to ascertain teacher priorities in science teaching.

The findings showed that teachers perceive the objectives of PSP as a "hands-on" activity orientated project. To this extent classrooms have moved from chalk and talk experiences of the past to one where children are involved in science activities. This is an important achievement.

The findings also showed that in most classrooms, only a sub-set of science process skills is being provided for to any extent in classroom practice. The findings tend to indicate that there is no significant variation in the experience of the process skills by pupils across class/age levels (P4, P5, and P6). Hence the notion of a hierarchy existing with the higher class/age levels using more of the "integrated skills" as PSP states was not substantiated in this study.

Teachers appear to be working closely with PSP materials giving overall the same relative emphasis to different process skills as intended in PSP. However, they are not varying the emphasis on different skills from lesson to lesson in accordance with the demand of the content of the activity. They tend to have a set approach and are not varying their teaching approaches with regard to the encouragement of process skills.

The centralised national science syllabus and the pressures of preparing pupils for an examination-orientated system appear to be a major constraint on primary science teachers. To the extent these teachers perceive the examination to be content orientated, it will continue to be a constraint on teachers and will raise doubts as to whether there will be a greater opportunity for pupils to work more with process skills.

Teachers continue to be very dependent on the teacher's guide. However teachers need to work with materials that are not highly prescriptive if they wish to use practical work to make children think.

Finally the study has shown that Singapore children are capable of using the process skills, and more importantly, that they can be analytical, critical and able to communicate their ideas when the opportunity is provided for them. This suggests a tendency to underestimate the capabilities of the children.

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INTRODUCTION

This study takes place in Singapore and its concern is the introduction of a new science scheme into the junior years of the primary school. To set the scene this section provides some background information about the Singapore education system and the place of science in it at the primary level. It also provides a brief summary of later chapters of the thesis.

In Singapore formal primary education begins at age six. All pupils follow a common curriculum for the first three years of primary education which emphasises language learning in English and a second language which may be Malay or Chinese or Tamil. At the end of Primary 3, pupils are streamed into one of three courses according to their academic attainment:

a) Normal Bilingual Course (N course). This course is for average and above average pupils and leads to the Primary School Leaving Examination (PSLE) after three more years, at the end of Primary 6.

b) Extended Bilingual Course (E Course). This is for slow learners and leads also to the PSLE but after five more years, at the end of Primary 8.

c) Monolingual Course (M Course). This is for very slow learners and emphasises the study of only one language. At the end of five years in the course (Primary 8) pupils will be given an assessment and then channelled to the Vocational and Industrial Training Board (VITB) for vocational training.

As Singapore has no natural resources and depends only on its manpower resources, much attention is given by the Government to Mathematics, Science and Technical education. Through education aimed at cultivating the enquiring mind, developing numeracy and scientific literacy, and fostering problem-solving skills and creativity, it is hoped to meet the manpower needs of an increasingly industrialised and technological society.

Since the introduction of the Science Syllabus for the New Education System, in 1982, the total curriculum time at the P3 level, is $23\frac{3}{4}$ hours per week. Of this time, Science is given $1\frac{3}{4}$ hours (7.4%). At the P4 N/E - P6 N/8E levels the total curriculum time is $24\frac{1}{2}$ hours per week. Of this time Science is given $2\frac{3}{4}$ hours (11.2%). At the P4M-P6M levels the total curriculum time is $24\frac{1}{2}$ hours per week. Of this time 1 hour is given to science (4%). The curriculum time at the P7M-P8M increases to 25 hours per week. However Science continues to have 1 hour per week.

This study looks only at Science in the P4N - P6N levels. Approximately 60 percent of children from P3 are streamed to the P4N classes at the end of P3.

Prior to 1982, science in schools followed an old syllabus which was wholly content oriented and was delivered via text books and workbooks produced by private publishers. The Primary Science Project (PSP) was first introduced into Singapore classrooms in 1982 at the P3N level. This cohort of children were the first group of children to have their whole primary science course using PSP materials. It must be pointed out that with a centralised education system in Singapore, PSP has a hundred percent adoption. This study is an investigation of the process skills component in the intended and implemented PSP of Singapore.

A summary of the chapters of this thesis now follows.

Chapter One provides a background to the primary science project and examines the research evidence for a case for a science curriculum which is orientated towards process skills.

Chapter Two reviews various curriculum evaluation approaches and looks specifically at implementation evaluation.

Chapter Three looks briefly at the philosophical bearings that have influenced science over the centuries before going on to review some of the major British and American science curriculum projects. Against this backcloth the Primary Science Project of Singapore is reviewed.

Chapter Four identifies the process skills categories for this study and the criteria for recognising the skills. An outline of the schematic process of classroom implementation of PSP developed for this study is presented.

Chapter Five discusses the research design and methodology. It presents the main instruments for data collection.

Chapter Six and Seven present the results of the data analysis. The focus of the analysis is the extent to which the pupils in the study used the process skills and the constraints on the teacher with regard to implementation of the process skills.

Chapter Eight reviews the main findings of this study and discusses selected issues arising from the findings. It includes the experiences the researcher had with a class of 10 year old Singaporean children and their ability to use the process skills. The thesis concludes with some reflective comments on this study and gives pointers for future research.

CHAPTER ONE

TOWARDS THE PRIMARY SCIENCE PROJECT

BACKGROUND TO THE DEVELOPMENT OF THE PROJECT

In a 1979 Review on Curriculum Development in Singapore, Morris and Thompson reported as follows:

> "Teaching is extremely didactic, permitting little by way of dialogue between the teacher and the taught... The teachers, ... rely heavily upon the textbooks to which they gear what they say and which they ask the children to memorise. The parents, likewise we are told, need the reassurance of seeing textbooks in the home. Methods which evade the use of textbooks can be and have in the past been deeply disturbing to parents." (p.6 para 3.6)

The Morris and Thompson study also made the following salient observations of the school situation. They saw the curriculum as mediating the goals of education and describing what it is intended the children to learn. The mediators they described as the body of teachers in the school and their chief resource as communication with their pupils "...if there is no communication between teacher and pupil, there is no curriculum for the pupil." (p.6, para 3.9)

They raised the issue of text books and stated that as teachers rely on text books, it is important that the quality of the texts they use should be the highest possible, and that the texts should, through the way they are designed, promote good classroom practice - that is, they be designed not only to impart information, skills and knowledge, but also powers of analytic reasoning, imagination and creativity.

However they argued that text books deriving from the open market are not likely to exploit audio visual materials which when integrated with the printed word are markedly more effective than those which are confined to chalk, talk and text books. Accordingly they recommended that "... the Ministry itself should, from time to time, develop full courses of integrated learning materials in various areas of the curriculum. Such work could involve the development of an effective textbook, and such other materials as could be deployed in a relevant way, together with a guide for teachers on utilisation." (p. 7, para 3.13)

That same year the Minister for Education in the Preface to the Report on the working visit to France (Goh, 1979) highlighted the Curriculum Development Division as the brain-centre of the educational system, particularly in a centralised system of education as in Singapore. He saw it as the main source of innovation and improvement. Amongst the innovative changes that subsequently followed, the next year saw the setting up of the Curriculum Development Institute, Singapore (CDIS). Its conceptualisation and establishment is certainly seen as a major event in Singapore's education history. A bold innovation it certainly was - a significant one it will almost certainly prove to be. Yeoh (1981a), as the Deputy Director of the Institute, remarks "the innovativeness of the scheme lies hidden in the ways whereby CDIS is so designed to work with schools and thereby to help teachers (and pupils) to help themselves. In this respect, the pupils, teachers and principals of schools form an indispensable part, and the more important part of CDIS. Ultimately, it is the schools who will make the process of curriculum development an effective means of bringing about change and reform in the education system." (p. 5, para 2.21)

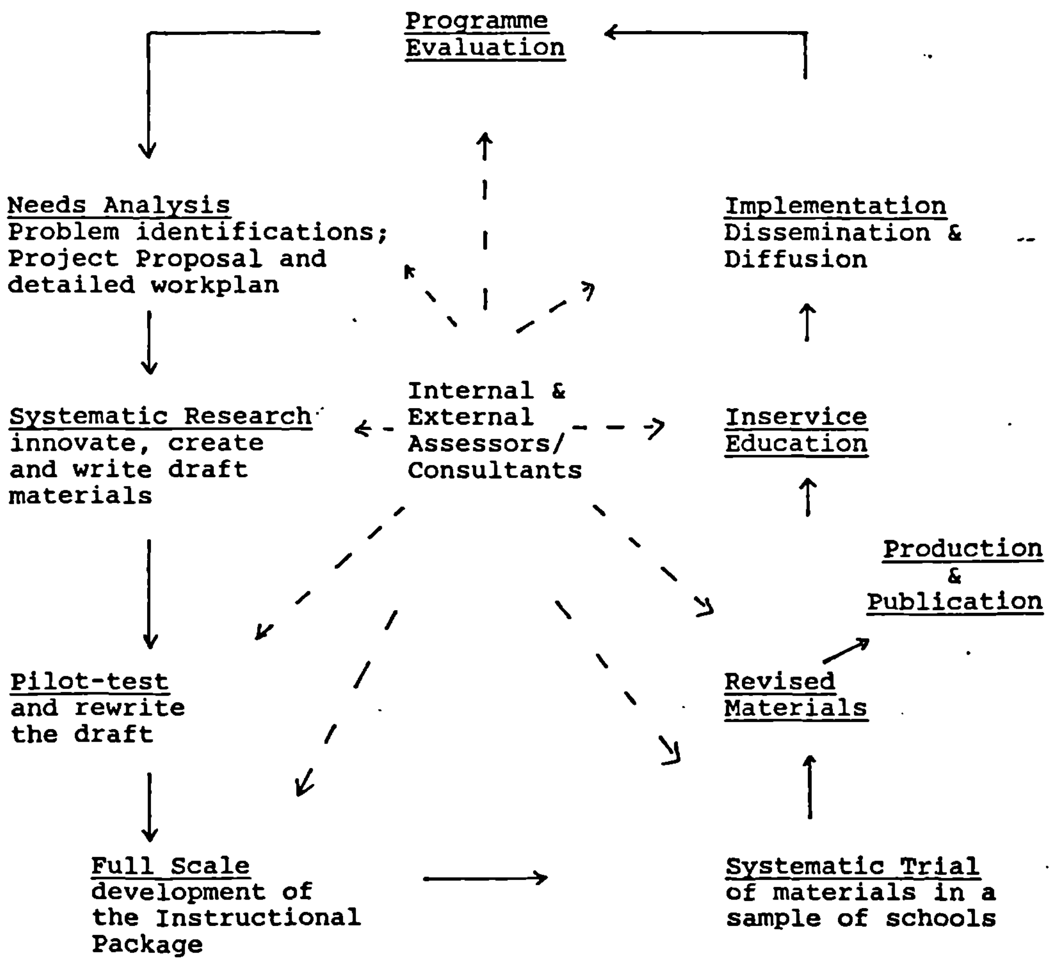
In the same paper Yeoh spells out the following:

> "To allow the creation and experimentation with new Curriculum Instruction Materials, it has been agreed that the syllabuses that have recently been revised will be held constant until the full cycle of development, trial and evaluation of the project has been implemented in the schools. This is a cycle of about 6 years and 4 years respectively for the Primary and Secondary Schools. The work of curriculum development assumes that Educational Policies will remain consistent for the duration of the development. At the close of the full cycle of curriculum implementation, then the syllabuses and the CDIS - published materials will be revised on the evidence of the feedback that is available. This is the rational and empirical basis for the process of curriculum change in schools." (p. 5, para 2.23)

Project teams were set up for each identified subject area. Each team comprised a Project Director and subject specialist writers. These teams were to plan, design, write and develop systematically the curriculum instruction materials to match faithfully and creatively the intended objectives, content and standards of each prescribed syllabus. The system of curriculum instruction and materials development, production and implementation was presented by Yeoh (1981a p.9) as a cyclic sequence of mandatory developmental activities. He outlined the major aspects of the operations schematically in Figure 1:1.

The Primary Science Project Team (PSP) was formed in June, 1980 under the umbrella of CDIS to produce a curriculum package for the teaching

Figure 1.1 The Stages in the Development of Curriculum Instruction Materials
(Source: Yeoh O.C. 1981a p. 9)



and learning of science at the primary level. In Singapore, Science is officially part of the primary school child's curriculum beginning from the third year of schooling (Primary Three, age eight years). It continues to be part of the curriculum with increasing exposure time till Primary Six (age eleven plus) when the child attempts the Primary School Leaving Examination (PSLE). This is a national examination of which science is one of the examinable subjects. A science syllabus provided by the Ministry of Education determines the content coverage expected for the examination. It should be pointed out that children who take the PSLE at age eleven plus are the children who have been streamed at the end of their Primary Three Year into what is known in Singapore as the Normal Stream. It is possible that for some children it is advised that they work at a slower pace - this could mean that they are at the end of their Primary Three Year placed in the Extended Stream. These children would thus have their primary schooling extended by two years and would attempt the PSLE at 13 plus (Primary 8E).

The Primary Science Project (PSP) of CDIS is responsible for the development and implementation of teaching and learning materials for science at the primary school level. Their Newsletter (October, 1981) circulated to schools says the materials are designed to:

a) make the learning of science both meaningful and enjoyable through providing pupils with a wide range of experiences,

b) enable teachers to teach more effectively through the use of the teachers' guide and teaching aids.

The instructional package for P3 to P6 (Normal Stream) and P3 to P8 (Extended Stream) for each grade comprises;

- a pupil's textbook
- a pupil's workbook in two parts, one for each semester
- a teacher's guide
- audio-visual aids mainly in the form of charts and slides.

Others may include transparencies, video cassette tapes and films.

Trial of Materials in Schools

According to the stages shown in Figure 1.1, the instructional materials were systematically pilot tested in schools. The first set of trial materials for P3 was tried out in the pilot schools from March, 1981 to May, 1981. During the trial, PSP team members made regular visits to the trial classes to monitor the suitability of the materials and to interview teachers and pupils for feedback. The three major questions the team wanted answers to were:

a) Is the recommended teaching approach suitable and workable?

b) Is the language used in the text and workbook pitched at the correct level and within the ability of the pupils?

c) Do the materials and teaching approaches arouse interest in the pupils?

A set of the materials comprising the teacher's guide, the textbook and the workbook were also sent to the external consultant. The project team for PSP had the service of Dr. Wynne Harlen of Chelsea College, University of London (now Professor of Education at the University of Liverpool) as their External Consultant. The revision of the materials based on all avenues of feedback obtained then proceeded before publication of the materials for use in schools in January, 1982.

Teacher Orientation to Materials

In that year the team also assigned two members of its 6-member team to take charge of the re-training and orientation of the teachers. All P3 teachers were invited over a period of time to attend at least a 2-day orientation course. The team members also took it upon themselves to give assistance to teachers when called upon by individual schools. This then was the general approach taken by PSP each successive year from 1982-1985 as it continued to introduce to schools the materials up to P6 (and P8 for the extended stream).

Schools were not obliged to use the CDIS curriculum materials. The CDIS materials in fact had to compete in the open market with other commercially published textbooks, approved and authorised by the Ministry of Education. In an examination oriented educational system however, the Deputy Director (Yeoh), in his summary report (1981b) found it necessary to point out that the "Exams Branch receives the Trial Editions of the printed materials ... The intention is to ensure that the public examinations at P3 and P6 will take into account the new materials that have been introduced for use in schools" (p. 8, para 11.3).

In page 9, Paragraph 12.4 of the same report he added:

> "CDIS will continue to work closely with the Exams Branch to ensure that the P3 and P6 examinations are consistent with the modes of teaching and the standards of learning that are prescribed by the new curriculum projects. <u>When the desired standards and kinds of learning outcomes are maintained by the public examinations, these in turn will encourage schools and teachers to adopt the necessary changes.</u>"

Pre-Service Training of Teachers

Yeoh also registers in the same report that collaboration with the Institute of Education (IE) will concentrate on the integration of the curriculum materials and methods of teaching with the pre-service teacher education programme that is offered by the Institute of Education. Every attempt would be made he said to inform and to disseminate the CDIS project to IE so that teacher trainers will be fully acquainted with the innovations that are being introduced in the schools.

In-Service Training of Teachers

Apart from some assistance from the Institute of Education, the CDIS used a "Multiplier - Effect" in-service workshop system initially to introduce the PSP materials to schools. In this instance, only the key subject teachers or subject coordinators from each school were retrained. They in turn conducted school-based workshops to train the other teachers in the school. Naturally, the success of this approach depended very much on the competence and capability of the co- ordinators, and the co-operation of the teachers. From this initial approach, there have over the years been other joint training programmes with staff from the CDIS, IE and the Ministry of Education Specialist Advisors coming together to conduct courses. Attendance at these courses is reportedly very encouraging.

External Evaluation of PSP

In 1983 at the request of the Board of Management of the CDIS the Institute of Education undertook the summative evaluation of the Primary Science Project materials.

The Preface to the 1983 published Summative Evaluation Report says "it was felt that a summative evaluation of CDIS materials undertaken by a separate, autonomous, educational organisation would result in a more objective and frank response from the users (principals, teachers and pupils) of the materials".

The constraints of time, manpower and other commitments restricted the evaluation study to looking at:

1. Intrinsic Evaluation of the materials developed and methodology advocated.

2. Classroom observation of the materials in actual use.

3. Teacher Opinion Survey regarding teachers' feelings on the materials and methodology.

As only the P3N/P4E materials had been produced and operating in schools at the time the above evaluation study was made, the report only reflected this one level. The study attempted to

a) find out how the teaching strategies, activities and materials recommended by PSP for P3 and P4E were being received and used in schools; and

b) identify problems or difficulties in carrying out the activities recommended by PSP.

Data were obtained through the use of questionnaires and classroom observation. A 6-point scale checklist was used by the classroom observers which gave an overall view of how the materials were being received by the teacher and used in the classroom. The observations did not attempt to monitor the opportunities that were being provided for and used by the children on the issues of process skills. Yet this appears to be the main thrust of the Primary Science Project materials as will be discussed next.

NEW ELEMENTS INTRODUCED BY PSP

The introduction to the Teacher's Guide at each level of the Primary Science Project (PSP) states that "Science has two dimensions. One is the body of knowledge that generations of scientists have accumulated. The other is the way this body of knowledge has been acquired". It points out that "in science teaching we must also maintain a balance between these two dimensions. We should be concerned with both - knowledge and the way, i.e. both the content and the processes". It goes on to urge science teachers to help children acquire a correct scientific attitude, to allow pupils to work as scientists, to speculate, to think, to explore, to learn from mistakes and to experience the joy of discovery."

To this extent it is pertinent to note in the introduction to the Teacher's Guide that one of the four aims of the PSP curriculum is to help each pupil "acquire the ability to use the process skills such as asking probing questions, making careful observations, planning and conducting investigations and communicating his experiences and findings". It provides a list of processes, which appear to resemble the SAPA list to be discussed in Chapter Five. It lists them in two categories; basic and integrated, explaining that as the integrated skills are relatively advanced skills their development is generally confined to higher classes. The priority given to process skills is also clearly directed in the Ministry of Education syllabus where it is stated "An activity approach to science teaching has two premises ... The first premise is that pupils learn best by doing, that is by actively manipulating materials and by sharing experiences with their classmates; the second premise is that content learning is secondary to process learning. (p. 3) It is also pointed out in the preface to the Teacher's guide that "science teaching/learning should stress the use of the process skills which lead to the acquisition of knowledge."

This then brings into consideration the role of the teacher. The Teacher's Guide also points out that

> "as the project adopts a child-centred and activity oriented approach its success depends greatly on the role of the teacher. The teacher is seen as a facilitator of learning rather than as a dispenser of science facts... he should seek to arouse the interest and curiosity of the pupils and motivate them to participate actively on their own learning. This not only promotes an understanding of their scientific method but also helps to inculcate a scientific attitude." (Preface to Teacher's Guide)

The teacher's guide is also careful to point out that the materials in the guide are to be seen as "guides and not as prescriptions." An explicit example of the teacher's role is noted in the statement in the guide "the development of communication skills will be hampered if teachers do most of the talking."

THE RESEARCH FOCUS

With such sentiments in the prescribed curriculum materials, the question that can now be asked is how has the progress been? PSP represents a large step away from the established pattern of teaching in operation in 1979 (See Page 1). However, in terms of content coverage, there has been no great change as the new PSP materials were developed around the existing national science syllabus. Apart from the formative evaluation of the materials that was carried out over the years the materials were being prepared, and the initial summative evaluation study plus monitoring by the project team members in schools, there has not been any other recorded attempt to investigate the operational curriculum. In the meantime three cohorts of pupils have completed that primary school education and had their primary science learning based completely on PSP materials. Further, the time for feedback and necessary revision as suggested by Yeoh (See quote p. 3) seems now ripe. Eisner (1985) points out "the existence of a well- planned body of curriculum material is no guarantee that they will be used effectively or with enthusiasm in the classroom." (p.48)

The Intended and Operational Curriculum

Eisner (1985) makes the following distinction:

> "The difference between what is planned in the way of aims, content, activities, and sequences and what actually transpires in the classroom can be formalised into a distinction between the intended and the operational curriculum. The intended curriculum is like the course of study: it is that which is planned. Such plans can ... be inspected, critiqued, revised, and transported to a multitude of locations. The operational curriculum is the unique set of events that transpire within a classroom. It is what occurs between teachers and students. To critique or appraise the operational curriculum requires one to be in a position to observe what classroom activities actually unfold. Inspection of plans or of the intended curriculum is no assurance that those plans are actualized." (pp. 46-47)

This study aims to look at the relationships between the intended and the implemented or operational PSP curriculum. The intended curriculum in general can mean the body of material that the developers of the materials have planned in advance of classroom use and that is designed to help students learn some content or acquire some skills. In a curriculum that goes beyond, there may also be the intention that pupils develop some beliefs or have some valued type of experience.

This study however, only aims to look at the specific aspect of the curriculum dealing with the opportunities the curriculum provides for pupils to experience working with the process skills in science. In terms of the operational curriculum, one would mean those activities that occur in the materials, content, and events in which students are engaged. An important question that can be posed here is why the particular focus on the process skills in science? This can best be answered by looking at the research evidence for the case for process skills.

THE CASE FOR PROCESS SKILLS - RESEARCH EVIDENCE

Singapore's Prime Minister in 1978 described what he thought were the desired traits for the Singaporean when he said,

> "... the best of the East and of the West must be blended to advantage in the Singaporean. Confucianist ethics, Malay traditions, and the Hindu ethos must be combined with the sceptical Western methods of scientific inquiry, the open discussive methods in the search for truth." (emphasis added) (Quoted from the Reply of the Prime Minister to the Report on the Ministry of Education 1978, para. 21.)

These words seem to have heralded the subsequent innovation in curriculum materials that Singapore Schools were to soon see. The past decade has seen the Government continue to stress the importance of a good educational programme for its young people, and schools have seen many a change, not only in the introduction of these new curriculum materials in the different subject areas, but also in the quality of training of its teachers, administrators and the supply of resources to schools.

In 1986, the Education Minister, Dr. Tony Tan made a major policy speech on Economic Change and the Formulation of Education Policy. In his speech he made the point that the kind of people required for the work force of the future were those who are creative and imaginative (para. 56). He asked, "... How do we foster the spirit of creativity and innovation in our schools?" (para. 58) He referred to the findings of a high level non governmental American committee set up in 1985 - the Committee of Economic Development. It produced a policy statement entitled "Investigating in our children : Business and the Public Schools" (para. 60). The basic conclusion of this committee was that the main function of a school was to teach students to think critically and analytically, to co-operate and communicate as well as to compete, to assume responsibility for themselves and to solve problems (para. 64).

The Education Minister also referred to a recent Japanese Committee on Education established by Prime Minister Nakasone which recommended that school education in Japan should move away from rote learning and should lay emphasis on fostering among children the abilities to imagine and create, think logically, conceptualize and express themselves precisely (para. 68).

It would appear then that the generally accepted view of education whether in Singapore or elsewhere is one that would develop in children the attributes of logical thinking and the ability to use the necessary skills to find solutions to problems. Theoretically it would appear that it is possible, but is it in practice? Does a science programme which emphasises process skills and provides opportunities for such, result in pupils developing the ability to be creative and to use the methods of scientific inquiry in their search for truth? What research evidence is there that when children are exposed to a curriculum emphasising process skills there are positive outcomes?

In 1985, Jacobson and Doron presented some of the American findings resulting from the International Association for the Evaluation of Educational Achievement's (IEA) Second International Science Study (SISS). As the US had participated in the first study (FISS) in 1970, they were able to make comparisons on pupil performance on 'bridge' items, that is, on scores to questions that were also used in FISS. Their findings at the fifth grade (10 year old) level showed that overall, pupil performance in 1983 was significantly better in the twenty- six bridge items. On eighteen bridge items the means in 1983 were more than 2 per cent higher than in 1970. (On five items, there were no significant differences, but on three items, 1970 pupils outscored the 1983 pupils). Jacobson and Doron provide the following explanation:

> "Many of the items on which scores improved assessed higher levels of thinking and such process skills as classification, calculation, measurement, and the analyses of data.... The data suggest that students in 1983 were better able to respond to items dealing with process skills. In

most of the newer science programs the development of process skills and the development of higher levels of thinking have been emphasized over the recall of factual material." (1985, p. 415)

In explaining the items on which the scores of US pupils declined between 1970 and 1983, they point out that the items dealt with topics on earth and space science. The years 1969 and 1970 were ones that saw the first ventures to the moon with the Apollo project. As such,pupils in those years were exposed to full media coverage unlike the 1983 pupils. They suggest that the "decline on these earth and space science items could well be related to the influence of the popular culture, especially television coverage, on the education of US students". (p. 416)

It would appear that in one form the evidence is coming through of the positive influence of a process skills oriented science programme. Bredderman (1982) looked at the literature reported over the past 15 years, comprising nearly sixty studies of the effect of three activity-based science programmes-Science A Process Approach (SAPA), Science Curriculum Improvement Study (SCIS) and Elementary Science Study (ESS). By examining the pattern of results in these studies he provides some insight into what pays off in science education. In each study he reports classrooms using an activity based programme were compared with classrooms using texts or other traditional ways of teaching science, but similar in other respects.

In all, 13,000 pupils and 1,000 classes were involved in the controlled studies. He comments, "... The benefits are most obvious for science process skills... On the average, children in activity based science programs performed 20 percentile units higher than did comparison students." He says the evidence suggests that with the use of activity based science programmes teachers can expect substantially improved performance in science processes and creativity. What may also be worth realising is that when a project like SAPA (which will be discussed in chapter 3 and has been described as process skills oriented) was compared to traditional programmes and SCIS (which was more concept oriented than SAPA) was compared to traditional approaches, SAPA had a tendency to show greater effects than SCIS on science processes, while SCIS pupils had a slight tendency to show stronger effects on science content than SAPA (pp. 39-41).

Shymansky, Kyle and Alport also have made their observations in the effectiveness of the hands-on science programmes. They say "... our quantitative synthesis of earlier studies revealed that when cumulative results of the research were considered, students in new programmes outperformed those in traditional, text-book based classrooms. Based on thirteen studies on process skill development in new curricula (SAPA, SCIS and ESS) versus traditional classrooms they made the following observation:

> "In the three elementary science curricula we studied, new curricula studies scored at least 18 percentile points higher than traditional class students on measures of process skill development." (1982, p. 15)

They also showed that on achievement scores ESS classrooms scored 4 percentile points higher than students in textbook-based classroom; SAPA students scored 7 points higher and those in SCIS classrooms scored 34 points higher. The results they commented indicated that "... contrary to a popular notion that hands-on, activity based science curricula lacked a potent academic content base, we found that students using these three new programs actually outscored students in the more traditional classrooms ..." (p. 14). This does show however that with a process skills oriented curriculum which also attempts to develop concepts there can be an improvement in both (skills and concepts development) but as can be expected, it is less than what is achieved through a programme which is very polarised in one direction as is with SAPA. This carries a strong message for PSP - a curriculum, in theory at least, which attempts to do both. Overall these research findings seem to indicate that PSP's direction in favour of process skills is a right one.

SINGAPORE CHILDREN AND PROCESS SKILLS - RESEARCH EVIDENCE

The research findings from Singapore's participation in SISS are worth reporting on. One of Singapore's objectives in participating in SISS was to assess the pupils' performance in science at the three grade levels stipulated by SISS - 10 year olds, 14 year olds, and those in their last year of schooling (i.e. 'A' levels). As Yeoh and Tan (1986) say, the study would help to show "indirectly, to what extent science learning has changed through the influence of the 'new sciences' ..." (para.4). Yeoh and Tan (1984) in their distractor analysis of some of the difficult science test items at the 10-year old level say the results indicate:

> " b) when given a set of information (quantitative data) our students have much difficulty in analysing the relationship between two sets of variables or factors.
>
> c) students are less able and ready to cope with problem situations that demand their use of available information and the application of thinking skills beyond the recall of knowledge of facts, concepts and rules. Apparently, for the majority of students still the skills of elementary inductive - deductive reasoning are too demanding." (p. 20)

It must however be realised that when SISS was administered in Singapore the cohort that underwent the tests had only been exposed to PSP for two years and three months. They were also the first batch of students whose teachers were working with PSP for the first time too. Teachers of PSP today have had three cohorts go through the materials and a degree of familiarity with the materials has since evolved. If the results of the research carried out with SCIS, SAPA and ESS show improved scores of pupils in the US on SISS compared to FISS, then it may be quite natural to expect that Singapore pupils, exposed to PSP which is process skill slanted should show some observable familiarity with the science process skills. If positive gains are potentially there, it would be in the interest of science educators to give PSP a critical look with regard to the effectiveness of the implementation of PSP in schools.

CHAPTER TWO

CURRICULUM EVALUATION AND CURRICULUM IMPLEMENTATION

INTRODUCTION

> "What is curriculum evaluation? It is different things to different people. It is a tabulation of specific behaviours triggered by selected stimuli. It is a survey of teacher reaction, adaptation and improvisation. It is a review of classroom dynamics which may help or hinder the learning process. It is an account of the teacher's personal struggle with new demands and expectations. It is an assessment, both quantitative and qualitative, of children's interests, attitudes and reactions. And it is undoubtedly many other things as well". (Karplus 1968, cited by Sim 1979, p.8)

Karplus succinctly characterises the diverse viewpoints from which the whole issue of curriculum evaluation is considered and from which approaches have been and continue to be made. Since the early 1950s several large scale curriculum development projects have been undertaken in several countries. In particular, the early 60s saw curriculum developers - "men and women of imagination and insight ...determined to introduce new materials, new subject content and new methods into the schools" (Sparrow, 1973 p.1). Sparrow suggests that as the first concern of those developers tended to be the production of teaching materials, little opportunity was left to address themselves to a careful evaluation of their products. But though evaluation may have been limited, a certain kind of evaluation began to emerge derived not from the use of any particular model but from a more pragmatic response to immediate needs.

Tawney (1973, p.4) supports this view. "As pioneers in a new sector of education, they (the curriculum developers) were greeted with few certainties, so it is not surprising they have approached their work in various ways...". The sceptic may well take the view that such diversity might suggest a lack of experience and thus question if such evaluation was at all worthwhile - more importantly, the money spent on it. The crux of the matter would, I believe, as Stake and Denny (1967, cited in Kemmis 1982, p.221) explain, "considered broadly, evaluation is the discovery of the nature and worth of something ... The purposes for evaluation may be many, but always, evaluation attempts to describe something and to indicate its perceived merits and shortcomings" (emphasis added). In the course of these attempts to evaluate curriculum projects various models of curriculum evaluation have evolved. The models do not necessarily pose alternative approaches to evaluation - a review of the literature tends to show a trend that shifts emphasis from one focus or function of evaluation to another. But their major contribution to current evaluation studies has been to broaden the understanding of the issues concerning evaluation of curricula and thus to the improvement of methods and strategies used by evaluators.

THE INFLUENCE OF MODELS ON EVALUATION PRACTICE

There are many diverse models for curriculum evaluation but a selection of three main ones will be discussed here because of their relevance to the study. These are Tyler's objectives model, Stufflebeam's decision making model and Stake's intended-actual model.

The Objectives Model

In many ways Tyler's emphasis on a behavioural objectives model of the curriculum - the need to formulate objectives, to define them in terms of student behaviour, and then, through measurement assess the extent to which the objectives had been achieved seems to have dominated the evaluative approaches before the 1960s. "The process of evaluation is essentially the process of determining to what extent the educational objectives are actually being realized by the programme of curriculum and instruction" (Tyler 1949, pp. 105-106). One may point out that evaluating students' attainment has been what teachers have been doing all along but Tyler's stress on defining behavioural objectives, it can be argued, has increased the precision by which such measurement of attainment was made. Tyler is uncompromising on this when he says

"They (behavioural objectives) should have been defined clearly by the curriculum worker. If they have not yet been clearly defined, it is absolutely essential that they be defined in order to make an evaluation since unless there is some clear conception of the sort of behaviour implied by the objectives, one has no way of telling what kind of behaviour to look for in the students in order to see to what degree these objectives are being realized. This means that the process of evaluation may force persons who have not previously clarified their objectives to a further process of clarification. Definition of objectives, then is an important step in evaluation" (op. cit. p.111).

FIGURE 2.1

Tyler's Model of Evaluation

(Source: Lewy, 1977, p.11)

Educational Objectives

↙ ↘

Learning Experiences ⟷ Examination of achievement

Walbesser (1963) who was in charge of the evaluation study of the new curriculum material for elementary school science developed by the American Commission in Science Education of AAAS described how the initial role of his team in the first phase of the evaluation was to specify precisely what they would expect to see the child do or hear the child say in order to be satisfied that the child had learned what was intended. In justifying the necessity or purpose of such rigid specification of the expected instructional outcomes he says

"It should be quite apparent that the specification of objectives in behavioural terms provides an immediate and direct vehicle by which to communicate the expected goal of any instructional activity. This is a device by which the individual whose chief responsibility is shaping of behaviours, the teacher, is informed of the desired outcome of instructional materials" (p.296).

As a result of this phase of the evaluation a list of objectives was prepared - a list that represented according to Walbesser the desired behavioural repertoire as specified by the writers who authored AAAS science materials. "The presence or absence of these behaviours in the children exposed to the experimental curriculum represents one significant measure of the success or failure of the curriculum" (op.cit. p.298).

This pre-specification of objectives has also been advocated by Harlen (1971). In listing four types of evaluation which may have different purposes and functions, she suggests that they all involve the same basic activities, the first of which is "clarifying objectives and analysing them to the point of expressing them in terms of behaviour changes" (p.129). At the time of writing this paper, Harlen was the evaluator of a curriculum development project sponsored by the Nuffield Foundation, the Schools Councils and the Scottish Education Department. It was according to her "one of the first Schools' Council projects to have an evaluator as a team member" (pp.129-130). Her role as evaluator of the project called Science 5 - 13 was to assist in the development of the project's ideas and materials - "with clarifying the objectives of the project's materials and providing information on how well it was achieving its intended purposes" (Harlen, 1973).

The popularity of the classical objectives model at that time can be seen in the leanings of the evaluator when she says that statements of aim need to be expressed as identifiable behaviours before the achievement of the aim can be evaluated. "Such analysis is essential, exhausting and apparently unproductive but unless it is done thoroughly everything which follows is insecurely based" (op.cit. p.22). However she does point out the approach taken was not successful in terms of assessment of objectives, which need to take into account classroom conditions which are often more important.

Although the Tyler model allowed for a variety of aspects of an educational programme to be evaluated, it nevertheless began to meet with criticism. Eraut (1984) suggests that "Tyler's mistake was to think that the complex web of participants' intentions would be adequately conveyed by a list of objectives" (p.61). Others like Glass and Scriven claim that Tyler's model does not deal with the occurrence of unplanned or unintended events (in Lewy, 1977 p.11). Atkin (1968, p.27) and Eisner (1967, p.250) both protest against the constraining effects of specified objectives on educators. Atkin warns that "when any piece of curriculum is used with real people there are important learning outcomes that cannot have been anticipated when the objectives were formulated (op.cit.).

He also states that "...The behavioural analyst seems to assume that for an objective to be worthwhile, we must have methods of observing progress. But worthwhile goals come first not our methods for assessing progress towards these goals". Hogben (1972) puts a neat perspective to the arguments for and against the use of objectives as criteria for evaluating curriculum when he says

> "Behavioural objectives certainly provide fairly clear instruction and evaluation guidelines within the restricted compass of simple instructional (training) models. Evaluation is a relatively straight forward task if one's sole concern is in assessing the extent to which students have mastered the

particular behavioural objectives enunciated at the outset. If there is to be a one-to-one relationship between unambiguous statement of intent and student performance, then we certainly can, with comparative ease, assess student achievement of minimum essentials. However, that is all we can do. If we wish to assess and evaluate beyond this, different models are needed" (p.47).

The Decision Making Model

Cronbach (1963) appears to have paved the way in time for a decision-making model when he defines evaluation as the "collection and use of information to make decisions about an educational programme" (p. 672). For the proponents of the decision making model, improvement to education implies alteration and these alterations can come only through actions which are different from those presently being taken. The job of the educational decision maker would be to identify the alternative actions and choose the one action or combination of actions that will give the best possibility to improve practice. This choice from among alternatives would require a decision - a process of interest to the evaluator. Stufflebeam (1971), comments that "it is in providing information to inform such choices that the evaluator relates most effectively to education" (p.38). The evaluators' role is not only to assist the decision maker in selecting among the possible alternatives, but necessarily to draw attention to alteration, even if the decision maker does not himself perceive them. Stufflebeam suggests that the decision maker needs a basis for choosing amongst alternatives and that the basis derives from his personal or organisational value system. The model rests on the assumption that information is available to the decision maker that permits him to judge how well a given option conforms to the values. His definition reads "Educational evaluation is the process of delineating, obtaining, and providing useful information for judging decision alternatives" (op.cit. p.40).

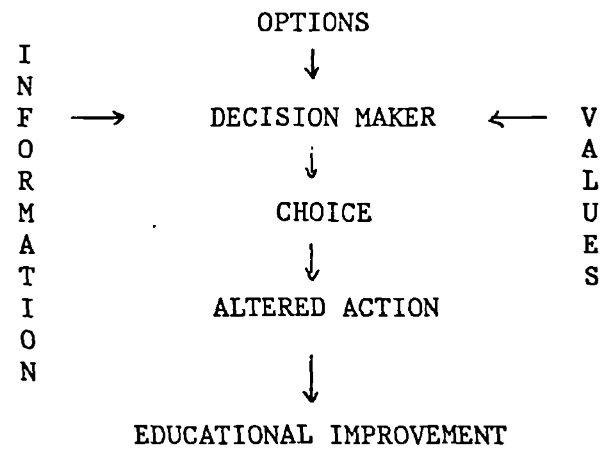
He provides the following schematic of the decision making model.

FIGURE 2.2

A Schematic of the Decision-Making Rationale

as a Basis for Evaluation

(Source: Stufflebeam, 1971, p.39)



Stufflebeam contends that judging is the central term of the definition of evaluation, but "the <u>act</u> of judging is <u>not</u> central to the evaluator's role". It is at this point that differences on the decision making model begin to surface. Prominent amongst those taking a view different from Stufflebeam is Scriven (1967). He argues that the determination of worth or value not only is central to evaluation, but that such judgements should also be made by the evaluator. In rather strong tones he says that the evaluator who refuses to engage in decision making is abrogating his role. To this Stake (1967) argues that the evaluator who does participate in decision making destroys his own objectivity and hence his utility. He saw the evaluator as processing judgements, rather than rendering them. In direct contrast to Tyler, Scriven at that time developed the view that the evaluator should begin his task by ignoring the curriculum developer's goals. Instead his attention and observations should be directed towards first the actual outcomes. It is only at the end of the study that the extent of differences between intentions and reality will be revealed and at that stage, the original or intended goals should be examined in the light of such outcome.

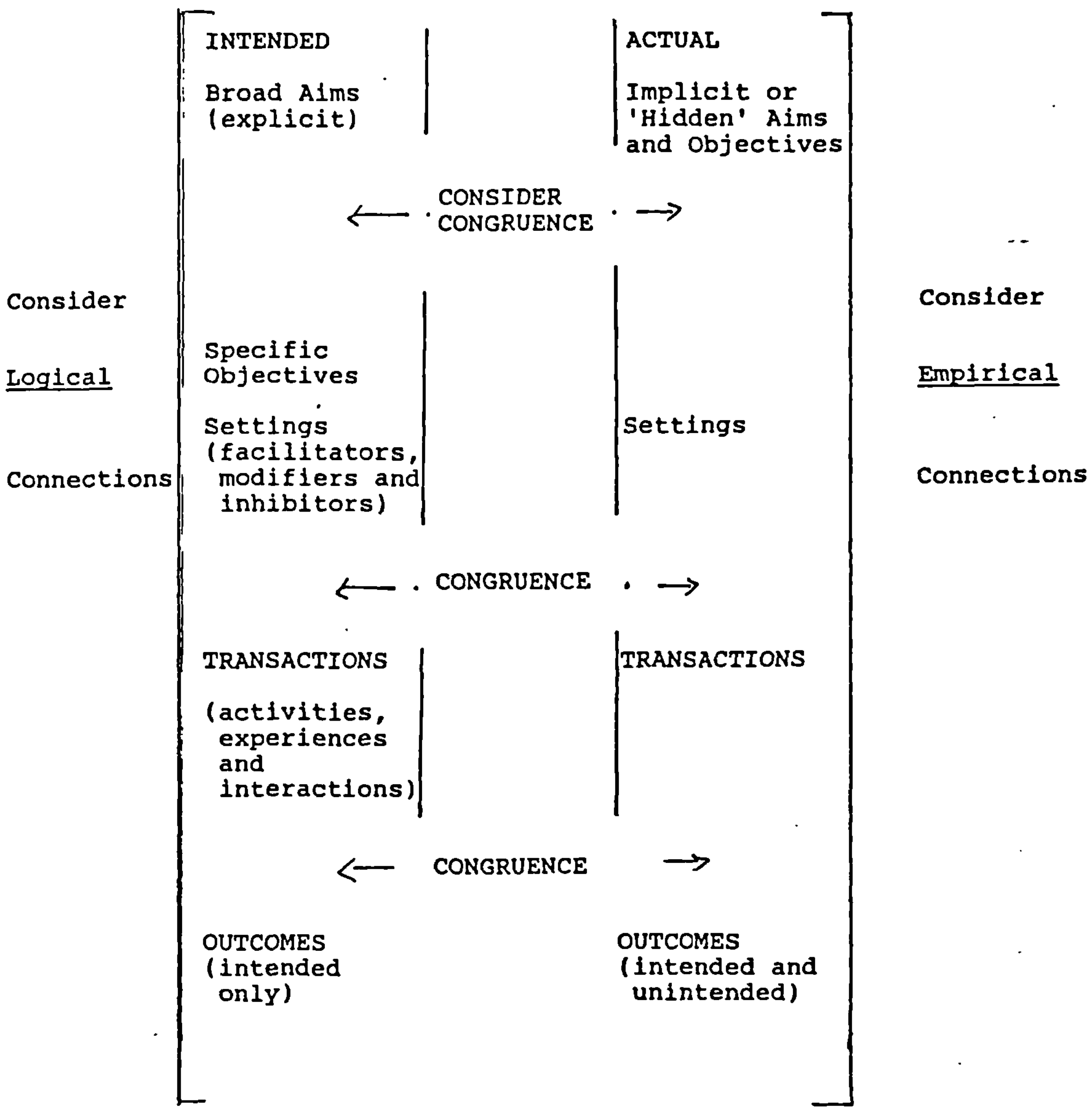
Amongst the evaluation projects that involved the evaluator in a type of decision making model was the Nuffield A Level Biological Science Project. "Evaluation was geared" says Kelly (1973) to decision-making throughout this work, being concerned in the broadest sense with the collection of data on which reliable judgements could be based (p.91). He mentions (p.107) that the evaluation processes produced a mass of evidence which was then applied to the reformation of objectives and the final redesigning and rewriting of the scheme prior to the commercial production of the books, visual aids and equipment.

Intended - Actual Model

Towards the end of the 1960s a more comprehensive approach to evaluation began to take shape. The broadening of the evaluation field at this time can be attributed to Stake. He saw the evaluator's task as "in the sense that evaluation is the search for relationships that permit the improvement of education, the evaluator's task is one of identifying the outcomes that are contingent upon particular antecedent conditions and instructional transactions" (1969, p.523). An antecedent is any condition existing prior to being exposed to the curriculum. It can include student and teacher characteristics, curricular materials and environmental conditions amongst other things. Transactions are suggested by Stake to include the many encounters that occur among for example students, teachers and parents - all of which comprise the process of education. Finally outcomes are the consequences of exposure to the curriculum - these may be short-term and long-term, cognitive and conative, personal and societal. In the course of working on these elements, Stake includes four types of data to be gathered. These are on interests, (the different goals people have) the standards (statements from experts on what should happen in the given situation and judgements (how people feel about aspects of the given situation). Figure 2.3 modified on Stake's 1967 model sets out these relationships between these elements of the curriculum.

Davis (1980, p.95) explains the model in figure 2.3 in the following way. On the one side he says the framework considers

Figure 2.3 Relationships Between Elements of Curriculum
(Source: Davis, 1980 p. 95)
Modified From Stake, 1967



relationships among elements of the curriculum and relationships between <u>intentions</u>, and <u>actual</u> aims, processes and outcomes on the other. Every curriculum programme, whether made explicit or not contains intended aims, objectives, settings, transactions and outcomes. These elements are all connected by logical or theoretical assumptions. On the right of the diagram are the Actual. Instead of logical evidence, these are connected by empirical evidence. Understanding comes about to the extent that logic and empirical data strengthen each other. But it would be naive to assume that well - reasoned intentions guarantee the successful achievement of aims and objectives. In Stake's model this transfer of intentions into actual settings and transactions leads to the degree of <u>congruence</u> between the intended and the actual.

One of the evaluation studies that comes close to using Stake's model is the Evaluation of the African Primary Science Programme (APSP) and reported by Yoloye (1977). In his paper he points out that the nature of the programme - emphasising the development of the child rather than the concepts of science, made conventional tests of cognitive achievement largely inappropriate. The major role of evaluation he describes as being one of informing the curriculum developers of the value of what they were producing and to help guide the production. It was he says a significant switch from <u>consumer oriented</u> evaluation to <u>producer oriented</u> evaluation, focusing mainly on formative evaluation. A framework for evaluation based on the model proposed by Stake was then drawn up to define the full scope of evaluation and identify procedures for collecting evaluation data.

Stake's model allowed for a widening of the evaluation perspective by drawing attention to the importance of both intentions and observations. However, Taylor and Richards (1985) criticise its approach as 'still heavily measurement oriented,and theoretical" (p.134). The new wave of evaluators wanted "description and interpretation rather than be overly concerned with measurement and prediction" (Parlett & Hamilton 1975, p.188). Various descriptors have been ascribed to these 'new wave' evaluators - the more notable being 'illuminative', 'portrayal', 'casting light', of being 'holistic', and 'comprehensive'. Taylor and Richards (op.cit. p.135) say the following about them.

> "In providing their description, the 'new' evaluators take a structuralist rather than empiricist stance, holding the view that ideas and meaning matter more than events and facts. They seek to discover what meanings those engaged in the operational curriculum give to their curricular encounters and to search for an appropriate mode of reporting these meanings truthfully."

Amongst the evaluation projects that can be encountered in the literature that opted for a 'holistic' approach is the evaluation of the Humanities Curriculum Project. The very nature of a curriculum project concerned with encouraging pupils of secondary age to explore areas within the humanities and through discussion of all kinds to reach their own conclusions made any notion of prespecifying learning outcome out of step with project intentions. "In an approach which is not based on objectives" comments Macdonald (1973 p.82) "there is no ready made niche for the evaluator." Eventually, the team had to "cope with an attempt at creative curriculum development with variable components, obvious disturbance potentials, and a novel approach" (op.cit. p.83). As an independent evaluation unit attached to the project, the team had their responsibilities in relation to likely readers of their reports. The idea of evaluation for consumers attracted them. In time ' consumers' became redefined as decision- makers "(p.87). Eventually this came to mean that of "feeding the judgement of decision-makers by promoting understanding of the considerations that bear upon curricular action" (p.88). Macdonald comments

> "The evaluators believed that much evaluation work in the past had been over-simplified in its approach, or so subservient to the canons of traditional research that its attention had been too narrowly focused. Perhaps, at this stage of our understanding, bolder evaluation designs can give us a more adequate view of what it is we are trying to change, and what is involved in changing it." (p.88)

A new and more sophisticated model of curriculum evaluation thus had begun to set in. The emphasis was now on providing continuous feedback, to an enlarged audience.

Hamilton (1976 p. 38) summarises the aims in such evaluation as to

> "... provide information rather than judgement by (i) featuring field studies which portray the innovation in the context of a recognisable reality; (ii) documenting a broad spectrum of phenomena, judgements and responses; (iii) reporting the study in a form appropriate to the audiences seeking information."

Have we now reached a satisfactory approach to the whole evaluation enterprise? Stenhouse (1975) seems sceptical:

> "The new wave of evaluators still seem to me to be concerned with 'merit' or 'worth' in a curriculum or educational practice, but their criteria are not clear and their concern with audiences and presentation of results appears to me to mask their problem. They aspire to' tell it as it is',... But there is no telling it as it is. There is only a creation of meaning through the use of criteria and conceptual frameworks."

THE EVALUATION MODELS AND THEIR RELATIONSHIPS TO THIS STUDY

The foregoing review to the state of the art in evaluation studies has served to establish the direction this study will take. It would be pertinent at this point to identify the stage of evaluation that the the study can be considered to provide. Scriven has introduced into the vocabulary of curriculum evaluation the distinction between what are now commonly used jargon in evaluation studies, 'formative' and 'summative' evaluation. Lewy (1977) gives the opinion "... the distinction between formative and summative evaluation is probably the most significant distinction that has been made recently in the field of evaluation" (p.12). To Scriven, formative evaluation is investigatory and provides information that enables one to understand better the issues pertaining to a curriculum and its possibilities. Summative evaluation, on the other hand, reports relative levels of success and failure, based on what criteria previously made known and is not intended primarily to provide information for subsequent modification and development.

In this context the evaluation of this study would be more summative than formative as it looks at a project that has been implemented in schools. However, as it is looking only at a very specific component of the overall project it cannot be justifiably labelled a full summative evaluation of the project. However, this evaluation will serve to give some information of the stage of implementation of PSP.

Firstly, from the classical objectives model established by Tyler comes the advice to clarify the objectives as part of the evaluative process. While it would be incorrect categorically to deny the need for establishing objectives as pre-requisite for evaluation studies, the debate I believe is more one on specificity. Tyler (1949, p.57) himself seems to have recognised this when he states "... other things being equal more general objectives are desirable rather than less general objectives." Eisner (1985, p.199) says "... There is, of course, a reasonableness in the desire to have objectives in order to evaluate the effectiveness of an educational programme." He does, however, warn that "... a conception of evaluation that <u>limits</u> itself to what has been preplanned is thin." (op.cit. emphasis added). Tamir's (1981, p.342) concern about Tyler's approach is that of treating the classroom and the school as black boxes. He elaborates that "... Even the learning materials are assessed only in so far as they succeed or fail to bring about certain achievements; there is no indication of direct appraisal of materials as such, for example, by content analysis." There is also the need to ask for purpose of this study if the educational objectives are what Eisner (1967, p.279) calls open or closed objectives : "To state an objective in terms clear enough to know what it will look like requires that the parameters of that behaviour be characterized in advance." Eisner believes this is possible whether one is working with open objectives or closed objectives. When one is working with open objectives the particular behaviours cannot be defined by a preconceived standard; a judgement must then be made after the fact.

The argument can thus be made in the study of process skills that they do lend themselves to being studied in behavioural terms - that the parameters of that behaviour can be characterised in advance. One of the research instruments in this study will therefore include the use of behaviourally stated objectives. However, these objectives are considered in the study to be expressed loosely in the behavioural terms and are not related to very specific performance criteria. But this said, Eisner's (1967, p.279) view that there is a difference between defining an objective and establishing a direction, is worth reflecting on. He suggests that "... To establish a direction for inquiry, dialogue, or discussion is to identify a theme and to examine it as it unfolds through the process of inquiry." The clarification in behavioural terms of the science process skills will help to give a central theme to the study.

The second issue arising from the review that concerns this study comes from the decision making model. While all proponents of the decision making model of evaluation conclude that their task is the obtaining and providing of useful information for judging decision alternatives, the bone of contention seems to be one of should the evaluator also be involved in the judgement.

This study takes the "notion that evaluation involves making explicit the criteria of judgement which distinguishes it from the mere collection of information and from the everyday use of the term to mean the expression of opinion " (Harlen, 1981, p.195). It is important to realise as Harlen points out

> "... to attempt to distinguish information from judgements suggests that information is somewhat value free, and denies the decisions which are unavoidable in selecting what to report, what is 'relevant' information, what is of value in a particular context." ... Any set of data is the result of a selection from all possible data and hence evaluation does depend on the values of whoever makes this selection" (op.cit, pp.195-196).

In accepting the sentiments expressed by Harlen, this study will involve the establishing of criteria that will be used both in selecting what is to be used as information and in making the related judgements about it.

The third issue arising from the review comes from a consideration of Stake's model. His approach is to look at intentions and observations and then the transfer of intentions into actual settings and transactions (which include teacher student encounters) leading to the degree of congruence between the intended and the actual. This approach relates clearly to this present study, which aims to look at the relationships between the intended and implemented Primary Science Project.

Finally, the new wave evaluators have contributed by their thinking in pointing to the need to document a broad spectrum of phenomena, judgements and responses, and reporting the findings in a form appropriate to the audiences seeking information. But while it may be interesting to 'tell it as it is', this study is cautioned by Stenhouse's (1978) advice that there is only a creation of meaning through the use of criteria and a conceptual framework. The framework for this study will be presented in a later chapter. In summary, I see evaluation as a process that involves the systematic collection of information about a specific object by both structured and less structured approaches and the identification of criteria which are used in placing a value on the information so that the analysis and reporting of the information can facilitate decision making.

FROM CURRICULUM EVALUATION TO IMPLEMENTATION EVALUATION

From the preceding paragraph, the 'specific object' in this study is the relationships between the intended and implemented PSP specifically focusing on the process skills. This inevitably narrows the study to one of an evaluation of the implementation of a specific aspect of the overall Primary Science Project. On the relationship between implementation and curriculum evaluation Fullan (1981, pp.335- 336) concludes

> "... effective curriculum evaluation must be integrated with and take account of the relationships between planned strategies, problems, and meaning of implementation, learning outcomes, and feedback and utilization of evaluation information for altering these relationships in positive directions... It is also clear that the growing integration between implementation and evaluation research during the past five years has considerably advanced our understanding of curriculum change in schools, and should continue to do so in the foreseeable future. Implementation may not be the foundation of curriculum evaluation, but

there should be no doubt at this time that it is a necessary cornerstone for effective curriculum evaluation, regardless of their scope."

In many a curriculum development project there has been a fundamental assumption that has often been taken for granted. Past attempts to change the curriculum in schools seem to have been based on the premise that merely to place materials on offer to teachers is to make them viable in the classroom. Waring (1979, p.220) says "... Successful realization in the classroom of the approach and content advocated by a project constitutes 'implementation'." But to achieve this, she comments, requires commitment, understanding and ability to put the proposals into operation in the classroom. In the process of diffusion of the project there is the possibility of distortion. If this distortion results in what then takes place in the classrooms no longer being recognisable to the developers then the "advocated change has neither diffused nor been implemented and it is preferable to use the term 'adoption'." To Waring, 'adoption' is a commitment that guides practice but it may not reflect understanding of the projects' most fundamental intentions. Eggleston et al, (1976, p.121-2) from their studies also suggest that a "considerable dissonance exists between the aims of curriculum developers and related classroom practice." The need then to look at the implementation of a curriculum project becomes one of necessity. Fullan and Pomfret (1977, pp.336- 339) give the following reasons as to why we should focus on implementation

"1. We simply do not know what has changed when we attempt to conceptualize and measure it directly.

2. It is important to examine implementation ... to understand some of the reasons why so many educational changes fail to become established.

3. Failure to do so may result in implementation being confused with other aspects of the change process such as adoption.

4. Unless this is done, it may be difficult to interpret learning outcomes and to relate these to possible determinants."

All four of these reasons apply to the need to study the implementation of PSP (even if it relates only to a specific aspect of the project). The sequel to accepting these reasons then leads to the kind of approaches that should direct the investigation.

A search of the literature shows the following as some of the possible ways of looking at implementation and its evaluation.

1. components of implementation
2. determinants of implementation
3. orientation of implementation
4. levels of implementation
5. degree of implementation
6. barriers to change.

Implementation begins when an idea, programme or set of activities which is new to the individual or organisation is put into practice. It involves the following components

a) Diffusion (the spread of information about the innovation through media channels);

b) Dissemination (the planned strategies and actions to convey the new materials);

c) Teacher education (the use of pre-service, in-service and other programs to inform practitioners).

d) Adoption (When the decision is made by the individual or organisation to utilise the innovation);

e) Adaptation (the modification and adjustment of the innovation to meet the local needs of the recipients);

f) Installation (the active provision of materials and conditions to enable the innovation to be put in practice);

g) Utilization (actual use of the innovation in the classroom).

At the time of this study, five years after the launch of PSP, it is assumed there has been sufficient time for stages (a-f) to take place. What can now be focused on would be the utilization of the innovation in the classrooms. But the factors that can affect the utilization of an innovation in the classroom are potentially numerous. These are what the literature refers to as the determinants of implementation. Fullan and Pomfret (1979, pp.367-368), based on empirically derived analysis of research studies, list the following four as the major <u>determinants</u> of implementation.

A. Characteristics of the innovation
   i) explicitness: who, what, when, how.
   ii) complexity.

B. Strategies
   i) in-service training
   ii) resource support (time and materials)
   iii) feedback mechanism
   iv) participation

C. Characteristics of the Adopting Unit
   i) Adoption process
   ii) Organisational climate
   iii) Environmental support
   iv) Demographic factors

D. Characteristics of Macro Sociopolitical Units

i) Design questions
ii) Incentive system
iii) Evaluation
iv) Political complexity"

If the determinants of implementation have worked in favour of implementation, then two modes of utilization may be identified. Fullan and Pomfret (1977) refer to these two orientations as the fidelity of implementation and the process perspective, more commonly called mutual adaptation. By fidelity of implementation is meant the extent to which actual use corresponds to planned or intended use. Mutual adaptation refers to the process by which modification and further developing of the materials to meet local needs takes place. Each of these orientations has its influence on the implementations of the innovation. Implementation studies show that both approaches have been used by people in the field. One of the better known examples of the fidelity approach is that developed by Hall and Coucks (1976, cited by Fullan & Pomfret 1977, p.353). Their model shows an explicit, very structural conceptualisation in assessing implementation. They suggest that individual users reflect different levels of implementation with regard to an innovation and that they may go to different levels over time as they develop the ability to use the innovation. The levels of use they formulated were validated in their research studies through focused interviews given by teachers about their use of a given innovation and by having tapes of the interviews, rated by trained interviewers. The levels are as follows

" a) Non use
b) Orientation (initial information)
c) Preparation (to use)
d) Mechanical use

e) Routine
f) Refinement
g) Integration
h) Renewal"

(Hall and Coucks, op.cit.)

Hall & Coucks' levels of use of an innovation rests on the assumption that the implementation of the innovation can be assessed and based on prespecified criteria. Against such an approach a second school of thought developed which appealed more to those who looked for a more open-ended approach to assessing implementation, particularly in examining the implementation of less clearly specified reforms. The Rand researchers who worked on the basis that most educational innovators require users to work out their own specific adaptations have provided a comprehensive single study that looked at implementation from a mutual adaptation orientation.

One of the criticisms of the Rand findings is that data were collected on reported or perceived changes. "Self reports by users .... are often inaccurate and misleading" say Fullan and Pomfret (1977, p.360). However, their findings as reported by McLoughlin (1976, pp.339-351) give a useful insight to implementation. In the 293 projects surveyed, the Rand's Change Agent Study found that the mere adoption of a 'better' practice did not automatically or invariably lead to 'better' student outcomes - instead successful implementation is characterised by a process of mutual adaptation. This mutually adaptive process is essentially one between user and the institutional setting. The participants themselves make concrete over time the goals and methods of the specific projects.

The study also found that implementation did not merely involve the direct and straightforward application of an educational technology or plan. McLaughlin (1976, pp.340-341) in stating that implementation was a "dynamic organizational process that was shaped over time by interactions between goals and methods, and the institutional setting" cites the following three different interactions incumbent on a highly variable process

> "1. Mutual adaptation - described successfully implementated projects. It involved modification of both the project design and changes in the institutional setting and individual participants during the course of implementation.
>
> 2. Cooptation - signified adaptation of the project design, but no change on the part of participants or the institutional setting. When implementation of this nature occurred, project strategies were simply modified to conform in a pro forma fashion to the traditional practices the innovation was expected to replace - either because of resistance to change or inadequate help for implementators.
>
> 3. Non-implementation - described the experience of projects that either broke down during the course of implementation or were simply ignored by project participants."

The question on the two orientations that can be raised is whether the approaches are intrinsically incompatible or are concerned about different goals or stages of the problem. Fullan (1981, pp.317-318) says the "answer is that it is a bit of both" and explains:

1. Projects which are concerned with content acquisition or specific skill/goals are probably more amenable to the structured approach than projects concerned with inquiry oriented or complex valuing goals;

2. Projects at early stages of development and use are more compatible with unstructured approaches than projects at later stages;

3. Projects being applied to homogenous or small scale situations are more amenable to the structured approach than projects applied to heterogeneous or large scale situations."

It would appear on the above explanation that the PSP, concerned more with specific skill goals would have lent itself better to the more structured fidelity approach. It is left to be seen at the end of this study to what extent this implementation has occurred i.e. the degree of implementation. Tamir (1981, p.350) points out that the degree of use is essentially independent of the level of use - that it can range from non-use, through partial use and regular use to integrative use. Dalin (1978, p.96) concurs when he says "... Often it implies that certain aspects of an innovation are adopted and implementated while other parts are omitted." But why might this be so? This leads to the final aspect mentioned earlier, that of looking at implementation from the aspect of barriers to change.

From an analysis of case studies of educational change in several countries, Dalin (1978, p.251) cites the following as barriers to change. They are

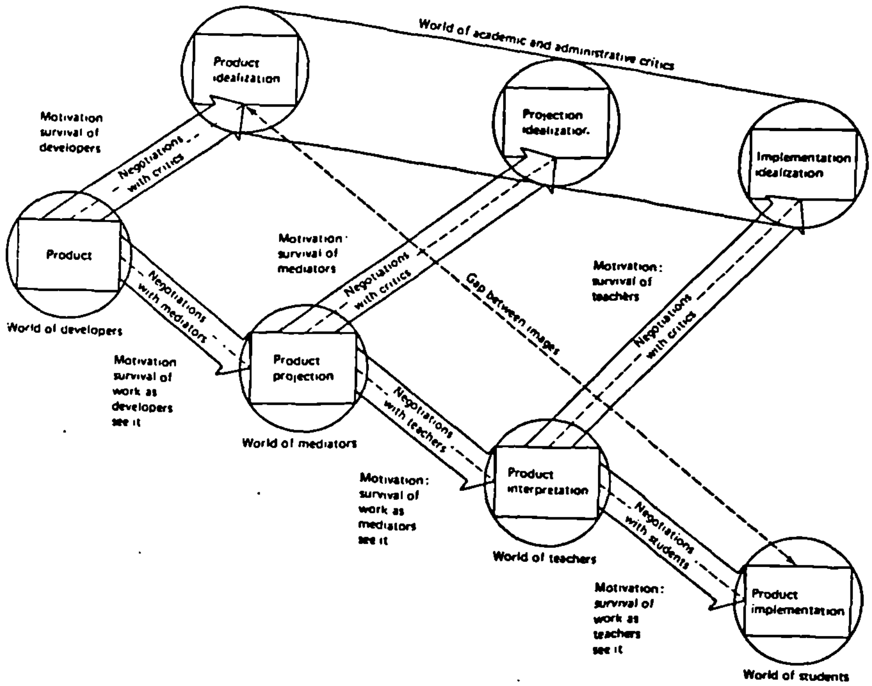
1. value barriers (these exist because individuals or groups have different ideologies)
2. power barriers
3. practical barriers (due mainly to ill conceived projects)
4. psychological barriers.

In looking at the gap between the ideals of curriculum innovation and the reality of resulting classroom practice in a centrally produced curriculum innovation, such as PSP, it is expected that some of the barriers (if any) to change will surface.

"What happens inside the school at the project delivery level is absolutely related to our success or failure, yet the gap in our knowledge about implementing change in the schools is formidable" comments Mann (1976, p.359).

Pitman (1981) in looking at this 'gap' has improved on an earlier negotiation model by MacDonald and Walker (1976) and has provided us with an extended negotiation model (see Figure 2.4).

Figure 2.4 Curriculum Negotiation - Extended Model (Source: Pitman, 1981, p.253)



It attempts to provide an explanation of the problem of curriculum implementation. Pitman (op.cit. p.253) suggests that the implementation of the innovation is dependant on

"a) A series of negotiations, each likely to widen the gap between the image idealizations presented to critics and the image transmitted toward implementation.

> b) The interpretation by the teacher of the product which he will then transmit to the final target the student" (emphasis added).

Pitman's emphasis that actual implementation of curriculum occurs in the world of students, rather than in that of teachers is an important one. Teachers to him then become necessary mediators in the "chain whereby the innovation is passed from the developers, to teachers (usually through other mediators such as inspectors or subject advisers), and hence to the students for whom the curriculum is intended" (p.253). The success of the implementation according to him depends on the success of the negotiations which occur as identified in his model. It may well be he says that "significant distortion will occur as a direct result of the teacher's conclusions as to what is best for that particular group of students." (p.255) It is against the background of what has been raised in this chapter that the research questions and design for this study will be raised.

CHAPTER THREE

ISSUES IN DEVELOPING PRIMARY SCIENCE PROGRAMMES

JUSTIFICATIONS FOR SCIENCE

In the 'Science 5-16: A Statement of Policy' (1985 pp.1-4) a number of valid reasons were put forth about the importance of science education for the pupil and to society as a whole. The arguments included the value of the introduction to scientific method in preparing children and young people for adult and working life as well as to their intellectual development.

Harlen (1985a) has provided in addition to those raised by her and many other science educators, the following three reasons for justifying the inclusion of science in primary education :

"1. Children's ideas of the world around them are being built up during the primary years, whether or not they are taught science; without a scientific approach in their exploration of the world the ideas the children develop are 'everyday' or non-scientific which obstruct learning in science at the secondary level.

2. The development of concepts and knowledge is not independent of the development of intellectual skills; unless children are to expand their ways of gathering and processing information then a 'scientific approach' is difficult to achieve.

3. Children's attitudes to science are formed earlier than are their attitudes to most other subjects; without experience of scientific activity many children develop unhelpful attitudes, through hearsay and the mass media, which affect their performance in secondary science" (p.5).

In Singapore the above would well serve to justify science being part of the primary school child's curriculum from Primary Three (i.e. 8+ years of age). The important place it does hold in the curriculum can be observed from the fact that in the Primary School Leaving Examination that culminates primary education and which is a very important national examination for children aged 11+, science is one of the examinable subjects. The Primary Science Project has, however, like many other science projects in other countries, had to contend with what such a programme for children should comprise. In stating why science should be included in the curriculum, Harlen has pointed towards a programme involving both the products and processes of science. Since the sprouting of curriculum projects in the 1960s, a controversy has arisen which has now come to be referred to as the process-content debate. The stand one takes will undoubtedly depend on one's philosophical leanings on what science is.

This chapter looks briefly at the philosophical bearings that have influenced science over the centuries, before going on to review some of the major British and American science curriculum projects. This would provide the backcloth against which it would be possible to view Singapore's Primary Science Project.

PHILOSOPHICAL BEARINGS ON SCIENCE

A brief look at the philosophy that has guided the evolution of science will show that it has hardly been static over the centuries. The Early Greeks, considered the happenings around them as being governed by the will of the Gods. Aristotle, in the fourth century B.C. in looking at the celestial system, while conceding that it was created by a God, also claimed that it was by a God who acted according to understandable philosophical and mathematical principles (UNESCO, 1980, pp.9-24). For Aristotle, one started with a principle or theory and sought evidence to test it or used it to explain observations - what is now referred to as the deductive method of scientific enquiry. Aristotelian thinking suggests that if one could arrive at the principles of the universe by theoretical thinking, observation was unnecessary. Taylor (1966 p.5) in a rather scathing attack of such a philosophy remarks,

> "Aristotle's stimulus to philosophy was immense and fruitful, but his influence on the growth of scientific method was small and detrimental. His tendency to think that knowledge gained by reasoned argument was superior to, almost independent of, knowledge gained directly by observation and experiment, inhibited development of science for twenty centuries" (p.5).

Francis Bacon some 2000 years later viewed science from a different approach. He suggested that understanding came about by collecting a vast number of facts through organised observation and deriving theories from them. In his book the Novum Organum he went on to lay down the steps to what is now referred to as the inductive method of scientific discovery. Taylor (1966) criticises Bacon's method for lacking the making of hypotheses. He says

> "... modern science starts inwards with an imaginative guess, a reasoned hypothesis, and then works outwards to detailed observation and verification" (p. 7).

Yet another dimension to science has been added by Karl Popper. Rejecting the inductive method, he proposed a 'falsificationist' interpretation of the scientific method. To him the statements that form the basis on which a theory might have been formulated can themselves be fallible. He makes the following analogy (1968) :

> "The empirical basis of objective science has thus nothing 'absolute' about it. Science does not rest upon solid bedrock. The bold structure of its theories rises as it were, above a swamp. It is like a building erected on piles. The piles are driven down from above into the swamp, but not down to any natural or 'given' base; and if we stop driving the piles deeper, it is not because we have reached firm ground. We simply stop when we are satisfied that the piles are firm enough to carry the structures at least for the time being " (Quoted from Chalmers, 1975 p.60).

Popper, appears to be holding a view held by David Hume way back in the 18th Century. Describing Hume's view as one where "... knowledge appeared to be no longer God-given and absolute but in fact to be highly tentative and uncertain, indeed to a point where the very possibility of our knowing anything with any degree of certainty seemed itself to be questionable... " Blenkin and Kelly, (1987 p.14) link it with a kind of epistemology that began to be developed by John Dewey. Recognising it as an empiricist position, they (p. 17) described Dewey's model as "... hypothetical, subject to constant modification and revision in the light of the emergence of new data from new experiences but at the same time enjoying current if temporary acceptance and agreement, especially among those best qualified to judge ..." Dewey's approach to science education is thus one of problem-solving, the framing and testing of hypotheses, but also recognising that knowledge can only be acquired though experience.

Finley (1983) sums up the criticism against an inductive empiricist view saying :

> "enquiry viewed as an inductive process is not tenable because there is no frame of reference for judging what facts should be collected and how they should be organised. In addition, there is no general way to derive inductively new general statements from specific sets of facts. ...the idea that all meaningful information is derived directly from experience is also untenable. Our perceptions are in large part determined and selected according to the a prior-- knowledge we possess about the nature of objects and events." (pp 52-53).

Finley suggests that science be viewed as hypothetical deductive rather than inductive. To science educators he says that "conceptual knowledge drives the science processes and does not result from them. ... science processes are likely to be context bound ... it is unlikely that there will be content-free intellectual skills... if science education aims to understand better the nature of science processes, the relationships between content and process must be better understood." (p. 53)

There seems now in the 1980s to be signs that an extreme inductive view of science is increasingly becoming unsatisfactory. Harlen (1985a p.10- 11), succinctly puts in perspective why a see-sawing of approaches is unnecessary when she asserts :

> "... scientific activity is neither purely inductive nor deductive but must involve both inductive and deductive reasoning ... stated simply ... process skills cannot be used

> and developed independently of concepts and knowledge and conversely ... concepts and knowledge cannot be learned with understanding without the use of process skill..."

If this is the epistemology being advocated for the present and perhaps beyond, then it would be useful at this stage to review the thrusts of some of the major primary science projects both British and American, against which backcloth it will then be possible to view Singapore's Primary Science Project.

REVIEW OF MAJOR PRIMARY SCIENCE PROJECTS

Nuffield Junior Science Project

Developed between 1964 - 1966, this was the first of the projects to break away from the nature study approach of primary science and to go for a 'hands-on' approach. It expressed a strong belief in children's natural powers of learning being closely related to scientific method. The project team did not concern itself either with the concepts to be developed or the content of what should be taught. From the list provided by Wastnedge (1983 p.143) the following selected statements will help to show the philosophy on which the project was based.

> "(i) An important aspect of primary education is that of helping children learn how to learn. "(ii) At this early stage

of development children learn and understand as a result of concrete experience... "(v) Following first hand experience, children will usually want to communicate their findings in various ways ... a child's way of examining his own ideas in a concrete form so as to understand them more fully. "(vi) ..The great emphasis, ...is on the so-called 'process' - observing, pattern-seeking, hypothesizing and planning experiments. "(vii) Children's questions are of paramount importance because a) they provide maximum motivation and b) the only person who can pitch a question at the exact level of difficulty for anyone is that person himself."

Based on this philosophy, the project team eventually published four source books, two of which were teachers' guides, and three background booklets. In the course of the development of these materials, the contribution from teachers is recorded by Wastnedge (1983 p.142) when he says "... of all the projects, this must be the one which was most firmly based with teachers in classrooms. Helped and supported by the team in the field, it was teachers who did the research and pointed the way ahead..." By the end of 1966 the Nuffield Junior Science Project had come to an end. It had served to establish says Wastnedge (p. 144) "... what kind of science was appropriate in primary schools, that it could be achieved with the brightest and the slowest children..." He went on to comment that given support all teachers could achieve it, but it was important to produce support materials for the teachers. It was left to another funded project to consolidate and extend the work on primary science initiated by the Nuffield Junior Science Project.

Science 5-13 Project

Shortly after the Nuffield Junior Science Project had completed its task, Science 5 - 13 was set up in 1967. Sponsored by the Schools Council, the Nuffield Foundation and the Scottish Education Department, it inherited and accepted most of the basic ideas of the Nuffield Project in the sense that it continued to place the emphasis on 'processes', to emphasise the use of the environment and recognised the need for concrete experiences and the desirability of starting from children's own questions. Where it differed from Nuffield Junior Science, according to Harlen (1978) was that Science 5 - 13 provides background for teachers about topics and activities. It also gives an explicit statement of objectives, and provides a structure for building by skills and concepts progressively. The project also considered that the statement of objectives was necessary for teachers to guide children's work effectively. But Harlen points out "... many of the Science 5 -13 objectives are clearly content free and can be achieved through pursuing investigations in a very wide range of subjects" (1978 p.10). It was however a project that left these objectives to be in the teacher's mind so that she could take any opportunities which arose to work toward them and thus it would not conflict with the project's child-centred philosophy. About 150 objectives were delineated, each related to one of the Piagetian stages of development in children. These were the transition from intuitive thinking to concrete operations; the concrete operational stage itself and the transition between concrete operations to formal operational thinking. The boundaries of the stages were however such that they could be more useful in the context of school organisations. The materials corresponded to the following broad aims for science teaching (Ennever and Harlen, 1972 p.59).

> "Observing, exploring and ordering observations; Developing basic concepts and logical thinking; Posing questions and devising experiments or investigations to answer them; Acquiring knowledge and learning skills; Communicating; Interpreting findings critically; and Appreciating patterns and relationships."

In all, the project prepared 26 thematic books, suggesting, where possible, the experiences that might be developed in order to achieve the behavioural objectives that were considered by the developers of the project to be central to conducting science with young children. The basic project's thinking was set out in an introductory book - 'With objectives in Mind' followed by a series of units for teachers in selected subject areas (eg. Minibeasts) and on themes such as 'change', 'like and unlike'. These were intended to be starting points.

Like Nuffield Junior Science, teachers helped to shape the nature of the trial materials. Because the objectives framework went down well with the initial group of teachers who assisted in the trials, according to Parker-Jelly (1983), it was reflected in the decision to publish, in full, a statement of objectives for children learning science although originally it was only intended solely as an internal working document. But Parker-Jelly adds, contrary to the expectations of those early responses, many later trial teachers "... found the treatment of objectives somewhat confusing and in some cases it was clear that its organisation formed an unintended barrier to guidance offered on the pragmatic front." (pp. 149-150).

Parker-Jelly went on to point out that mediation attempts to improve the quality of teacher action resulted, for example, in Local Educational Authority activity concerned with providing resource kits for teaching Science 5 - 13, or structural work cards for children based on the practical suggestions of the units. But she says "... Whilst such activity can improve classroom activity ... the mediating role is one that denies to a large extent the reflective thrust of the project because much of the thinking about the appropriate selection and development of children's activities has been done by others for the teachers concerned." (p.151).

Progress in Learning Science Project

Subsequent to Nuffield Junior Science and Science 5 - 13, 1973 saw yet another Schools Council - sponsored Progress in Learning Science Project. It attempted to examine ways in which individual children's scientific progress could be assessed by direct observation. It also attempted to list the scientific attributes considered worthy of developing in children. Its main point was to help teachers with the decisions they had to make in 'matching' and in using material such as Science 5-13.

Learning Through Science Project

In 1978, the Learning through Science Project was developed. Its stress was also the developing of the processes of science. It was a project that was based on twelve themes generally considered to cover those areas of scientific knowledge when scientific experiences are presented to children. The major task for the project team was to persuade more teachers to be like the few observed in the DES Primary Science Survey (1978) who recognised the important contribution which science could make to children's intellectual development. The main aspect of the project work has been the production of pupil materials. It worked around twelve units, each comprising a series of twenty four cards. The materials were intended to confront children with problems, while "... giving help to the teacher on ways of encouraging and guiding the enquiries". (Richards, 1983 p.163). It was also intended for "...children who have reached stage 2 of the developmental sequence set out by the Science 5 - 13 project and are moving towards stage 3 ... through to those who are, albeit tentatively, beginning to think about things abstractly". (op.cit.)

Oxford Primary Science Project

At about the same time that Nuffield Junior Science was being developed, another British Project also began to take shape. The Oxford Primary Science Project, supported by the Ministry of Education/DES from 1963 - 1967 took a rather different approach from Nuffield Junior Science in that it started from a definition of four basic scientific ideas, namely energy, structure, life and chance. It took the view that,

> "If it is possible to discover which scientific concepts children can form and to identify the experiences which are fruitful in helping children to form concepts, this may be a valuable pointer to the work in science which it is profitable for children to do in primary schools, and this work might come to be seen as an appropriate foundation for the science schemes to be followed later in secondary school". (Redman et al, 1968 p.132)

The team did stress that any work done within the scheme of topics should only be done if it was relevant to the things children wanted to do, but essentially it was a project that went more for content rather than processes.

SUMMARY OF THE BRITISH PROJECTS

What the British projects tended to have in common (though far less emphasised by the Oxford Primary Science Project) was the belief that for children to learn with understanding it was essential for them to have first-hand experiences of manipulating objects and materials. They "rejected any idea of a simplified version of the science taught in secondary schools, and stressed the importance of science as a way of working rather than a body of knowledge to be mastered" (Harlen, 1978 p.60). The ASE Policy Statement (1963) to some extent had its influence on these projects when it stated in reference to primary sciences "... at this level we are concerned more with the developing of an enquiring attitude of mind than with the learning of facts... at no time is the imparting of factual knowledge to be regarded as an end in itself" (ASE, 1963, cited by Harlen, 1978). They intended to show a whole-hearted embrace of process as opposed to content mastery and tried to be descriptive of a teaching style rather than being prescriptive. Some like 'The Progress in Learning Science Project', for example, show a close relationship to the list of objectives and intentions of Science 5- 13. The question that can be asked is *how did these projects fare? Black (1980* p.*62)* says a "survey has shown that Science 5-13 has only been studied seriously in 30 per cent of schools and is being used by 22 per cent while the corresponding figures for Nuffield Junior Science are 20 per cent and 7 per cent respectively. It is interesting to note however that Parker- Jelly (1983 p.150) reports the sales figure for Science 5-13 standing, then, at well over a million copies, with 60 per cent relating to the home market, making it, in publishing terms, highly successful.

With regard to the very different approach of the Oxford Project, Redman (1968 p.138) concludes that the Oxford Project was successful in achieving some of its objectives though Harlen (1978 p.94) points to the "project not having much impact on primary science outside its trial schools." In examining the causes for the lack of impact of the British projects, Black (1980) suggests that "primary teachers almost certainly lack confidence to take up the new philosophy" (p. 62) and makes the point that "it is not now obvious, a priori, that the best route for developing understanding of science up to age 11 is to concentrate exclusively on the process skills of concept-free science." Before the arguments for the content-process debate is considered, some of the major American Projects for Primary Science will first be reviewed.

Science - A Process Approach (SAPA)

The commission on Science Education of the American Association for the Advancement of Science, established in 1962, accepted as its major activity the preparation and evaluation of science materials for the early grades. These materials were published eventually under the title Science - A Process Approach. They formed a series of exercises, each designed to improve the child's skills in using the processes of science.

In two conferences in 1962, the commission was strongly influenced by a paper by Robert Gagné in the direction that the "materials stress the processes of science in the early grades - not science content alone" (Livermore, 1964 p.272). The Commission subsequently expressed its attitude towards science education in a Statement of Purposes and Objectives. It was prepared by Sears and Kessen and a team of consultants. Some of what they said was:

> "Science is best taught as a procedure of enquiry ... science is more than a body of facts, a collection of principles, and a set of machines for measurements; it is a structured and directed way of asking and answering questions. It is no mean pedagogical feat to teach a child the facts of science and technology; it is a pedagogical triumph to teach him these facts in their relation to the procedures of scientific enquiry ... It is here that the future citizen who will not become a scientist will learn that science is not memory or magic but rather a disciplined form of human curiosity" (1964 p.4).

Livermore reports (1964 p.272) that as "skills cannot be developed by reading about science" the exercises were written as "instruction for teachers, not as reading material for children". The team identified eight processes for the primary grades K-3. These are:

observing

classifying

measuring

communicating

informing

predicting

recognising space/time relations

recognising number relations

At the levels of grades 4 - 5, integrated processes are used. These are says Livermore (p.273) "rooted in the simple processes and seem more appropriate to the aim of acquiring a scientific approach to knowledge at the intermediate grade levels. The integrated processes are:

formulating hypotheses

making operational definitions

controlling and manipulating variables

experimenting

interpreting data

formulating models

The above certainly shows SAPA placing the process skills as a hierarchy of skills. Gagné (1964 p.5) says "...one of the key ideas of the process approach is the progressive building of more complex intellectual processes from simpler ones. This is in fact one of the more fascinating central hypotheses of the whole approach." SAPA exercises thus presented in a hierarchy indicate 1) the pre-requisites for a particular exercise. (2) what the child is expected to learn in the exercise and (3) what the exercise will prepare him to undertake in later learning. The behavioural hierarchies are also guides to the assessment of student achievement and programme education. SAPA went on to build in performance tests which are intended to be consistent with the behavioural hierarchies, so that in each case what is being measured is a new achievement, and not something that has already been achieved as a result of some earlier exercise. SAPA also provided for a measurement of achievement in a developmental sense. The basis for this measurement rests in the developmental sequence of the behavioural hierarchy - pupils take a test that will attempt to assess how far a pupil has progressed in each process. Gagné (1968 p.9) says the "... hierarchies also guide the development of measures of achievement which are 'terminal' to the program, in so far as they help to define what the minimum set of behaviours may be for children who have participated in the program for a period of years". The Evaluation for SAPA thus comprises :

1. An appraisal which is a gross measure of performance for the whole class, to determine, whether the behavioural objectives have been attained. This it is suggested, will help the teacher decide whether the class is ready to move on to the next exercise,

2. A competency measure which is designed to evaluate the individual's achievement. It is given to an individual or small group and specifically tests one or more of the behavioural measures.

Science Curriculum Improvement Study (SCIS)

Another major American project, SCIS stressed, like SAPA, pupil inquiry, and began by defining content, process and attitude objectives. It identified four main ideas around which the content was developed - matter, energy, organism and ecosystem . It is a programme heavily embedded in a Piagetian framework, suggesting highly diversified set of experiences for the young child heavily oriented towards concrete manipulations. It provides for three stages in a child's learning cycle - exploration, invention and discovery (SCIS, 1970, pp. 16,17). Exploration occurs when children learn though their own spontaneous behaviour relative to objects and events; that is, by handling objects and by experimenting with them. It is presented however within a context which aims at building a conceptual framework. Invention occurs when a child needs new concepts to interpret his observations. But since few children can phrase new concepts by themselves, the teacher is expected to provide the definition and a term for the new concept. Finally, discovery occurs when a child discerns a new application for a concept. In keeping with progression thinking the early units in the first three grades are aimed at the concrete operational thought while those designed for the higher grades are directed towards the beginning of formal thought.

The programme in all consists of twelve interrelated units organised into two sequences - the physical and life sciences. The teaching materials for each unit include a teacher's guide, a complete kit of equipment, a set of student manuals, and visual aids. The teachers' guide provide the teacher with the objectives of the unit, some background information and teaching suggestions. In this sense SCIS may appear to show a guided-discovery approach to teaching. Each unit progresses though a set of experiences in which the related concepts are explored.

In the sense that the approach in SCIS began with what children should learn before how they should learn, SCIS has much in common with the Oxford Primary Science Project. They both outlined selected themes or ideas around which content was developed.

Elementary Science Study

Developed in the mid 1960s, one of the main considerations given in developing the materials was that it should allow for "children to raise their own questions about the materials and use them to find their own answers" (Duckworth, 1964 p.241). She describes ESS as having three stages. The first describes an unguided exploration arising from the children, the teacher and their various backgrounds. The second, stage demands providing materials and programmes that can cope with and continue the pupils' beginnings wherever they lead. There is then a final summative stage which requires discussion, even formal or informal teaching to 'pull it together'. In all, ESS consists of fifty-six units. While covering a wide range of topics, they are not rigidly sequenced nor specifically grade placed. Says Ivany (1975 p.285). "...the emphasis on active exploration of concrete materials provided in kit form, and the lack of grade level or specification, illustrate a fundamental concern of ESS." While some units are designed to teach the skills - others are more oriented towards content. Each unit of work has a teacher's guide, a student kit, other print materials for students, but avoids a textbook approach to learning. The teachers' guide contains background information about the content of the kit for the teacher as well as teaching suggestions. Some units have pupil worksheets. In the sense that no sequence to the use of the materials is recommended, it is the most open of the three American Projects.

ISSUES ARISING FROM THE REVIEW OF CURRICULUM PROJECTS

From the review of the British and American Projects, certain curricular issues arise that have a relevance to the Primary Science Project in Singapore. These are

a) the question of a content and or process skills oriented science curriculum,

b) the question of a hierarchy of skills;

c) specification of behavioural objectives and extent of programme prescription and

d) the teacher's role in a pupil inquiry oriented programme.

a) Content and/or Process Skills

The child-centred philosophy which dominated the British Primary Science Projects in the past two decades encouraged a process approach. In general the British projects tended to emphasise that to approach a problem scientifically was more important than the mere learning of scientific knowledge. It was no wonder than that the Oxford Primary Science Project was not received with much enthusiasm. However, more recent experience with, for example, the Learning through Science Project, the HMI Science Committee (DES, 1983) and the assessment of Performance Unit (1981) seem to indicate that "...processes, generalizations and concepts are all seen as important criteria for the selection of activities ... process criteria are still pre-eminent but not really to the degree as in the orthodoxy of ten years ago." (Richards, 1983 p.6). Kerr and Engel (1980 p.48) plead for a more practical balance saying

> "At present the content of primary science is left almost entirely to chance, a state of affairs which puts a considerable strain on conscientious teachers who lack sufficient background and experience of science. We conclude .. an adjustment of policy is desirable. Perhaps we should begin by forgetting all about the process - content dichotomy, and look more closely at how the child acquires scientific skills and attitudes as well as an understanding of essential concepts, and then at what the teacher is required to do about it."

Black (1980 p.64) argues for a strategy in which children's interests and their need for first hand experience be given full attention but that these be fulfilled within a few particular concept areas. He also sees in such a strategy teachers being given more direct guidance, for he replies to those who see planned provision as an obstacle to excellence "without such provision, teachers can only be given vague advice, and the demands for decision, anticipation and preparation become too great." (Black, 1980 p.64)

Harlen (1978 pp.62-64) has summed up the arguments for and against a common content. The following points have been selected from the many points made, and summarised as follows. Against a common content, Harlen says when children are constrained to work on particular problems in a given way, some of the important aims of primary science cannot be achieved. Second, because ideas change and what we regard to be true today may not hold for the future, it is better to equip children with skills of learning and finding out that will enable them to master a variety of content as required later. Thirdly, the motivation for learning skills and developing concepts is very strong when children are working on what interests them, and it will not be the case that all are interested all the time in the content chosen by someone else. In favour of a common content curriculum are the following points. First, children need knowledge of some scientific ideas and mastery facts to help them make sense of their world and teachers should ensure that the children encounter the content from which they can gain this knowledge. Second, based on the theory that the development of ideas and mostly of facts depends upon the earlier group of ideas which are basic to them, a common content will lay a foundation of basic ideas chosen so that they contribute to future understanding and knowledge. Thirdly, a prescribed content does not necessarily dismiss as less important the development of enquiry skills. The development of these skills may be aided with a more structured use of materials.

It would appear that a case could be made either way with regard to a common content curriculum. The pendulum is however, swinging away from an extreme acknowledgement of only a process oriented programme. But to let it swing to the other extreme would be a regressive step. The mood for the 1980s certainly seems to be one for compromise. What seems to be required are curriculum materials that will ensure that children encounter the range of ideas and facts which are relevant to understanding their environment, yet loose enough to enable teachers to use a variety of routes to arrive at them. Holford (1983 p.169) may well be right when he says "... processes remain a powerful aide - memoire in the planning of courses, but as an aid towards concept enrichment rather than ends in themselves." While there may be a re-evaluation of learning in science, one must not lose sight of the important role process skills play in connecting ideas with experience, thus enabling children to make sense of their experiences.

b) The Question of Hierarchy of Skills

One of the problems that has plagued primary science programmes is the difficulty in determining precisely when certain concepts or ideas or even materials should be presented to children. Likewise the issue of a hierarchy or otherwise of skills. SAPA process skills have been listed in two categories - basic and integrated. The integrated processes are supposed to be built up from the basic processes.

Harlen (1985a) has however not presented a list in any hierarchy, suggesting instead a more global list of titles each covering certain subskills. Stating her main categories as observation, interpretation of information, raising questions, developing investigations, hypothesising and communicating, she displays them in a layout (p.25) "deliberately chosen to avoid suggesting a sequence or order of priority among the items." Her list she points out implies no theory of how a scientific investigation would or should be conducted. Instead all the items are to be seen as parts of the total process of investigation, which explains why neither 'performing investigations' nor 'experimenting' appear in the list.

For those who argue for a hierarchy, it is often based on their understanding of what children are, or are not capable of at a given point of their development. For example, Tobin and Capie (1982a pp.27- 28) take the view that "... unlike data processing, investigation planning exceeds the understanding of most elementary school students. The optimal time for introducing investigation planning skills is probably in middle school."

Tobin and Capie (1982b p.114) also cite doubts raised by Good (1977) about the suitability of integrated process skills for students in grades 5 and 6. He noted , "that current research on cognitive development suggested that ten and eleven year old students would have difficulty in controlling variables, interpreting data and constructing generalizations." On the other hand, Atkin (1958 pp.420- 422) investigated the ability of children to frame satisfactory hypotheses. Atkin's study found that children ventured their hypotheses readily although they did not recognise the fact. His study identified authority, experimentation, observation and 'original guesses' as the sources on which the children draw for hypothesising.

Harlen (1983 p.99) refers to APU findings on children aged eleven which found for example classrooms giving low priority for children to incorporate controls in experiments, identify variables operating in certain situations and design their own experiments. She says that it can be argued that these areas are just very difficult and hence teachers avoid them. However, against this view she argues "is the evidence that children of this age can plan investigations, carry out 'fair tests' and become critical of procedures which omit necessary controls if they are given the opportunity".

It is important to note that there is a hierarchical development within each process but not among the processes. Recognising this, the view I take is not whether a skill should or should not be introduced at a particular grade level, but rather to what extent and at what level of sophistication it can be expected of children at a given point in each child's development. There is, after all, as Harlen (1985a p.x) points out "no invariant order in which these skills will be deployed, it will depend on the familiarity and nature of the experiences."

c) Specification of Behavioural Objectives and Programme Prescription

Gagné's view that influenced the American programmes is clear when he remarks "there must be a deliberate and concerted effort to identify what are usually called 'goals' or 'objectives' ... specific objectives to be attained by the student ..."(1963 p.32). However, for those who take the view more reminiscent of the British programmes, that the outcome of children's enquiry is not something we can predict, and that one should not direct such enquiry with specified outcomes in mind, they would certainly not entertain the notion of specific behavioural objectives. But once again there seems to be a shift from any extreme view. The science programmes in the early 1960s had little to guide them on what should be learnt and thus says Harlen (1985b p.4458) it could be regarded as being 'prudent' to hold back from specifying. However, she adds " the evaluation studies of these earlier developments have shed considerable light on this matter and the issue has now evolved into one concerning the degree to which objectives should be specified rather than whether they should be specified at all." She suggests that knowledge objectives can be achieved in a few activities but for process skills there is no one activity or group of activities but rather, a wide range of activity that will have to be pursued. Hence if one attempts to specify objectives it is the content- related one rather than the skill related objective that will best lend itself to the exercise.

What we need to be cautious about here is that if specific objectives in behavioural terms are identified early, it does not produce a limiting element built into the new curriculum. Atkin (1968a p.28) makes the subtle point that "when any piece of curriculum is used with real people, there are important learning outcomes that cannot have been anticipated when the objectives were formulated."

On the issue of programme prescription, it can range from the developers providing teachers' guides, pupil manuals, kits and textbooks. In some situations, it becomes a case of teachers working through the materials in the order in which they appear in the programme. SCIS and SAPA are two programmes which are closely prescribed and where teachers were given detailed directions. However, other programmes developed have taken a more flexible route such as ESS and many of the British programmes of the 1960s. Their programmes allowed for the teacher to select and adapt according to pupil needs; thus attempting to accommodate a philosophy of starting from the interests of children. But, says Harlen,(1985b p.4459), it did cause problems for teachers who found themselves unable to stimulate children's interests in their investigations. The approach that developers finally will need to take will be one that takes cognizance of both teacher ability and confidence to handle any science programme.

d) The Teacher's Role in a Pupil Inquiry Oriented Programme

In a programme that allows for open-ended activity in which a teacher has to encourage particular skills by careful guidance of pupil's own interests the teacher requires some knowledge or confidence to learn about many topics and have some first hand experience of the skills involved. As Labahn (1969 p.589) indicates, the role of the teacher needs to be re-defined in programmes which emphasise children doing, and de-emphasise teachers "telling', The teacher needs to shift from being a demonstrator to one of stimulating inquiry, encouraging creativity, guiding students when necessary and providing the environment in which children can pursue their investigations. Such a teacher will also need to withhold as far as possible giving answers to questions from children, when these answers can be obtained through children's own investigations. Hence as Labahan (op. cit) again points out, there is a need for a total interacting system, in which the components are the children, the materials of the programme and the teacher. "What happens in the interaction between teacher and children is of great significance to the ultimate success in the presentation of a modern science programme." In this communication system though, with a process skills emphasis, there is a recognition that communication means maximum interaction among all individuals in the classroom. This implies an atmosphere where children communicate also with children. The teacher's skills that are required are summed up by Harlen (1985b p.4450) as relating to:

"a) Communication and interaction with children, of which questioning skill is of prime importance;

b) classroom management and ability to use a range of teaching techniques.

c) improvising equipment, collecting and organizing resources;

d) applying knowledge of how children learn so that procedures can be adapted to the needs of individuals;

e) the science process skills, which the teachers must have themselves before they can encourage, recognise, and assess their development in pupils."

The skills a teacher has acquired will to a large extent determine the final role she will assume in the classroom. Good (1977 p.221) has summed up five such roles:

"A. Lecturer and Question-Answerer
B. Discussion Leader
C. Activity Director and Evaluator
D. Activity Facilitator
E. Co-investigator"

He explains that roles A and B are mainly verbal in nature, hence the corresponding learning by children is largely verbal too. Role C he says implies that children will be engaged in 'activities' and the teacher will direct these activities. Learning in this case he infers will be a combination of verbal (from directions and evaluations by the teacher as well as non-verbal (from the child's own actions during activities). Role D he suggests is one where the teachers avoid evaluating and directing behaviour in favour of accepting and non-directive behaviours, thus increasing non-verbal, self- directive learning opportunities. Finally as co-investigator, Role E allows the teacher to engage in genuine investigative activity along with the children. Verbal interaction he points out is usually initiated here by the child rather than by the teacher.

What does this imply for teachers working with different curriculum projects? Good (p.241) believes "... curriculum materials can, to a large degree, restrict the teacher's role". According to his analysis, looking at SAPA, SCIS and ESS, he says that while each curriculum is activity centred, the emphasis on the teacher's role can vary greatly:

"1. SAPA emphasises Role C with some of Role B in most lessons.

2. SCIS emphasises Roles C, B and D respectively, at various points in the development of a unit of study.

3. ESS emphasises Role C and D respectively, depending on the particular unit".

He adds, "very little use of Role E, co-investigator, is made by any of the science curricula in use in today's elementary schools, and in fact the major emphasis is with Role A, B or C or some combination thereof." (p.242). The issues this raises will be looked at later in relation to PSP.

DIRECTIONS OF THE PRIMARY SCIENCE PROJECT (PSP)

Against the backcloth of the philosophies, thrusts and issues arising out of the British and American Primary Science programmes, an analysis will now be made of PSP.

In Chapter One, it has been shown that PSP has elected to highlight a process skills approach to primary science. PSP was, however, developed around a National Science Syllabus for primary schools, prepared by the Ministry of Education (Singapore) and published in 1981. This syllabus also gave special consideration to process skills, but it is important to note that it did not disregard concepts and knowledge of content when it said (p.1):

> "For the purpose of teaching and learning science at the primary school level, science is viewed as a study of the environment that is based on direct experiences of the learner. Such experiences constitute the content, namely the facts and concepts ideas of the world around the child .... Equally important are the science skills or processes which assist in the development of concepts"(emphasis added).

It is interesting to note that the word 'equally' has been used to indicate the degree of importance one may expect of either content or process on the content-process scale. Interpreting the study of the environment, the syllabus provided the following model of the conceptual framework. (Fig 3.1). Arising out of this model, four main themes were suggested - animal life, plant life, matter and energy. The syllabus however, made the point (p.3) that "although the content of the syllabus is arranged along these themes, the topics were not to be viewed as independent compartmentalised blocks of knowledge." Rather, "they were to be perceived as a coherent and inter-related conceptual scheme." Figure 3.2 of this thesis gives the scheme that was offered by those who drew up the syllabus to show how the topic along each theme were to be sequenced and inter-related through the four levels. The syllabus thus did intend the child to move in his four years with the science programme "through a progressive increase in the complexity of the topics and abstractions of concepts (pp.3-6). This it said is "matched to the increase in the developmental maturity

Figure 3.1

Model of the Conceptual Framework

'Man In His Environment'

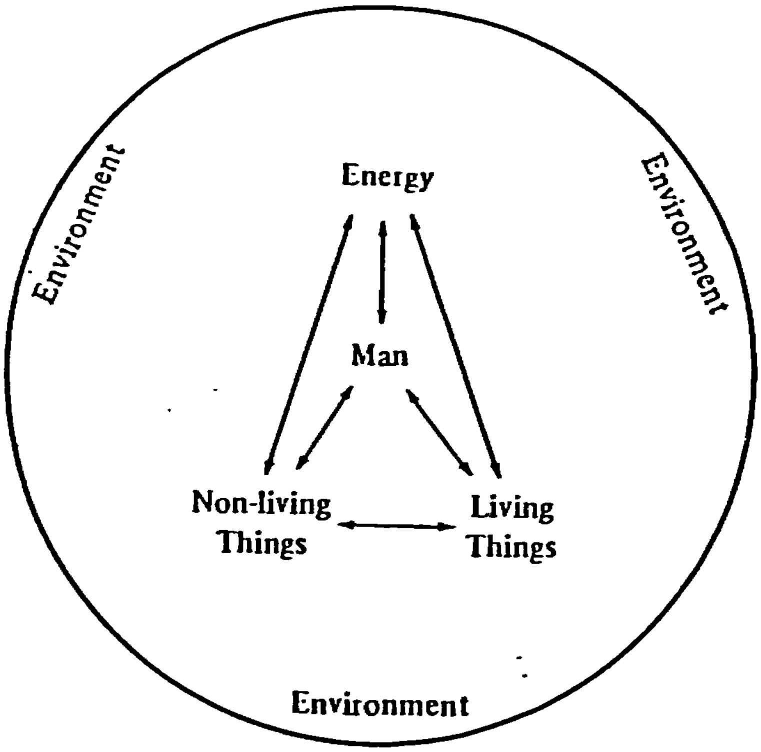
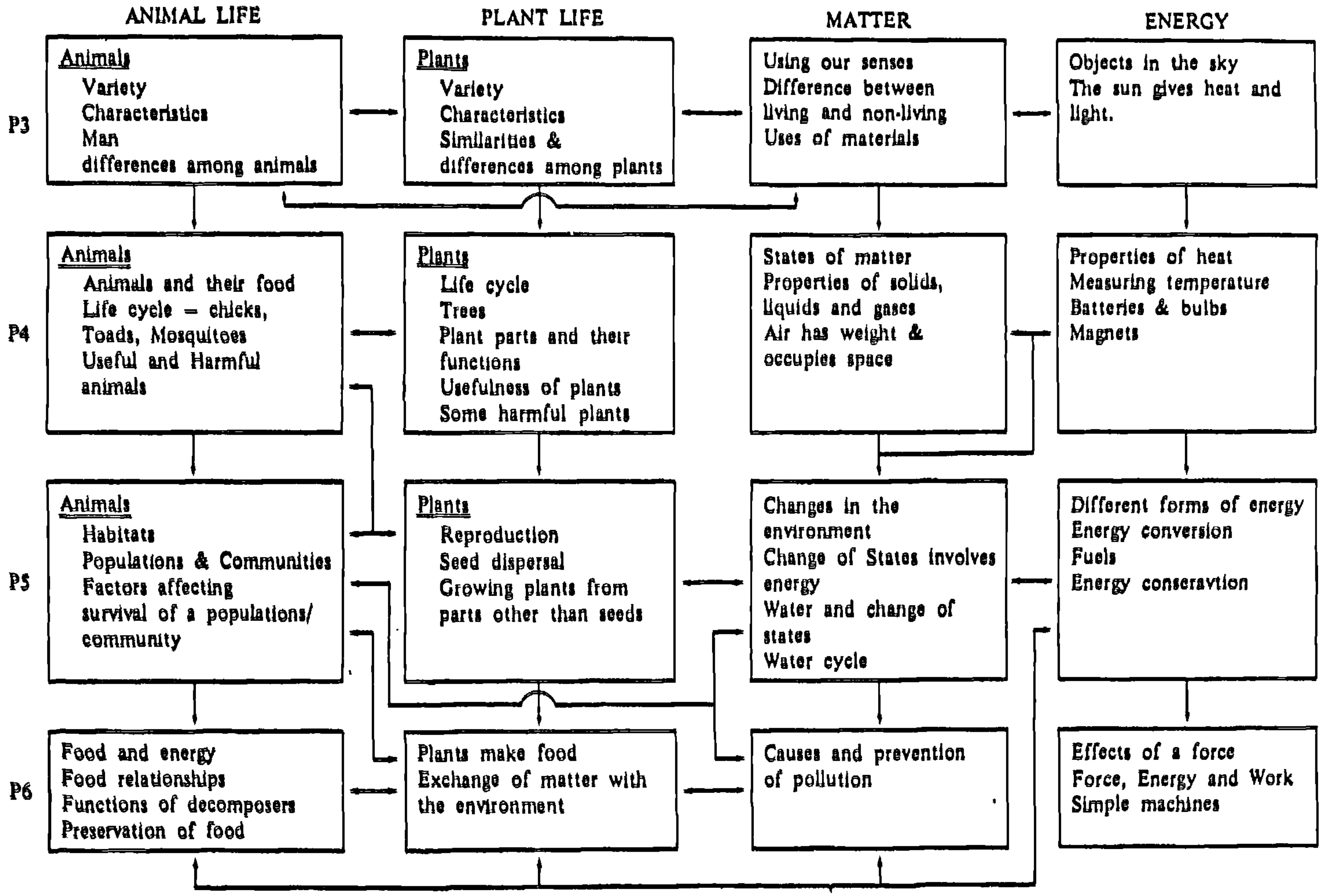


Figure 3.2 Sequence of Relationships Among the Topics in Science for Primary Schools



of the pupils" (emphasis added). The Primary Science Syllabus also listed the behavioural objectives for each year with reference to the topics and the main concepts to be developed. Some of these behavioural objectives were broadly stated, e.g. for Primary 4 (p.9) that children "be aware that some plants and animals may be harmful to man." Others were more specifically stated, e.g. "to use a thermometer correctly in measuring temperature". The syllabus also spelt out the main concepts for each year, specifically stated as in this example for P4 (op cit), "Matter commonly exists in three distinct states (forms) - solids, liquids, and gases." The syllabus also provided a breakdown of the process skills at each level against specific topics e.g. for P4 (p.9).

Observing: Observe similarities and differences in similar parts of different plants.

Communicating: Demonstrate how a piece of iron can be temporarily magnetised.

An analysis of the breakdown of the process skills from P3 to P6 (age 8 - 11 plus) shows the following hierarchy:

P3 (age 8)	P4 (age 9)	P5 (age 10)	P6 (age 11)
Observing	Observing	Observing	Observing
Classifying	Classifying	Classifying	Classifying
Communicating	Communicating	Communicating	Communicating
	Inferring	Inferring	Inferring
	Predicting	Predicting	Predicting

cont'd

	P5	P6
	Interpreting Data	Interpreting Data

PSP - its main issues

The PSP team began its task of developing the project against the thus described framework of objectives, concepts and skills. While it is true that the syllabus had at the time the PSP team were preparing the materials only recently been revised, one cannot in the Singapore context ignore what has historically always been the importance attached by the professionals in education to the dictums from the Ministry of Education. With a centralised education system and the vital role the 11 plus national examinations play in the future of the child, the PSP appears to have embraced the science syllabus in most of its expectations.

The PSP team looked at the learning sequence as one of exploration, assimilation and application. In this it appears to resemble SCIS and its learning cycle. Content is organised into chapters at each level. Each chapter focuses on a major concept or a number of concepts, each requiring a few lesson periods to work through.

The PSP has also taken the process skills referred to in the syllabus, which showed a hierarchy and presented them in two categories - basic and integrated. It bears very close resemblance in this respect to the list presented in SAPA. The PSP list of skills is as follows:

Basic Skills	Integrated Skills
Observation	Controlling variable
Space/Time Relations	Interpreting
Classification	Formulating Hypotheses
Measuring	Making operational definitions
Communication	Experimenting
Prediction	
Inference	

The materials that were produced include, at each level, Teachers Edition of the Pupil Text (i.e. Teacher's guide) a Pupil Textbook and Workbooks and a general collection of audio visual materials comprising of slides, charts and video cassettes.

The Teacher's Guide is described as the 'teacher's edition of the pupil's textbook. It provides the following :

- Rationale
- Background Information
- Objectives
- Concepts
- Materials required for activities
- Vocabulary
- Teaching suggestions

- Optional activities.

What the textbook comprises of is described in the Teacher's Guide (p. iii) which says "... As science is also factual, the book contains descriptive and factual information and also summarises the information in the form of concepts which pupils will hopefully form as a result of the learning activities" (emphasis added).

The workbooks that are provided for the pupils are geared to the textbook. The Teacher's Guide elaborates on the workbook (p iii) thus:

> . It provides a means for pupils to record their observations, influences and predictions.
>
> . It enables pupils to communicate in the written form.
>
> . It reinforces learning by means of exercises and allows some aspects of the pupils achievement to be assessed.

SUMMARY OF PSP ISSUES

Three issues are discussed here. They are:

1. Programme prescription of PSP.

2. Hierarchy of Skills.

3. The Teacher's role in a Pupil-Inquiry oriented Programme.

In a description of the materials developed by the project team for PSP, the following can be surmised.

1. Programme Prescription:

It is clear that PSP embraces both the pursuit of skills and concept goals. In respect to having clearly defined concepts around four broad themes, it resembles the approach taken by the Oxford Primary Project and SCIS with the most obvious links being 'energy' the 'study of organisms in their environment and 'matter'. Harlen (1978) has given the following content guidelines (p.81) that might influence decisions about what activities children can carry out. These broad themes are intended to be developed over a primary school child's years of primary science. They are :

1. about ourselves and other primary science.
2. about the physical surroundings and
3. about forces, movement and energy.

When these themes are examined against the four themes of PSP around which the concepts are developed, there appears to be a fair degree of commonality. The fairly close match they also have with the themes selected by the Oxford Primary Project and SCIS tends to indicate that generally these are the ideas curriculum developers seem to be agreed upon for children in primary science to begin work with. The point that Harlen has also raised in favour of a common content, can be used by PSP as supportive of their choice to work with such a common content.

Two issues that are at play in the Singapore context need to be presented. One is that in the workbooks that children are provided with, questions are asked and space is provided for answers. Children's explorations may thus tend to work around these questions only. Further, the answers to these questions are provided in the Teacher's Guide. The textbook is also seen by the developers as an aid to developing science, to stimulate interest, to arouse curiosity and to motivate investigation. But the text also goes on to provide descriptive and factual information, summarising the information in the form of concepts which it hopes pupils will form as a result of the learning activities.

There is then the inevitable problem - answers to many questions raised may find their way into the text. This raises the issue that if children's ideas are to be given an opportunity to be developed and tested a textbook where 'right' answers are provided must to some extent stultify such development. The opportunity for pupils to reach their own conclusions will not be given a chance if pupils also know that as far as the teacher is concerned there is a 'right' answer and more important, this might be found somewhere in the text. Would the child, for example, still feel motivated to work out his own ideas using the science process skills for enquiry?

Another aspect that needs mention is one that has occurred through no intention by the PSP team, but probably as an initiative from the Ministry of Education in their attempts to 'help' the teacher on her way. There has been with the introduction of PSP, a simultaneous exercise to encourage schools to list specific instructional or behavioural objectives (SIOs) for the various subject areas, right down to daily lessons. Schools, faced with the task of establishing this, not only for teachers in their classrooms, but also to be made available to inspection by staff from the Ministry of Education Inspectorate Division, felt the best route to take was to join forces with other schools, and thus, in groups to develop these objectives. What has eventually happened is that these 'groups' of schools come together often because of geographical proximity or affiliation (eg. to a church denomination). What may thus have got lost as a focus, is the actual teacher and her set of pupils. Established and presented to the teacher as a 'syllabus guide', the SIOs in instances have limited the flexibility teachers require to begin with the child's needs. Sometimes, help provided with the best of intentions, can turn out to be the worst possible assistance that one can provide. Hence a focus of the study will be to try and understand within the degree of prescription in the Singapore context (eg. content and behavioural objectives specification, pupil textbook and workbooks) if there is sufficient scope to accommodate a philosophy allowing children to work with their ideas.

Hierarchy of Skills

The list of process skills PSP has proposed is very close to that presented in SAPA. Authors of curriculum materials have always presented their lists consistent with their philosophy of science education and its intended outcomes. As such, PSP's list presented in two categories indicating a hierarchy reflects an acceptance of a developmental sequence by children in using the process skills. My argument is however not whether a skill should or should not be introduced at a particular grade level, but rather to what extent and at what level of sophistication it can be expected of children at a given point in each child's development. Hence, though PSP is laid out on the basis of a hierarchy of skills, for purposes of this research, I believe it would be far more useful to put aside any pre-determined notion of a hierarchy and work towards observing children as and how they use the science process skills in their activities.

The Teacher's Role in a Pupil-Inquiry Oriented Programme

Finally, PSP in providing a fairly detailed Teacher's Guide, not only giving some suggestions for conducting the lessons, but also providing the answers to pupil exercises, has acknowledged the teachers need for assistance. It appears to be a view taken by Black (1980), and the LEA's which supported Science 5-13 materials with back-up materials. It was also the view of many of the American curriculum developers. However, Whittaker (1983 p.253) has identified a possible danger when she says:

> "... Unless effort is spent on identifying a teachers' stage of understanding of science as a process and a human activity, suggestions for content will be treated as a syllabus, to be 'done'. Even worse, we shall find offered in the primary school 'experiments' which 'prove' something only when they 'work', the so-called proof being often an argument of perfect circularity, or at least very dubious logic."

This is then another focus of this study - for if we wish to achieve a high degree of congruence in what is intended and what has been implemented, the role of the teacher in bringing this about cannot be underestimated. Good (1977 p.242) sums it up in an interesting way when he says,

> "What this boils down to is simply this: It is the teacher variable that really counts! Whatever role the teacher chooses to assume will largely determine the nature of the science program for children."

CHAPTER FOUR

IMPLEMENTING PSP

THE PSP PROCESS SKILLS

In any intended science curriculum such as PSP, the aims include the process skills, concepts and attitudes that the project team would wish to see developed. This study will however only focus on the process skills. In so doing it does not intend to indicate that concepts and attitudes are any less vital in a child's development relevant to science education.

Gagné (1966) in suggesting a possible meaning of process centres upon the idea that what is taught to children should resemble what scientists do - the 'processes' that they carry out in their own scientific activities. However, he stresses (1968) that "this line of reasoning does not imply the purpose of making everyone a scientist. Instead, it puts forward the idea that understanding science depends upon being able to look upon and deal with the world in the ways that the scientist does." (p.4)

A second way of looking at the meaning of process, suggests Gagné, is to consider processes in a broad sense "as of ways of processing information". He moves on to say that the individual's capabilities that are developed may reasonably be called "intellectual skills." Wynne Harlen's view is more in this direction when she says the kind of science we are looking at concerns basic ideas which can emerge from simple investigations of objects and materials around. "What ideas do emerge will depend not only on the events but on the way the children reason about them, on the way they process information." (1985c, p. 4) She goes on to say that in all cases the ideas must be related to evidence, subjected to critical examination and modified or reconstructed, if necessary, in the light of the evidence. "This is where the process skills come in - to gather and interpret information, to describe and carry out fair tests and to communicate results." (p. 5)

What then are the distinguishing hallmarks of these skills that need to be developed in children to help them process information? The skills that I shall focus on in this study arise from a classroom situation in which I see children are

- themselves handling materials, living and non-living
- designing, making or manipulating apparatus using a variety of materials
- using measuring equipment
- moving around freely and finding the materials they need
- working in small groups and discussing their work with each other within the group or with the teacher

- trying to work out for themselves what to do from step to step, and not always expecting to be told what to do

- puzzling over a problem

- comparing their ideas or observations with those of others

- sharing the groups' findings with the rest of the class

- communicating or raising questions on the work carried out by other groups

- accepting comment on their work provided by other children.

In such a classroom environment opportunity would certainly be provided for children to use and develop the process skills. In presenting a list of the process skills that will be used in this study it would be relevant to recapitulate the lists provided by both PSP and the Ministry of Education's (MOE) Science Syllabus.

PSP List	MOE science syllabus
Observation.	Observation
Space/time relationships	
Classification	Classification
Measurement	
Communication	Communication

Prediction	Prediction
Inference	Inference
Controlling variables	
Interpreting data	Interpreting data
Formulating hypotheses	
Making operational definitions	
Experimenting	Experimenting

It can be seen that the PSP list provides for a more elaborate breakdown of the skills compared to the one from MOE. The list that will be used in this study attempts to incorporate the skills referred to by both those lists. However, as will be seen in the next chapter, any list that will be used would need to be sufficiently convenient to be used as a checklist as part of a classroom observation schedule for purposes of data collection. As such, the proposed list that will be used in this study broadly categorises the skills.

In incorporating the lists by PSP and MOE, in the proposed list 'classification' has been included under 'observation', 'prediction' under 'inference', while operational definitions' come under 'devising investigations.' The 'space/time relationships' which PSP describes as a process concerning spatial relationships and relating to the study of shape, distance, direction, motion, speed and rate of change is somewhat ambiguous when isolated as a specific skill. I believe it comes naturally within the other skills as the situations arise when children are involved in experimenting.

One important feature that the proposed list will include, and which has not been reflected by PSP and MOE lists is the skill of raising questions. It is a skill that is pivotal I believe when a curriculum is designed as child-centered and with children working on questions they raise about their own environment. It has thus been included in the following proposed list that will be used in this study. The list does not however specifically mention experimenting or investigating. Experimenting or investigating is the capstone of the science processes. The skills that are now listed are part of the total process of investigation. The process skills in this study are thus broadly categorised with no intended hierarchy. They are:-

Observation

Interpretation

Raising Questions

Hypothesising

Devising Investigations

Handling equipment and measuring instruments

Communication.

INDICATORS OF THE PROCESS SKILLS

The following provides a description of the process skills. The descriptions have been modified for this study from training materials used in workshops for PSP teachers in Singapore with Wynne Harlen as consultant.

Observation:

This is recognised as a mental activity involving more than the use of the senses to gather information. The significant aspect of this skill is that there is a gradual development toward a pupil being able to distinguish the relevant from the irrelevant in the context of a particular investigation or problem. It involves a pupil asking 'what can I notice?' To answer this he may need to

- make quantitative and qualitative observations
- use instruments to extend the range of the senses
- notice changes in objects and events
- be aware of differences and similarities
- be aware of differences between observations and inferences
- recognise cause and effect.

Interpretation

This is a skill that is required when a pupil, faced with data either provided to him or collected by him, begins to put the various pieces of information or observations together and deduces something from them. Often it would mean that a pupil works with a hypothesis in mind to collect data accordingly. Included in this category would be subskills such as finding patterns, inferring, predicting and finding relations. The main question the pupil asks would, for example, be 'what does all this information tell me?' To answer such a question he may need to,

- put various pieces of information together and infer something from them; to infer he would need to be able to suggest a reasonable explanation based on available evidence

- use patterns or relationships in information, measurements or observations to make predictions; to predict he would need to recognise regularly repeated events

- identify trends or relationships in information

- realise the differences between a conclusion that fits all the evidence and an inference that goes beyond it.

Raising Questions

This concerns, at the primary level, the questions to which children can find answers, through their own activity. The variety of questions that children often ask needs to be encouraged. Part of this skill where children raise questions, also requires the development of an awareness by the children that not all questions can be answered by science. Some of these questions children ask may not necessarily be for information, but rather as an expression of interest. Others require direct answers either from the teacher or some other source of information. Yet other questions by children need more complex, not merely factual answers - compounded by the fact that answers, may not always be understood by children, even when provided with the explanation. What the teacher needs to promote is the opportunity to help children define testable questions - children will soon realise from their experiences what kind of questions they can and cannot answer from investigations. Children in raising questions will,

- ask questions sometimes based on a hypothesis which will lead to enquiry

- put questions in a testable form.

Hypothesising

This refers to the process of attempting to explain observations or relations or making predictions in terms of a principle or concept. These explanations may reflect the different levels of children's experiences and their ability to apply ideas or concepts towards describing or finding or applying a general principle to a given problem. For a child to respond with a hypothesis, it will involve an

- attempt to explain observations or relationships in terms of some principle or concept

- apply concepts or knowledge gained in one situation to help understand or solve a problem in another

- recognise that there can be more than one possible explanation of an event

- realise the need to test explanations by gathering more evidence.

Devising Investigations

Once children have posed testable questions, a subsequent activity would involve children in defining operationally, identifying variables to be changed, controlled or measured and planning procedures for fair testing in an attempt to devise investigations with regard to their testable questions. For children, devising and performing an investigation are not necessarily separate entities. For some of them, each step of their investigation may be planned as they go along. With experience, however, there comes greater initial anticipation of the stages. In answering the question 'how can I find out?' they will

- construct questions or hypotheses for investigation

- devise ways to find answers

- decide on equipment required and measurements to be made

- identify the variables involved

- control the variables so that the effect of only one variable can be observed

- decide on what observations and data are to be collected

- in identifying variables and manipulating conditions affecting them, to arrive at a fair test.

Handling Equipment and Measuring Instruments

Children will also encounter the process of using measuring equipment as well as other apparatus that will help them extend their observations and conduct investigations. They will ask questions like 'Let's check which is bigger?' or ask 'What do I use to find this out?' This leads them to :

- make qualitative comparisons with standard units

- make estimates and confirm by measuring

- select appropriate instruments when measuring

- know the function of various pieces of equipment and if necessary, improvise.

- exercise care in handling equipment

- work co-operatively with others.

Communication

This is a process of conveying information orally, in written, pictorial or even display form. It is a case of a child saying 'let me tell you what I have done'. It involves the child in

- describing an object or event

- describing similarities and differences

- describing changes

- making records

- constructing tables and graphs

- selecting the form of presentation of information appropriate to the purpose.

Harlen (1985a) comments that communication is an outward extension of thought. "As thought is such an important part of learning science and communication is essential to thought, both as a process and as a means to an end, so development of the skill in communication is central to education in science." (p. 40)

With those descriptions providing the working basis of understanding of the process skills we can now look at the research study.

THE RESEARCH STUDY

This study aims to look at the relationships between the intended and implemented primary science curriculum (PSP) in Singapore, focusing specifically on the aspect of the process skills. The research questions that are raised and the data subsequently to be collected will be guided by various determinants. For a clear understanding of what these determinants are in the Singapore context, a model showing a Schematic Process of Classroom Implementation of the PSP has been developed. Each of the determinants is understood by the researcher to play a role in the implementation of PSP materials.

SCHEMATIC PROCESS OF CLASSROOM IMPLEMENTATION OF PSP

The model of the Schematic Process of Classroom Implementation of PSP is provided in Figure 4.1. The starting point of the model is the NATIONAL SCIENCE SYLLABUS. As has already been elaborated in Chapter Three, it was also the starting point for the developers of PSP. Teachers continue to refer to it in their day to day preparation of their lessons. The assumed reason is that in an examination conscious environment, the syllabus from the Ministry of Education is taken to be an important guide to preparation of pupils for examinations.

Arising from the syllabus is the CONTENT and MATERIALS of PSP. Among the many factors influencing the structuring of the materials and the selection of the activities are the PROCESS SKILLS. Emerging thus is the INTENDED PSP CURRICULUM. This curriculum is presented to the teacher in the form of the Teacher's Guide, Pupil's Text and Workbooks. As the teacher examines these materials, she is faced with the task of UNDERSTANDING the objectives, Philosophy and Rationale of PSP. She emerges with some conceptual understanding of what is intended, but these are filtered through what she perceives as CONSTRAINTS to her implementation of the curriculum.

The constraints she sees imposed on her can be categorised into:

a) Personal and Social constraints

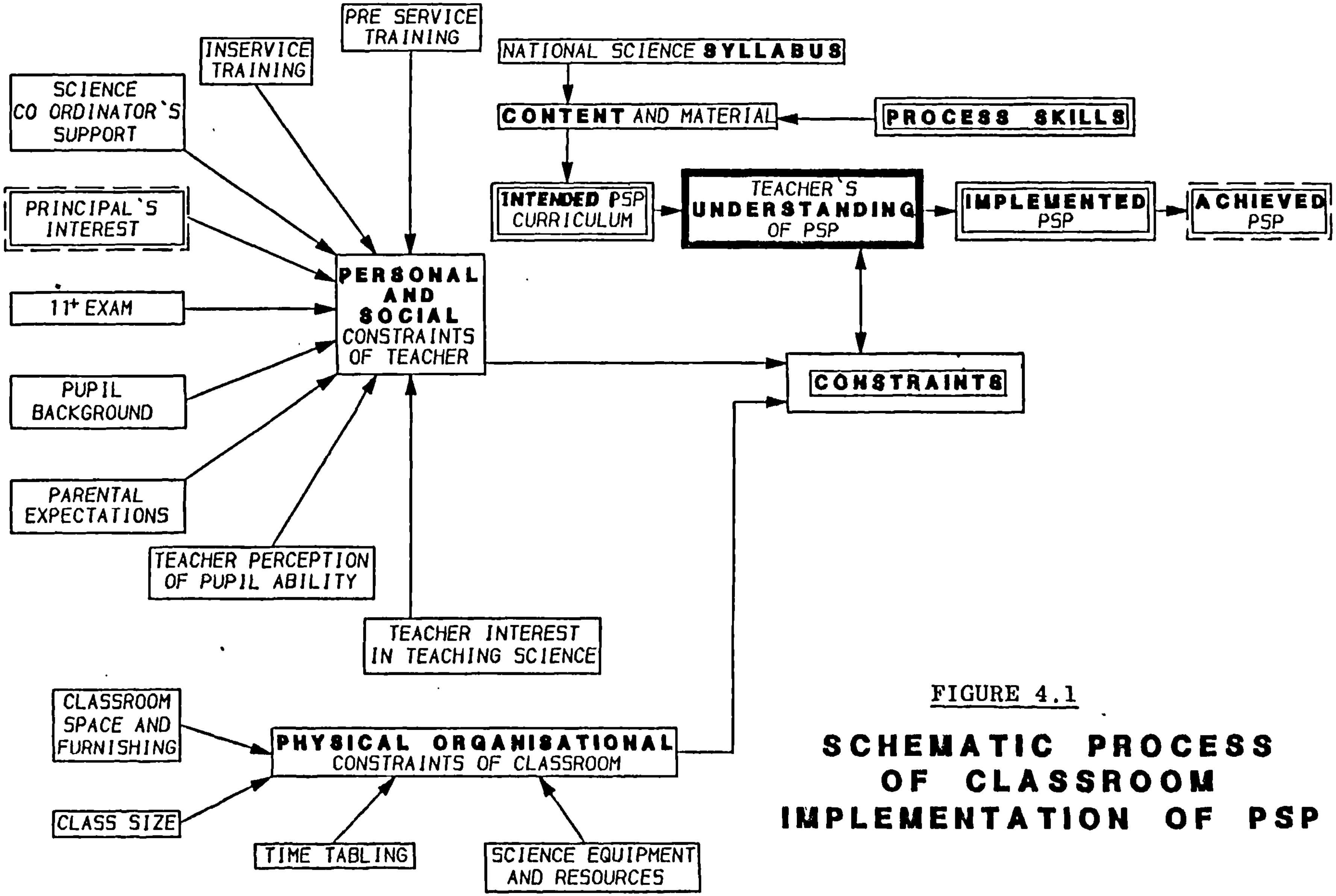


FIGURE 4.1

SCHEMATIC PROCESS OF CLASSROOM IMPLEMENTATION OF PSP

b) Physical organisational constraints of the classroom.

In the remaining part of this chapter, each of these constraints, referred to as the determinants of implementation, will be considered individually. They will help to guide the research study and the research questions that will be posed in the next chapter.

Personal and Social Constraints on the Teacher

In the Singapore context the following determinants can be seen to have an influence to varying degrees on the teacher in the classroom. In no order of priority, they are :

- Pre-service training of the teacher in science
- In-service training of the teacher to use PSP
- Science co-ordinators' support
- Principal's Interest and support
- Pupil background
- The 11+ Examination (PSLE)

- Parental expectations

- Teacher Perception of Pupil Ability

- Teacher Interest in Teaching Science

Pre-service Training

All primary school teachers would have had a two year pre-service training programme at the Institute of Education. Primary School teachers are not seen as specialist teachers, but the more recent training programmes at the Institute have required that trainee teachers in the second year select areas of the curriculum to 'specialise' in what would be regarded as the new teacher's 'strength'. Thus some teachers may have a stronger grounding in science if this is their option, while for others, they are dependent on the basic programme in science provided in their first year of training. Since 1982 this basic programme has included exposure to PSP materials. Teachers who had their pre- service training before 1982 would not have had any exposure and would be dependent on In-service programmes.

In-service Training

For PSP, the in-service training programmes have been conducted in the main by the Project team members developing the materials. There have also been courses offered by the Institute of Education and the Schools Division of the Ministry of Education to update and or upgrade the knowledge, skills and new roles of the science teachers.

Some courses have been the joint efforts of the Institute of Education, the Curriculum Development Institute and the Ministry of Education. Other agencies that have helped are the Singapore Science Centre and the Science Teachers Association of Singapore, both of which conduct regular workshops for teachers.

How teachers come to attend the in-service courses is another matter. In some schools, principals appoint teachers to attend the courses. Some teachers willingly attend, while others are less enthusiastic. In other schools, it is a matter of interested teachers volunteering to attend. It is thus not surprising, that some teachers may not have attended a single course while others have been to more than one.

Science Co-ordinators Support

In Singapore Schools there is the practice of appointing a member of staff to be a science subject co-ordinator. There is also a pilot scheme in some schools to appoint, instead, a Head of the Science Department. The duties of the science co-ordinator have been listed by the curriculum branch, schools division of the Ministry of Education, Singapore (Reference R/SC4/d4). From the coverage of their duties listed it can be seen why the science co-ordinator can play a vital role in the successful implementation of PSP. This is especially so when their duties include the development of teaching strategies and the selection and organisation of teaching/learning materials. The duties and responsibilities of the science co-ordinator are:

1. To establish an overview of the subject as chairman of the subject committee comprising teachers teaching the subject.

2. To plan and implement a comprehensive programme of instruction including remedial and enrichment programmes.

3. To develop teaching strategies so as to increase learning effectiveness in the subject.

4. To co-ordinate, advise and give practical assistance on the teaching of the subject.

5. To promote team spirit among teachers teaching the subject.

6. To select, prepare and organise teaching/learning materials eg. textbooks, supplementary materials, teaching aids and science apparatus etc. and to encourage their effective use in the classroom.

7. To develop evaluation strategies and instruments to assess learning effectiveness - this entails checking of marking schemes, vetting and moderation of examination papers set as well as the analysis of results.

8. To assist science teachers with a continuous programme of professional growth.

9. To act as contact person between school and the Ministry for the dissemination of information concerning the subject.

10. To be advisers to the Principal/Vice-Principal on all aspects of the subject.

Principal's Interest and Support

From the list of responsibilities of the science co- ordinator, item 10 provides the link with the school Principal. Ultimately, in Singapore Schools, the Principal plays a key role in how the various subjects are developed in his school. He may in most cases play no part in the teaching of any of the subjects, but the support and interest he provides can enhance teacher morale. It is not uncommon to hear in the staff room reference being made to the Head, and his image as a good leader can indirectly affect teacher input in the classroom.

Pupil Background

This can cover many aspects including the pupil's socio-economic background, his home language and for the teacher in the classroom the pupil's academic ability and his preparation in the subject at the previous level. In Singapore, the pupils' home language and his fluency in English are particularly important. This is because science is taught in schools in English though this is not the language used most frequently in the home. In the classroom, the teacher faced with a multi-racial class of pupils needs to pace the vocabulary and oral interaction at a level suitable for her class. For some teachers, this may be a handicap towards free expression. It is not uncommon in a Singapore classroom to have pupils during group work interact in their home language and shortly after, make their recordings and present their findings as required by the teacher in English.

11+ Examination (PSLE)

This is a national examination called the Primary School Leaving Examination. It is a crucial examination that determines streaming into the secondary school. Based on their PSLE results pupils are promoted to the secondary school and join Secondary One in one of three possible courses. These are the Normal (N) course, the Express (E) course and the Special (S) course. Pupils in the Express and Special courses will take a four year course, sitting for their GCE 'O' levels at the end of the fourth year. The only difference between the E and S courses is that the S courses pupils do two languages at first language level. Pupils in the N course take five years to sit for their GCE 'O' levels. Another route that pupils taking the PSLE examination can be channelled into are courses conducted by the Vocational and Industrial Training Board (VITB).

Parental Expectations

Level of interest shown by parents can vary from school to school. Quite often, it is the schools which are geared towards very competitive examination performance that also have a high level of parental expectations in terms of their children acquiring good examination grades. In turn, such situations may influence teaching methodology which can be geared towards producing desired academic results above everything else.

Because National Examinations play a crucial role in the life of pupils, parents and teachers, their influence on the teacher in the classroom should not be underscored. A study by Holley (1974) of secondary school physics teachers in England dealt with factors which teachers perceived to be constraints on their work. The study, reflected only a 55 per cent response rate from a sample of 93 heads of physics departments in a representative group of schools. Their responses showed that the most frequently mentioned constraint was the external factor - examination requirements.

Teacher Perception of Pupil Ability

The teacher's perception of the ability of her pupils determines to a large extent the teaching strategy she adopts and the kinds of interactions she provides opportunities for in the classroom. It is important in a science curriculum which allows for pupils to work with their ideas and questions that teachers do not underestimate the potential abilities of their pupils.

Teacher Interest in Teaching Science

In Singapore Primary Schools, teachers are seen as generalists. It is quite possible that a teacher in a primary school may not have an interest in teaching science but finds herself having to teach the subject as part of her job. For some teachers who have not furthered their science education beyond their mid-secondary school level, a question of confidence in handling the subject also may become a constraint. However, for those teachers who have an interest in teaching the subject irrespective of their own background in science, the constraint can be overcome through the knowledge and skills being acquired via in-service programmes.

Physical and Organisational Constraints of the Classroom

The four important factors that I see as influencing implementation are

1. Time Tabling

2. Class Size

3. Science Equipment and Resources

4. Classroom Space and Furnishing

1. Time Tabling

Time tabling plays an important part, particularly when enquiry science is advocated, as such lessons require sufficient time for a teacher to develop her lesson. In Singapore schools the appropriate number of hours schools have to devote to the subject is specified, but the Ministry of Education does allow schools some lee way depending on the school and needs of pupils. The hours stipulated per week for science at the P4-P6 level are 2 3/4 hours. The total curriculum time for a week at the P4-P6 level is 23 3/4 hours.

This weekly allocation is then worked out by the schools into a number of periods. A single period is approximately thirty-five minutes and a double make go on for seventy minutes. In most cases, schools time table the periods based on staffing and science room demands. Science teachers certainly would favour having double periods, but not always can this be possible.

2. Class Size

In Singapore classrooms this can vary, but the maximum is set at forty-four. Teachers find this a constraint for enquiry science activities, feeling that only through a smaller class size can personalised attention on the part of teachers be possible. Class size also has implications for the use of resources, and should this be limited in supply, it could affect the nature of group work as well as the issue of physical space in which to carry out the activities.

3. Classroom Space and Furnishing

Ainley (1981, p. 130) quotes Englehardt's work (1966, p.70) on the issue of facilities and says the following. Schools have two lines of influence on science teaching. First, the provision of suitable science rooms could remove a barrier to certain activities - hence in this sense rooms are a potentially limiting factor. Secondly, the presence of suitable features in rooms may suggest the possibility of new activities - hence the notion of "suggestive" space. Whether space and room furnishing are a constraint to implementation of PSP in Singapore classrooms will be an issue to be examined.

4. Science Equipment and Resources

This is always recognised as important in the successful implementation of any science programme. Generally, the Ministry of Education has been generous in funding resources for schools. Ainley (1981 p. 132) points out from his studies as part of the Australian Science Facilities Programme that

> "being frequently in science rooms, using rooms of good quality, and having sufficient apparatus were all associated with a reported greater involvement of students in learning activities. Student reports of active forms of learning, defined as more experimental work, less learning from textbooks, and greater encouragement to explore were also associated with better science facilities."

Referring to the model again, the arrows from the two categories thus lead to what constraints the teacher faces. It must be noted that not all teachers will face all the constraints.

Further, some teachers may be able to consider the various factors and work out solutions which reduce the constraints. For others, they may prove to be serious barriers to any implementation move.

Once the teacher has come to an understanding of what PSP requires of her and has resolved for herself the teaching strategy she will adopt, she moves into the stage of IMPLEMENTING PSP in her classroom. Based on the interactions that take place in the classroom, a stage will arrive when the developers of the curriculum and other interested persons in the education system will want to look at what the children have ACHIEVED.

While it is realised that information on the achieved can be useful for diagnostic work with children's learning, the achieved as well as the role of the school principal will not be looked at in this study, due to the limited resources available for this study.

What this study attempts to look at is the extent to which the process skills have been implemented and to establish what constraints teachers may continue to be facing. The research design and the research questions for this study, based on the model just discussed will be the subject of the next chapter.

CHAPTER FIVE

RESEARCH DESIGN AND METHODOLOGY

THE MAIN RESEARCH QUESTIONS

The preceding chapters showed how important a successful implementation of the process skills component of PSP would be for Singapore pupils in the light of the current trends and research findings in primary science education. This study looked at the process skills component of PSP, using as guidelines the identifiers described in Chapter Four. The research problem examined centered around the relationships between the intended and the implemented PSP specifically focusing on the process skills. This study looked at:

1. The learning opportunities for process skills that pupils experience with PSP.

2. The provision in PSP materials for pupils to use the process skills.

3. The provision of the necessary context for implementation of PSP.

The study was guided by the variables described in Chapter Four when the Schematic Process of Classroom Implementation of PSP was discussed. Each of these variables plays an important role in the implementation of PSP materials and thereby contributes to the present operational status of the PSP curriculum. They have guided the main research questions. Data collected on these variables will help to explain the relationships found in the research between the intended and implemented PSP. The main research questions are:

1. To what extent are the process skills used by the pupils of PSP?

2. What is the teacher's understanding of the intended PSP, in terms of its philosophy, objectives or rationale relating to process skills?

3. What influence does the national syllabus with its stipulated content coverage have on the teacher using PSP?

4. To what extent are the following acting as personal and social constraints on the teacher using PSP?

    a. Pre-service training

    b. In-service training

    c. Science co-ordinator's support

    d. 11+ examination

    e. Pupil background (language)

f. Parental expectations

g. Teacher perception of pupil ability.

h. Teacher interest in teaching science.

5. To what extent are the following physical organisational aspects of the classroom acting as constraints on the teacher implementing PSP

   a. Class size

   b. Classroom space/furnishings

   c. Time tabling

   d. Science equipment and resources.

In attempting to collect data within the time frame and resources available, not all aspects outlined in the model (see Fig 4.1) could be explored to the fullest. 'Principal's Interest' was not explored, while 'Pupil Background' was only explored with a language focus. It may be asked why the 'Achieved PSP' i.e. the obtaining of data through assessment tests was not included as part of the scope of this study. The considerations leading to its exclusion are discussed.

Fullan (1981, p. 330) in referring to the relationship between implementation and the testing movement says that while implementation is the means to achieving student outcomes and while "effective implementation of a quality curriculum programme leads to better achievement by students" the reverse relationship - good testing data—tells us very little about implementation. He goes on to say (p.331) that

> "testing data which indicates that there are certain problems, only raise, but do not address implementation questions - questions regarding what new implementation behaviour or curriculum practices will be more effective, what is the current state of implementation of the existing curriculum (the testing data provides no meaningful information about this)..."

Another problem Fullan sees about the testing movement is the "well-known one that the simplest, easier to measure (eg. content-based) educational objectives will be disproportionately addressed vis-a-vis the more complex, harder to assess (eg. inquiry skills) objectives" (p. 331).

Another researcher to cast doubt on the role of measurement in evaluation is Harlen who in 1973 in her report to the Schools Council on the evaluation of Science 5-13 said,

> "From the first set of trials, it was learned that information coming from children's test results was tentative and not really useable for guiding rewriting without being supplemented by other data.... whilst it could not be said that the information was without value for this Project, it can be said that where resources are limited and it is necessary to concentrate upon gathering information to give the greatest return on money, time and human energy, then the choice would be for teacher's reports and direct observations in the classroom and not for testing of short term changes in children's behaviour. " (quoted in Stenhouse, 1975, p. 105)

A choice inevitably had to be made in this study, within the available time and resources of the researcher, as to what data would provide the best evidence. Taking into consideration views expressed by both Fullan and Harlen, it was considered that priority should be given to classroom observation of pupils and teacher interviews. This is not to say that student outcome data should be deemed unimportant, but that it had low priority in a study attempting to explore reasons relating to implementation rather than merely to measure its outcome. In order to provide, to the extent possible, the answers to the research questions the maximum amount of relevant data needed to be collected. Classroom research has greatly depended on evidence from documents, student work, classroom observations - both direct and via recordings, log book diaries and opinions collected by interview questionnaires or meetings.

It was planned that for this study data would be collected :

a. by direct classroom observation to gather information in the classroom of PSP pupils (using a systematic observation schedule). Participant observation was not considered as the study was aimed at looking at how children in a number of sample schools used the science process skills. The study did not intend to make case studies of a few individual children.

b. by direct classroom observation to record relevant information about the lesson observed.

c. through teacher interviews to obtain information on the teachers understanding of the process skills and the constraints they perceived, or otherwise, on PSP implementation.

d. by teacher questionnaire to ascertain the priorities of the teacher when teaching science.

e. through analysis of the PSP materials for the observed lessons in both the text of the Teacher's Guide and Pupil Workbooks to determine as far as possible the opportunities provided for pupils to experience the process skills.

f. through school records to obtain a profile of the schools in the research sample.

RESEARCH INSTRUMENTS

In order that the data could be collected instruments had to be selected that could be used in the environment the researcher was working in. The research was seen as entirely exploratory and was entered into with no assumed notion of the status of implementation of PSP. It did not start from a preconceived hypothesis - hence the absence of any hypotheses.

Classroom Observation Systems

In looking for an observation schedule, the following characteristics were kept in mind.

1. It should facilitate the recording of those classroom behaviours associated with the processes in science, i.e. the process skills discussed in the last chapter.

2. It should allow for a record of interaction involving pupils and teacher in dialogue (i.e pupil-pupil, pupil-teacher) as well as pupils interacting with their science materials.

3. The record should allow for appropriate statistical analysis that would aid the understanding of the extent of implementation that has occurred in schools with regard to the process skills as well as throw some light on deficient areas.

4. The schedule should be usable by a lone observer in the sample classrooms.

5. It should not require the additional use of recording equipment such as audio taping or video taping. Audio taped material in a classroom where science investigations are taking place would not have been viable because of the background noise created by children involved in activity. Further, the fact

that thirty classrooms would be visited in ten different schools ruled out video taping possibilities.

A search was thus made for an appropriate observation schedule. Observation schedules appear to have been used from almost a century ago (McIntyre, 1980 p.4). It is however only within the last two decades that systematic observation has become a commonly used procedure. One of the main purposes was that it provides a description of selected features of activities and interactions in the educational system and the classroom in particular. 'The Teacher's Day' (Hilsom & Cane, 1971) STOS (Eggleston et al (1975) and ORACLE (Galton, Simon and Croll, 1986) which was reported in 'Inside the Primary Classroom' are some examples where systematic observation was used to provide descriptive accounts on a large scale across a sample of classrooms with the aim of providing an insight about teachers and classrooms.

Classroom observation has also been used to monitor teaching approaches and monitoring individuals - such as recording aspects of a child's behaviour. Systematic observation has also come to be associated with attempts to improve education, both in-service and in the initial training of teachers. In the latter case systematic observation has become a useful technique which can be used to "give students feedback on their own teaching either in 'real' classrooms during teaching practice or in specially designed teaching situations such as those employed in microteaching." (Croll, 1986 p. 14).

In looking for an appropriate observation instrument for this study one inevitably was submerged in the large number of instruments that have sprouted over the years. Flanders (FIAC) is almost certainly the best known of all systematic observation systems, and as Croll (1986, p. 37) observes, "it is sometimes, wrongly, regarded as epitomising systematic observation". Devised by Ned Flanders in America and made available in the early sixties when large numbers of people were turning to systematic observation as an approach to the study of teaching effectiveness, it has now seen many modified versions used in many countries. Critics of FIAC however, find it has limited applicability in that it was originally designed for relatively static classrooms when teachers stood in front of pupils who were arranged before them in rows while working on the same subject matter (Silberman, 1970; Hamilton and Delamont, 1974). FIAC classifies teacher-pupil interactions into ten categories, of which seven refer to aspects of teacher talk and two of aspects of pupil talk. The remaining category is 'silence or confusion'. It adopted an almost quasi-continuous coding system. Perhaps the best known result coming from FIAC studies is the two-thirds rule - that is, two-thirds of time pupils spend in the classroom involves talk and two- thirds of that talking is done by the teacher.

Since FIAC three major anthologies of observation systems have been produced. Two are 'Mirrors for Behaviour' by Simon and Boyer (1970) followed by 'Mirrors for Behaviour III' by the same authors (1974). Both these reflect, in the main, American observation systems, while a third more recent British anthology called 'British Mirrors' (Galton,

1978) provides a collection of British observation systems. The majority of the systems in the American anthologies tend to reflect derivatives of FIAC, while this has not been the case in British Mirrors. The systems in 'British Mirrors' tend to have been used for research at the primary stage of schooling where informal approaches are more likely to be found (Galton, 1983, p. 3646).

In British Mirrors there were three systems in particular out of a collection of forty one which dealt with science as the subject of focus. These were by Alexander (1974) McIntyre and Brown (no publication date) and Eggleston et al (STOS, 1975). Alexander provided an instrument to observe the degree of pupil involvement in science lessons. It had its applications for classroom practice and for relating curricular objectives to process, as well as showed potential for use in training of students, teachers and lecturers and others in in- service work. However, it had little to offer in terms of observing the process skills.

The instrument by McIntyre and Brown attempted to operationalise a number of theoretical questions relating to the implementation of guided discovering teaching, teaching mixed ability classes, integration of classes and teaching towards specified objectives. It was attractive to the extent that it covered the following.

1. Observation of Teacher Activity

2. Observation of Teacher-Pupil Interaction

3. Observation of Pupil Activities which included,

   a. Experimenting (eg. observing, measuring, manipulating, apparatus, discussing within groups.

   b. Reading/writing (worksheet, textbook)

   c. Readying (collecting, cleaning up equipment, collecting)

   d. Interacting with Teacher.

The McIntyre and Brown schedule provided application for description of classroom practice and relating content and curricular objectives to outcomes. However, its categories did not sufficiently provide for the kind of detailed breakdown for observing the process skills that this study proposed to do. It was a schedule designed for and better suited for a secondary classroom setting. Another more important reason for not considering it for this study was that it required audio visual methods for recording data in addition to the presence of an observer.

The schedule by Eggleston et al (STOS) was designed to classify and record certain kinds of events as they occur in science lessons. In all it had twenty three classified behaviours in a "dichotomy into those events initiated by the teacher entitled 'teacher talk' and (2) those events initiated and/or maintained by pupils, entitled 'talk and activity initiated and/or maintained by by pupils" (Galton et al, 1975. p. 5).

The main aspect of STOS is that it was designed to record intellectual transactions occurring in science lessons, particularly those transactions which facilitated a differentiation between contrasted teaching styles. It was, too, an instrument that was designed for use in a secondary class setting.

There have been a number of criticisms made against the use of systematic observation. More notable of these has been the list of criticisms raised by Hamilton and Delamont. In their original article 'Classroom research: A Cautionary tale?' published in 1974, and in their sequel 'Revisiting classroom Research - A continuing cautionary Tale"' 1986 . Delamont and Hamilton set out the following general points as criticism of systematic observation.

1. The data from coding schemes using pre-specified categories such as in systematic observation only tell about 'average' or 'typical' classrooms, teachers and pupils.

2. Systematic observation schemes typically ignore the temporal and spatial context in which data are collected - thus one does not have a record of about the physical setting.

3. Pre-specified coding systems are usually concerned with overt observable behaviour and tend not to consider the different intentions that may lie behind such behaviour.

4. Pre-specified coding systems are expressly concerned with what can be categorised or measured, and then may distort, obscure or ignore qualitative features through crude measurement techniques or by using categories with ill defined boundaries.

5. These systems tend to focus on small bits of action or behaviour rather than global concepts. The potential of these systems to go beyond the categories is limited, and lacks a potential to generate fresh insights.

6. The categories are pre-specified and hence such systems may assume the truth of what they claim to be explaining.

7. The placing of arbitrary boundaries on continuous phenomena may create an initial bias from which it is extremely difficult to escape. The issues related to the use of systematic observation will be taken up at a later stage of this Chapter after the system used in this study is introduced.

SELECTION OF AN OBSERVATION SYSTEM FOR THIS STUDY

It may have been possible to take the more salient aspects of the McIntyre/Brown schedule and STOS thus developing a new schedule for this study. However, there was also available a schedule that was near completion in mid-1986 developed under a joint research project by the Department of Education at Liverpool University and the School of Education, Leicester University. My experiences with the development of the schedule however go back to 1985.

From October, 1985 to March, 1986, a DES Regional In-Service course was conducted by staff of the Education Department directed by Professor Wynne Harlen at Liverpool University. It was billed as the 'Development of Scientific Process Skills and Basic Concept through Science Activities in the Primary School.' As part of the course, participating teachers were involved in evaluating the trial work in selected schools on Merseyside. This evaluation activity had important value for course participants who also took upon the role as observers of each other's science lessons in their various schools. Such experiences were intended to help them know what to look for and listen for as evidence of children using the process skills and as evidence of teachers helping children to think things out for themselves. I was fortunate to be a team member involved in this exercise. The early instruments used were a fore-runner to the eventual classroom observation schedule to be called SPOC (Science Process Observation Categories). The initial schedule was fairly rough and it was intended that observers could use them without special training. It comprised of five separate forms intended for use between three observers working simultaneously in one classroom observation session. They were:

1. Form for observing teacher activity during group work.

2. Form for observing teacher activity during whole class observation.

3. Form for observing one group at work.

4. Form for observing children during whole class discussion.

5. Form for observing the whole class.

Forms (1) and (2) were to be handled by one observer, (3) and (4) by the second observer and (5) by the third observer. Form (3) in particular dealt with the observation of the process skills. It meant that the third observer had to move as close as possible to the groups to be able to see and hear all the children did and said. In the use of the forms, the observers had to tick off the categories as they occurred in each two minute interval. The observers also kept a record of particular events noticed as interesting extensions to the activities that children tried out.

These early trials certainly served their purpose of familiarising both teachers and myself with the process skills and observation of the skills. However, it also showed that the existing schedule in five parts was cumbersome and inconvenient to use. It needed modification, especially in the direction of a schedule that could be used by one observer.

A simplified version was attempted which incorporated the main categories of the five forms into two forms. These were the observation form to observe the teacher and another to observe the pupil. The categories included the observation of both dialogue and non— dialogue activities. One of the draw backs of this stage of the schedule was that the observer had to tick off categories which had the inconvenience of being on two pages of the schedule.

An improved version of this schedule was a one — page observation schedule which incorporated both the above schedules. This version, referred to as SPOC, was later improved upon by the team of researchers based at both Liverpool University and Leicester University and working under the joint Primary Science Teaching Action Research Project (Primary STAR Project). The version used in this study is based on Draft Four (Appendix 1) that was available in June, 1986, at the time when the data collecting procedures in this study had to be finalised. A later version of SPOC with minor changes is now used in the STAR Project.

OPERATIONAL DEFINITIONS IN SPOC

The SPOC (Draft Four) provided in Appendix 1 of this thesis is a schedule made of ten broad categories. They are:

1. Target (identifies pupil observed)

2. Audience Interaction (of target)

3. Teacher Interaction (with pupils or monitoring)

4. Curricular Area

5. Categories referring to pupil's involvement in dialogue in using the process skills.

6. Other Pupil-Talk Categories

7. Non-Talk pupil activities

8. Teacher-Talk Categories

9. Categories when teacher is not interacting with Class.

10. Non-Talk teacher activities.

<u>Pilot testing of SPOC in Singapore</u>

Before presenting the operational definitions used in SPOC it is relevant to describe the additional pilot testing of SPOC that took place in Singapore Schools.

As SPOC was developed for use in U.K. Schools, it was, on my return to Singapore in July 1986, tested on a pilot basis in a Singapore School. The main objective here was to find out if the categories as they stood would cover sufficiently the classroom situation prevailing in a primary science lesson in Singapore, and to make the necessary alterations to SPOC for local use. It was found that on the whole, the categories referring to the process skills worked well, but as the manner in which lessons are presented differed in some aspects, some additions were necessary. These essentially were to allow the observer, at a later stage, to understand the flow of the lesson, and not so much for purposes of being included in the analysis of the data. Following is a list of the additions made. The category numbers refer to the SPOC schedule presented in Appendix 2.

Category 5.7 'Reporting' This appeared to be quite a common feature for teachers to ask pupils to report to the class their findings - while at the same time allowing the teacher to collate the information on the chalkboard.

Category 7.13 'Organising for group work' Unlike UK classrooms where pupils sit in groups, Singapore primary pupil desks are arranged in rows. When group work is initiated in the classroom (as opposed to work in the science room where work tables are arranged in groups) the teacher spends some time rearranging desks to facilitate group work.

Category 7.15 'Watching a film/video'. Again provision had to be made for this, as teachers do introduce such AVA as part of the lesson, and in some situations organise worksheets focused on the film.

Category 7.16 An open category was provided for any category of activity that might occur that was not already listed.

Category 8.5 'Questioning' This was included as a separate category under 'teacher talk' as it referred to a variety of questions, especially for recall and recapitulation that Singapore teachers tend to practise.

Category 10.5 'Collecting pupils' work' As Singapore primary science pupils have workbooks that are marked by the teacher, this category was included as it formed a stage in the overall lesson.

In addition to the above categories, for research records purposes, the schedule made provision for additional data to be recorded, together with a Remarks Column where relevant details of the lesson (eg. sample of teacher question/pupil question or answer, teaching strategy, classroom atmosphere etc) could be recorded. The additional data were:

School code	Lesson/Topic
Teacher code	Time
Class size	Date

In all other aspects, the schedule and operational definitions are similar to that of SPOC, and produced as Draft Four of the STAR Project.

Scoring in SPOC

Whenever an observer considers that a particular behaviour which is specified in the schedule has occurred, she places a tick in the particular category. The whole lesson is divided into two minute intervals or time units. Having referred to a particular category within a two- minute period, no further reference to it is made until the next time unit commences. Several categories may be marked in this way in the time interval. No category can therefore be ticked more than once during a time unit. At the end of the lesson the observer adds up the number of ticks which have occurred for each category, and these totals are recorded. Thus the totals give a minimum frequency of incidence across the lesson. Each behaviour is recorded once only during any time unit, no matter how frequently it actually occurs in this time or for how long. When however, a behaviour extends across the next time unit it is recorded in both time units.

Target Pupil

In using SPOC in Singapore schools, the targets were pupils selected at random. Each target pupil was observed for two time units (ie. four minutes). No attempt was made to observe the same set of pupils on each visit. Instead, as many different pupils were recorded by random spanning of the classroom over the lessons observed. The same pupils were not observed each time as no developmental studies of these pupils over a period of time was intended. Eventually, the overall scores to be analysed would reflect that of a class as a unit rather than that of individual pupil scores.

ISSUES RELATED TO THE USE OF SYSTEMATIC CLASSROOM OBSERVATION

Having introduced the SPOC schedule it is now useful to consider the criticism made by Delamont and Hamilton and others on the use of systematic observation and the methods of data collection.

In considering the points made by Delamont and Hamilton my response is that firstly, this study only intends to present the 'typical' classroom. One can envisage using systematic observation and also providing information about the physical setting, as a side recording. Further, while it may be true that the use of systematic behaviour by itself may not consider the different intentions behind the overt behaviour that is observed, in this research, together with systematic observation are the teacher interviews. Through these interviews it is possible to establish some of the intentions behind the observed behaviours. Points (3) to (7) raised by Delamont and Hamilton are I believe, well replied to by McIntyre (1980) when he says what happens in a classroom no matter how many children there are, is always complex. He adds,

> "... the actions of each of whom are guided by their own distinctive intentions, perceptions and concerns. Each individual engages in different activities and relates in distinctive ways to others in the room. Furthermore, since it is generally in the interests of at least some of those involved to attempt to influence the activities of others and since there are always wide differences among participants in the power they hold, efforts are inevitably made by participants to hide their definitions of the situation and the nature of their ongoing activities from one another. Additional complexity is created by one of the defining characteristics, from the perspective of teachers..." (p. 3)

If the nature of classroom life is inherently complex, can an observer hope to provide an objective description of the totality of what is happening in any classroom? McIntyre responds by saying that "only by recognising that he must ignore much that is happening and by focusing on carefully selected and predefined facets of classroom activity can the observer hope to avoid a subjectivity, of which he cannot be aware and to provide descriptive evidence in which he and others can place some confidence." (1980, p. 3).

On the choice of categories, certainly they are subjective and of necessity reflect the values of the developer of the schedule. But as Galton (1985, p. 3646) points out "the technique is objective in the sense that the criteria used to describe classroom life are clearly defined and that when the system is used correctly it is unaffected by the personal biases of individual observers."

Hence the categories in the instrument used in the present study reflect the interest of the researcher in the use of process skills in the classroom, and to that extent may reflect the bias selection of what is monitored. However, as Galton points out, the definitions provided mostly require low inference and should be unaffected by individual observer bias.

Another major criticism that has been levelled against systematic observation has been in the specific area of scoring. In particular, it has been directed at the system of one-zero scoring which has been used in STOS and which has been the system intended for use in this study.

Altman (1974 pp. 253 - 254) points out that;

> "It is too easy for both the author and reader to forget that a one-zero is not the frequency of behaviour but is the frequency of intervals that included any amount of time spent in that behaviour... Nor is the percentage of intervals the same as the percentage of time spent in an activity."

The point was certainly recognised in this study and will be dealt with in the next chapter when the analyses of data are discussed. Another issue raised on the method of one-zero sampling has been by

Dunkerton and Guy (1981). They raised their doubts about the reliability of STOS- based data saying that its methodology employs a time- sampling technique in which, if a behaviour occurs in a three-minutes interval, it is recorded only once, no matter how many times it actually occurs. They also query the use of a three-minute interval. They argue that the "degree of underestimation becomes more severe as the time interval for the observation lengthens relative to the duration of behaviour (bout length)." (pp. 315)

In replying Eggleston and Galton point out ;

> " While we do not doubt that the relationships between 'bout length' and 'time-sampling unit' determines the reliability of an observation instrument using 'one-zero' systems when estimates of total frequencies are required, there is nothing to be gained by reducing the time-sampling unit to a point where the observer has insufficient time to make an accurate judgement." (1981, p. 317)

They further go on to explain that 'STOS' does not propose to give an absolute frequency of occurrence of behaviour, but "what STOS gives is the minimum frequency ..." (p. 318).

This defence of the use of the one-zero sampling method and time interval of STOS certainly applies to the acceptance of a similar methodology in using SPOC in this study. However for SPOC, from the earlier trials in schools, it was found that a two-minute time interval was sufficient for applying the categories where most were of low inference types, as well as allowing for the smaller number of higher inference categories such as 'hypothesising' to be categorised.

An issue which will normally be of concern to researchers using a systematic observation schedule is one of training observers and the eventual inter-observer reliability. In the case of this study this issue did not arise as the researcher was the only observer involved. In the planning of the sample to be used in this study and which will be presented at the end of this chapter, it had to be recognised that in the Singapore context it would not have been feasible, particularly in the short three month period that was available for data collection to enlist the help of persons who could be trained as observers. Such personnel if enlisted would have needed to have some background knowledge of both the specific areas for observation which in this study were the process skills, and the flexibility of time to be involved in such an exercise. For practising teachers such flexibility in time would have been difficult particularly as the data collection period was in the second semester and all observations had to be completed between July and early October 1986 to allow for end of semester examinations.

A final issue that needs mention is one that deals with the presence of an observer in the classroom. While some concern is inevitable as to the way in which an observer can affect the normal interaction in the classroom it can be reported that in the sample schools used, happily, good relationships were maintained throughout. With painstaking explanations provided at the beginning, often or a one-to-one basis with the teachers of the sample classrooms, teachers were able to understand the objective of the study and any threat situation they may have anticipated was soon stemmed out. Further they were told they should carry on as normal with no additional burdens imposed on their teaching as a result of their being involved in the study. Their response has helped a long way to make the data collection proceed to completion without any change.

ANALYSING THE PROCESS SKILLS PROVISION IN PSP

In considering a scheme for analysing the provision for process skills experiences in PSP materials, one was sought which allowed the researcher to quantify in some way, albeit crude, the individual skills so that a comparison could be made with what was observed through systematic classroom observation. It was intended that through such an exercise, a relationship could be established between what was intended and what was observed (ie implemented). For this purpose only those lessons observed during classroom sessions were analysed in the corresponding text of the teacher's guide and pupils' workbooks. This was possible in the Singapore context as, in a centralised system, the lessons taught are easily linked to a given lesson described in the Teacher's Guide. It would not, however, be possible in British schools where the approach is less formal and lessons cannot easily be linked to specified subjects in curriculum materials.

Eraut et al (1975) in their list of roles and goals for curriculum analysis include curriculum criticism as one of them. They use the term 'curriculum criticism' to describe a curriculum analysis which is not specifically decision-oriented, and see the main purpose of such criticism as the disclosure of meaning and the extension of knowledge about the curriculum. "The critic" they comment, "unlike the evaluator, is free to choose his own standards and values and to focus on particular issues rather than attempt to cover a wide range." (p. 23) In this sense the analysis of PSP materials for process skills provision will serve a research function by providing extended knowledge on the implemented status of PSP.

In looking for an appropriate scheme to make such an analysis, the available published schemes were examined. The four that were more closely looked at were the Social Sciences Education Consortium (SSEC) scheme (1968), the Berkeley scheme (1970), the Curriculum Materials Analysis System for Science (CMAS) scheme (1973) and the Sussex scheme (1974).

The SSEC scheme (published by Stevens and Morrissett, 1968) used by the Social Sciences Education Consortium in the US was one of the first and one of the more comprehensive of analysis schemes. Three versions of it are available for different purposes - for use in methods courses in teacher training, for in-service training and for curriculum selection. It was not developed however with the natural sciences in mind, though for an analysis in the area of values and other affective domain it has much relevance should a science curriculum with such a content be analysed.

The Berkeley Scheme (edited by Hutchings, 1970) was designed for use with elementary science curriculum. It covers questions on the main goals and objectives, content, classroom strategy and implementation requirements. However, like SSEC it provides a purely qualitative analysis and the only figures demanded are these relating to cost or to time. Hence use of either the SSEC or the Berkeley scheme was not considered appropriate for this study.

The CMAS scheme developed by Haussler and Pittman at the IPN in Germany was constructed specially so that curricula in the natural sciences could be analysed. One of the interesting features provided was the quick access to data through the use of a punch-card system for data storage. Bloch (1977) comments that "CMAS is structured so that one does indeed learn a great deal about particular randomly-chosen curriculum." (p. 46) However Eraut et al (1975) point out that the authors of CMAS did not "attempt to capitalise on their lesson unit analyses by combining the data on individual units which might show the balance of the material as a whole." (p. 36). While CMAS had its merits, it did not provide the necessary method for the kind of quantification that this study required.

The Sussex scheme arose when the authors Eraut, Goad and Smith were involved in the training of teachers and others for curriculum work at the local level. One goal of the scheme was to improve the implementation of new curricula and to guide the selection of curricula materials. The scheme is divided into five parts of which two deal with the description and analyses of materials. One of the difficulties of using the Sussex scheme was that because it was intentionally developed to be applicable to the analysis of any subject area curriculum for any age level it did not provide the specific type of analysis this study required.

An example, however is provided by Eraut et al (1978, p. 81) when they refer to the kit "Decisions". The author provides a quantitative way of making a profile of Student Task Descriptors based on measurement shown in relative terms - that is, the amount of time that might be assumed to be involved, as a proportion of the total time for tasks.

MATERIALS ANALYSIS FOR PROCESS SKILLS IN PSP

While an analysis through an estimate of the amount of time that might be involved has its merit, it was not the method that was used in this study. This was because the manner in which teachers in Singapore would treat the lessons which involved a high degree of practical work could vary and hence a subsequent comparison with the observed valves for each class would not have been a fair approach. Instead, a method was adopted whereby the relevant pages of the Teachers Guide and the Pupils' workbook corresponding to each lesson observed was studied. When a sentence appeared in either the text of the Teachers' Guide which was also repeated in the Pupil's Workbook, care was taken not to double score the skill. In this way a frequency count was made of the intended skills, acknowledging however that the count is an arbitrary one.

Categories:

Dialogue involving	Observation
	Interpretation
	Hypothesis
	General Planning
	Specific Planning
	Measurement
	Recording
	Raising Questions
	Recall
	Recap
Non Dialogue involving	Making observations
	using Measuring Equipment
	using other Equipment
	Recording

As these categories correspond to those monitored in the SPOC schedule used for classroom observation, through correlation analysis between the data from the classroom observation and the data from the materials analysis, some investigation of the correspondence between the intended and implemented PSP should be possible. To show how the analysis of the PSP materials was made the following example is provided. The analysis is made on the text from the Primary Five

Teacher's Guide page 123 and the corresponding Pupil's Workbook page 57.

SAMPLE ANALYSIS FOR PROCESS SKILLS IN PSP MATERIALS

Teacher's guide text	Skill Category	Frequency
Get the children to plan a test to decide whether a thing gives out light or reflects it	General planning	1
Get the children to hold the screen (white card-board) so that it faces an open window.	Using Equipment	1
Hold the hard lens about 20cm in front of the screen	Using Equipment	1
	Using Measuring Equipment	1
Move the hand lens back and forth until they can see a sharp image on the screen.	Making observation	1

Get the children to describe the image	Discussing Observation	1
then get them to compare	Discussing observation	1
the images of things that are in bright and in dim places.	Interpretation	1
Get the children construct a pin hole camera	Using Equipment	1
Use a small nail and hammer to punch a hole	Using Equipment	1
Direct the camera at a bright distant object	Using Equipment	1
outside the classroom	Making observation	1
Move the paper cylinder slowly back and forth	Using Equipment	1
until a sharp image is seen on the tracing paper	Making observation	1
Get them to describe the image	Discussing Observation	1

Pupil's Work Book

A hand lens made an image on a white card. Are these statements true or false?	Discussing	
	Observation	5
The image was bigger than the real thing		
The colour of the image was the same as that of the real thing	Recording	5
The image was upside down.		
Light was not needed to make the image.		
The image looked like the real thing.		

Pupil's Workbook	Skill Category	Frequency
Answer these questions about the pin hole camera that you made		
How did light get into the camera	Discussing	1
	Interpretation	
	Recording	1
Was the image in the	Discussing	1

	observation	
camera upside down	Recording	1
What else did you notice	Discussing	2
about the image in the	Interpretation	
camera		

(since 2 answers are given in Teacher's Guide)

	Recording	1

Total count for the lesson:

General Planning	1
Using Equipment	6
Measuring (dialogue/non dialogue)	1
Observation (dialogue/non dialogue)	12
Interpretation	4
Recording	8

In making the analysis and totalling the frequencies, certain assumptions have to be made.

1. It was assumed that when children make an observation, they would also discuss the observation amongst themselves or with the teacher. Hence the frequency count for making observations was added to that for dialogue involving observations, and thus the figure for both these categories is the same. A similar assumption was made for making measurement and dialogue involving measurement.

2. The relative frequencies represented in this analysis were not made on estimated time, thus it is not intended here that the frequencies represent a proportionate distribution of the time a pupil would spend on each skill. Also, two categories, i.e. 'specific planning' and 'asking questions' could not be discerned and scored in the analysis of the text. In the absence of such a possibility a zero score was given.

TEACHERS INTERVIEW

Cannel and Kahn (1968) define the research interview as

> "a two person conversation initiated by the interviewer for the specific purpose of obtaining research-relevant information, and focused by him on content specified by research objectives of systematic description, prediction, or explanation."

Tuckman (1972) goes a little further when he says "... by providing access to what is inside a person's head', (it) makes it possible to measure what a person likes or dislikes (values and preferences) and what a person thinks (attitudes and beliefs)'." (quoted in Cohen and Manion, 1985. p. 292). It is in this spirit that the teacher interviews were conducted in this study. The main objectives of the interview were to ascertain:

A

1. The teacher's understanding of the objectives, philosophy or rationale of PSP.

2. The teacher's understanding of the process skills.

3. The teacher's opinion of the influence of content versus process skills in PSP.

B. In terms of the Personal and Social constraints on the teacher the teacher's view of the relative effect of

1. Pre-service training

2. In-service training

3. Science co-ordinator's support

4. 11+ examination (PSLE)

5. Pupil's background (language issue)

6. Parent's expectations

7. Teacher's perception of pupil ability to use the process skills.

8. Teacher's interest in teaching science.

C. In terms of the Physical Organisational constraints of the classroom, the effect of

1. Class size

2. Classroom space/furnishing

3. Time-tabling

4. Science Equipment and Resources.

Teacher Understanding of PSP Objectives

The teacher's understanding of the objectives of PSP is an important first step in the implementation of the curriculum. Secondly, what the teacher understands of the process skills will certainly affect her provision for these skills. However, the way to elicit this information from the teacher posed a problem. One could ask a direct question, but it cannot be assumed that the teacher is referring to the skill in the same way as the questioner. Hence a teacher who comments that her pupils cannot make a hypothesis may actually not have the same notion of the skill as another teacher who comments that her pupils can. To avoid ambiguity, it was thought that if teachers could make their comments in reference to pupils' actual involvement with the skill that both the interviewer and interviewee are viewing, the level of mis-communication as it were or ambiguity could be reduced. For this purpose a videotape was made that showed ten-year old pupils involved in science lessons.

The preparation of the video tape involved the researcher teaching selected science topics in a school in Liverpool. A mixed ability class was selected for this purpose. The process skills at the focus of the study can be broadly categorised under the following headings:

a) Observation
b) Interpretation of Information
c) Raising Questions
d) Hypothesising
e) Devising investigations
   (including planning)
f) Communication

Each of these would have a number of sub-skills. The children worked in groups of five and each group was provided with an easel board and paper for making their recordings. Because of the larger size it gave the members of the group and the rest of the class the opportunity to read easily what was recorded. The groups were left to appoint a 'spokesperson' and a 'recorder' but as the lessons progressed it was noted that these jobs were shared by group members. One important feature of the lessons was that the groups presented their experimental designs and later their findings to the class and those from other groups were given the opportunity to question them or add their comments. In this way the opportunity was also provided for children to be able to not only share their ideas but also defend them.

The three lessons that were videotaped were on

a) Floating Blocks

b) Snails

c) Clockwork (Spring) Toys.

The lesson on Floating Blocks was fairly structured. The questions were posed to the children and the experimental procedure provided. It would reflect a teaching approach familiar to Singapore teachers.

These lessons on floating blocks gave opportunity for teachers being interviewed to see children involved in;

1. Observation (including seeing similarities and differences)

2. Using equipment (including measuring equipment)

3. Inferring (including predicting and pattern finding)

4. Recording (because the method was deliberately not instructed, children chose to present their findings in different ways - e.g in sentences, tables).

5. Presenting their findings to the whole class.

The lesson on 'Snails' was different in structure to the previous one. Here the main emphasis was on children raising their own questions. From their initial list of questions, they were instructed to select one that they could then plan an experiment for. Their list of questions gave an opportunity for the teachers interviewed to note that not all questions can be tested by experiment. Further the video tape showed children involved in planning, a feature which was not part of the first topic. Their findings showed that unlike the first topic which had 'right' answers and a level of accuracy that could be discussed, this topic on snails did not always provide a 'right' or 'wrong' answer to the children's questions. It is an important part of science investigations for teachers to understand this. This video tape thus on the topic of snails provided evidence of children.

1. Raising questions for involvement.

2. Making plans, both general and specific.

3. Discussing the control of variables by considering 'a fair test' in their experiments

4. Hypothesising.

5. Presenting their plans and findings.

6. Defending their plans and findings.

The final topic was on 'Clockwork Toys'. This was selected particularly as it is a topic in the PSP - Primary Five Materials.

However, in presenting it to the children the researcher made some modification to the teaching suggestions provided in PSP. In thePSP Teacher's Guide the following questions were provided:

"Find out how far the toy will go when the key is turned different numbers of times. How do you plan a fair test? What measurement do you make?" (Teacher's guide P5 p. 98) Instead of posing the questions, the video tape provided evidence of children raising questions about their toys which also included the above. The children had raised questions similar to those suggested by the developers. This change to the teaching suggestions was made to obtain the reaction of teachers during the interview to to the possible adaptation of curriculum materials.

The interviews with teachers took place after all classroom observations were completed. This was done so as not to influence the teachers in any way in terms of their teaching methods. Further, the interviews were carried out on a one to one basis as it was preferred that the interviewee not be influenced in her response by the presence or opinion of another interviewee.

Teachers were briefed on the nature of the experiments, while at the same time the interviewer was mindful of not divulging information that would influence their responses. They were also told not to view the tapes as a model of preferred teaching/learning. Permission was obtained from all teachers to have the interview audio taped, and they were assured of their confidentiality. Because of the possible difficulty Singapore teachers might have with a foreign accent of the children, a transcript was provided for teachers, and a complete set of the children's work mode available for them to examine. They were also invited to stop the video at any time for examination of the children's work in connection with what they had seen on the video. Prompting by the interviewer was kept to a minimum. Teachers were invited to make their responses in any way they wished to the following:

1. Identify as you watch the video the skills you think the children are involved in.

2. Comment on any aspect of the way the children approached their work.

3. Comment on any aspect of the teaching approach adopted by the teacher.

It needs to be pointed out that this part of the interview was conducted as informally as possible. Apart from the above beginning questions, it did not have a structured format. This was deliberate, as an important part of this interview was to ascertain the teacher's understanding of the process skills through her correctly categorising the skills she observed the children in. Further, it was also intended that through her comments on teaching style and the way the children worked, a profile could be obtained of the kind of teaching she would favour.

When a teacher failed to identify a skill, the interviewer unobtrusively provided a reminder. If she still avoided comment, it was taken as a case of non-recognition of the skill.

The second part of the interview was more structured. It was structured around two main sections, Personal and Social Constraints on Teacher and the Physical and Organizational Constraints of the classroom. Through the second part of the teacher interview it was hoped that some of the constraints affecting the implementation of PSP and as expressed by the teacher could be established. The interviews were conducted in a way in which questions were not posed unless some of the issues presented in the model on implementation were not raised by the teacher. This was done as a counter-check to the constraints the researcher had posed in the model, and seen as a way of verifying the determinants of implementation in the model. When, however, a teacher did not raise any particular issue related to the model, the relevant question was posed to the teacher.

The following is a list of questions that covered the second section of the interview.

PART ONE.

Personal and Social Constraints on Teacher

1. Pre-service training - did the teacher have any exposure to PSP.

2. In-service training - has the teacher attended any course on PSP.

3. Does the teacher have any difficulty in conducting lessons involving any of the PSP experiments.

4. Would the teacher be happy to work without a Teacher's Guide.

5. Would the teacher be happy without pupils having work books.

6. Did the teacher feel at *liberty to omit exercises in the* workbooks.

7. What was the teacher's reaction to the set of Specific Instructional Objectives (SIOS) provided for her to work with.

8. Did the teacher have any view on the level of prescription of PSP materials, and did she view the materials in any way limiting free enquiry by pupils.

9. Science Co-ordinator's support - how did the teacher view the role of the science co-ordinator.

10. 11+ examination - Did the teacher see the demands of the examination affecting her teaching style. Did the teacher see a congruence between the materials in PSP and the PSLE examination questions in terms of process skills.

11. Did the pupils view the workbooks as a source for exam preparation.

12. Did the teacher consider the giving of notes essential.

13. Pupil background - did the pupil's home language affect the lesson.

14. Parental Expectation - Did the teacher feel any pressure from parents that might affect her teaching style.

15. Teacher interest in teaching Science - Did the teacher like to teach science. Did the teacher favour the idea of a specialist science teacher. Would the teacher like to specialise in science teaching.

16. Teacher Perception of Pupil Ability - on each of the skills seen in the video programme the teacher's perception of her pupils' ability was sought.

   a. Did the teacher see her pupils using the skill satisfactorily.

   b. Is sufficient opportunity provided in the PSP materials for the skill to be developed.

   c. Should the skill be encouraged in children at primary level.

d. Does the teacher see her pupils improve in the skill through better opportunity being provided.

The skills referred to were:

Observation

Using measuring equipment and other equipment

Interpretation < predicting / controlling variables

Raising questions

Planning of experiments

Explaining/hypothesising

Free format recording - this refers to children being given the opportunity to make their recordings without the prescription found in workbooks.

PART TWO

Physical and Organisational Constraints of Classroom.

Class size What was the teacher's present class size. What would her ideal class size be.

Classroom space Was the classroom suitable for PSP activities. Did the school have a science room. If so, how often could it be used. Would the teacher find the availability of a 'laboratory' attendant helpful.

Time Tabling Is the present time tabling in terms of the overall time allocation per week sufficient for PSP. Would the teacher like a change. Is the sequencing of the science periods (eg. single/double) satisfactory.

Equipment/Resources Was the teacher able to obtain all the necessary equipment for PSP experiments. Was the AVA material both from PSP and other sources suitable. Does the school have a science garden and pond that help the teaching of PSP.

Transcripts were made of the complete interviews. The statements were then carefully analysed and scored.

Teacher Questionnaire on Priorities

At the end of the interviews teachers were asked to complete the following questionnaire. Information from this questionnaire would help to ascertain the teacher's priorities in science teaching and be a useful source of understanding the outcomes of the other aspects of the interview. The questionnaire has been adapted from a version used in the IEA study (1984). The six statements provided in the IEA study have been retained with no change and are given in the table following.

List in order of priority the top 3 factors from the following statements that determine what and how you teach.

a. presently on a day to day basis

b. your ideal priority.

	Present Priority	Ideal Priority
1. What I think the students in my class will need when they leave school.		
2. The official curriculum or syllabus		
3. Prescribed text books		
4. What the students will need in the next grade/ course.		
5. Developing the ability of the student to think scientifically and to use the process skills.		
6. Helping the student to acquire a systematic knowledge of scientific concepts.		

Sampling Statistics

In Singapore, access for any research work carried out in schools has to be through permission granted by the Ministry of Education. Once this was obtained, in principle, individual schools had to be approached for their willingness to participate in the research. In this research, the following factors were considered in the selection of schools.

1. Geographical Distribution: Schools were selected to cover the main geographical districts on the island. In this way a fair representation of School types and pupil ability could be obtained.

2. A selection of both government and government —aided schools. In Singapore all schools can be considered state schools. However, some schools have had a traditional association with religious bodies and were at one time totally independent of state funding. Today this is no longer the case, though these schools have retained a tradition of these associations.

3. A selection of schools that included both single sex and co-educational.

No. of Schools in Sample

There are 231 primary schools in Singapore. In all ten schools were used in this research. This figure was selected only because it was the maximum number that could be handled within the limited time available.

Classes Observed

Although science is in the curriculum for children in Singapore Schools from their third year (P3) to their Sixth year (P6), this research only covered years P4 to P6. This was done to control one variable i.e. the total exposure time pupils have per week for science. Classes in Singapore Schools are categorised into Lower Primary (P1 to P3) and Upper Primary (P4 to P6). Lower Primary classes have one three-quarter hours/week of science (i.e. 7.4 per cent of curriculum time. Upper Primary Classes have two three-quarter hours/week of Science (i.e. 11.2 per cent of curriculum time).

The classes observed in each school were one from each level (i.e. P4, P5, P6). This study has not taken into consideration the extended stream which has classes for children who take two years longer in primary school as a result of streaming after P3.

Number of Periods Observed

In each class the guideline applied was five periods, each period being half an hour. Teachers were thus asked for either 5 single period or a combination of double and single periods amounting to 5 periods (two and a half hours).

Number of Teachers

In each school three teachers (one from each class level) were involved. The teachers were first consulted by their Principals and later met with me before they committed themselves to the project. The total number of teachers involved was thus thirty.
teachers involved was thus thirty.

SUMMARY

Number of Schools	10	
Stream	Normal	
Type of school	Girls Government	1
	Boys Government	1
	Co-ed Government	5
	Girls Govt-aided	2
	Boys Govt-aided	1
	Total	10
Classes within each school	P4N	1
	P5N	1
	P6N	1
	Total per school	3

Number of visits per class: 5 periods (2 1/2 hours)

Total number of teachers involved per school: 3

Total number of teachers involved overall (10x3): 30.

Visits to schools for classroom observation took place during July-October, 1986.

The next two chapters will provide the methods of analysis of the data and the ensuing discussion of the results.

CHAPTER SIX

RESULTS AND DISCUSSION, PART ONE

INTRODUCTION

This chapter looks at the analysis of data concerning the following research questions:

1. To what extent are the process skills used by the pupils of PSP?

2. What is the correspondence between the intended and the implemented PSP in terms of the use of the process skills?

3. What is the teacher's understanding of the intended PSP, in terms of its philosophy, objectives or rationale relating to process skills?

4. What influence does the national syllabus with its stipulated content coverage have on the teacher using PSP?

5. What is the teacher's understanding of the process skills?

Information for Questions 1 and 2 above are obtained from the classroom observation data collected by using the SPOC schedule as well as that obtained from the analysis of PSP materials. The information for Questions 3 - 5 was obtained from data collected through teacher interviews.

TO WHAT EXTENT ARE THE PROCESS SKILLS USED BY THE PUPILS OF PSP

Analysis Procedure for SPOC data

For each SPOC schedule completed for a class, the number of ticks for each category was totalled. This gave the total minimum frequency of incidence for each category in the lesson observed. Also counted was the number of possible occurrences - this was the total number of columns used during the lesson. Although during the visits to classrooms, the total contact time per class was kept the same, that is, two and a half hours, this did not automatically mean that for each class the total maximum number of possible occurrences was the same. This was because teachers needed time to settle in. However, it was not felt that this difference in maximum number of possible occurrences made a difference to the analysis as the final analysis was not time dependent but based on the minimum number of occurrences expressed as a percentage of the maximum possible. This percentage was obtained by collating for each class over all the lessons observed the total number of observed number of occurrences for each category and computing that as a percentage of the maximum possible. In this way, for each class, the percentage of minimum frequency of incidence was obtained for the following fourteen process skill categories listed in the SPOC schedule:

(i) Discussing Observations

(ii) Discussing Interpretations

(iii) Discussing Hypothesis

(iv) Dialogue involving General Planning

(v) Discussing Specific Plans/Procedures

(vi) Discussing Measurement

(vii) Discussing Recording

(viii) Dialogue involving Raising Questions

(ix) Dialogue involving Recall

(x) Dialogue involving Recap Work Done

(xi) Making Observations

(xii) Using Measuring Equipment

(xiii) Using Materials and other Equipment

(xiv) Recording

The above list is a more detailed break down of the broad categories of the process skills listed in Chapter Four. These were Observation, Interpretation, Raising Questions, Hypothesising, Devising Investigations, Handling Equipment and Measuring Instruments and Communication. While 'Communication' is not listed as a category on its own in the SPOC schedule, its verbal and written aspects are monitored in the form of process skills in dialogue situations, as well as in the category of 'recording', both in dialogue and non-dialogue situations.

From the percentages calculated for each category of Process skills in each class, it was possible to look at the extent to which pupils were experiencing the skills in two ways, that is the mean of the percentage of minimum frequency of incidence across

a) all thirty classes (N = 30)

b) at each age level (N = 10, P6 11+, P5 10+, P4 9+)

The data arising from the use of the process skills across all classes as well as that across the three levels will show the extent to which children of PSP are using the process skills. This is the implemented PSP. In the discussion of these results, the intended use of the process skills arising from an analysis of PSP materials was also examined. In Chapter Five, the method of analysis of the PSP materials for the process skills has been discussed. Each lesson taught in a given class was analysed to get the tally for each process skill category. The total for each skill in each lesson corresponding to the lesson observed was then collated over all the lessons for a given class. The total for each skill for each class was then treated as the 'intended' for that class. It must however be recognised that this is only an arbitrary measure and can only be used as a correlation in terms of rank orders. Thus the research question - To what extent the process skills are used by the pupils of PSP is looked at from both the implemented and intended perspective.

DISCUSSION ON THE EXTENT OF USE OF THE PROCESS SKILLS BY PUPILS OF PSP IN RELATION TO THE INTENDED CURRICULUM OF THE LESSON.

a) Across Thirty Classes :

Table 6.1 provides the observed or implemented values for the fourteen process skill categories. Table 6.2 provides a tally of Intended scores from analysis of PSP materials. The scores presented are made for each class and cover the lessons observed specific to that class. Figures 6.1 to 6.14 provide a graphical presentation for each skill across the thirty classes. To preserve the anonymity of the classes the graphs show across the x-axis a code for each classroom. However, the reader will be able to recognise the level of the class by looking at the final digit for each class code. A final digit showing 1 indicates a class at the P6 level, while a final digit of 2 at P5 level. A final digit of 3 indicates a P4 level class.

(i) Discussing observations and making observations:

Figures 6.1 and 6.2 show that in all thirty classes pupils were involved in making observations and discussing their observations. Table 6.1 shows that overall, the mean of the percentage of the minimum frequency of incidence (MPMFI) for making observations was

Table 6.1 Mean values of observed % minimum frequency of incidence for 14 Process Skill Categories for all classes and lessons (N = 30 classes)

Process Skill Categories	% Min. Freq. of Incidence (Mean)	S.D.	Min Value	Max Value
Discussing Observations	27.7	8.7	10	40
Making Observations	37.5	11.3	10	53
Discussing Interpretations	24.2	8.6	7	41
Discussing Hypotheses	4.9	5.2	0	19
Dialogue General Planning	0.8	1.9	0	8
Dialogue Specific Plans/Procedures	8.1	5.5	0	22
Discussing Measurement	6.7	9.2	0	38
Using Measuring Equipment	5.3	7.7	0	29
Discussing Recording	5.9	5.4	0	20
Recording	14.6	5.9	3	27
Dialogue Raising Questions	2.5	2.5	0	9
Dialogue Recall	12.1	7.8	0	29
Dialogue Recap Work Done	7.0	5.8	0	20
Using Materials and Other Equipment	25.2	14.1	5	65

Table 6.2 Tally of Intended scores of the Process Skill Categories (Arbitrary Units from Analysis of PSP Materials)

Intended Scores for Process Skill Categories

Class Code	Discussing Observations	Interpretations	Hypothesising	General Planning (Dialogue)	Specific Planning	Measuring (Dialogue)	Recording (Dialogue)	Raising Questions	Recall	Recap Work Done	Making Observations	Using Measuring Equipment	Using Other Equipment	Recording
011	12	37	0	0	0	12	17	0	3	1	12	12	6	17
021	8	21	1	0	0	15	19	0	3	1	28	15	11	17
031	15	53	0	0	0	3	14	0	0	0	15	3	15	14
041	14	27	0	0	0	8	26	0	0	0	14	8	26	26
051	19	56	0	2	0	14	21	0	0	0	19	14	17	21
061	41	26	11	0	0	3	45	0	0	0	41	3	36	45
071	36	25	1	0	0	23	24	0	0	0	36	23	10	24
081	21	18	0	3	0	16	19	0	0	0	21	0	16	19
091	18	23	4	4	0	0	20	0	0	0	27	8	16	26
101	27	45	0	0	8	16	26	0	0	0	27	8	16	26
012	27	24	1	3	0	8	21	0	0	1	27	8	22	21
022	14	20	1	0	0	0	20	0	1	0	14	0	10	20
032	20	42	3	0	0	10	14	0	9	0	20	10	0	14
042	14	23	4	0	0	0	13	0	1	0	14	0	10	13
052	26	14	1	0	0	0	12	0	0	0	26	0	34	12
062	16	16	0	0	0	0	23	0	0	0	16	0	16	23
072	11	4	2	5	0	0	5	0	0	0	11	0	10	5
082	16	14	0	1	0	0	25	0	0	0	16	0	13	25
092	33	25	1	0	0	7	32	0	0	0	33	7	42	32
102	19	13	0	1	0	0	13	0	0	0	19	0	17	13
013	46	22	0	0	0	3	32	0	1	0	46	3	40	32
023	60	22	12	0	0	0	55	0	0	1	60	0	49	55
033	28	18	9	0	0	0	23	0	0	0	28	0	10	23
043	28	13	2	0	0	0	28	0	0	0	28	0	11	28
053	25	8	1	0	0	9	35	0	9	0	25	9	16	35
063	34	14	0	0	0	0	33	0	0	0	34	0	35	33
073	36	15	0	0	0	21	29	0	0	0	36	21	21	29
083	40	21	2	0	0	22	49	0	0	0	40	22	28	49
093	45	17	0	0	0	0	34	0	0	0	45	0	45	34
103	26	12	1	1	0	0	18	0	0	0	26	0	13	18

Making observations

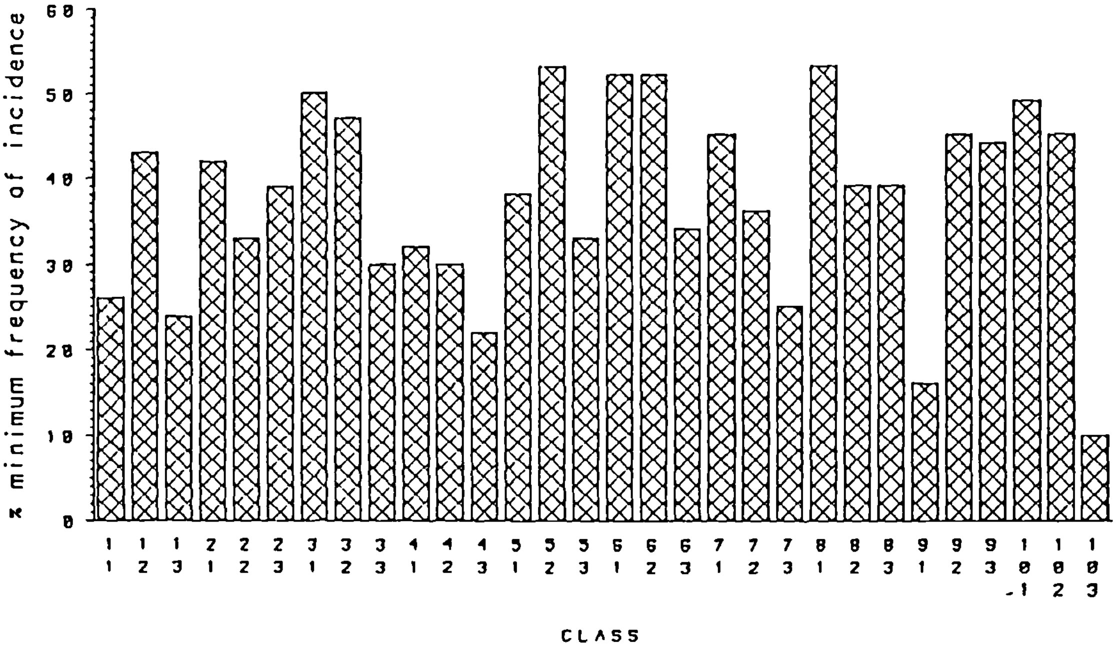


Figure 6.1

Discussing observations

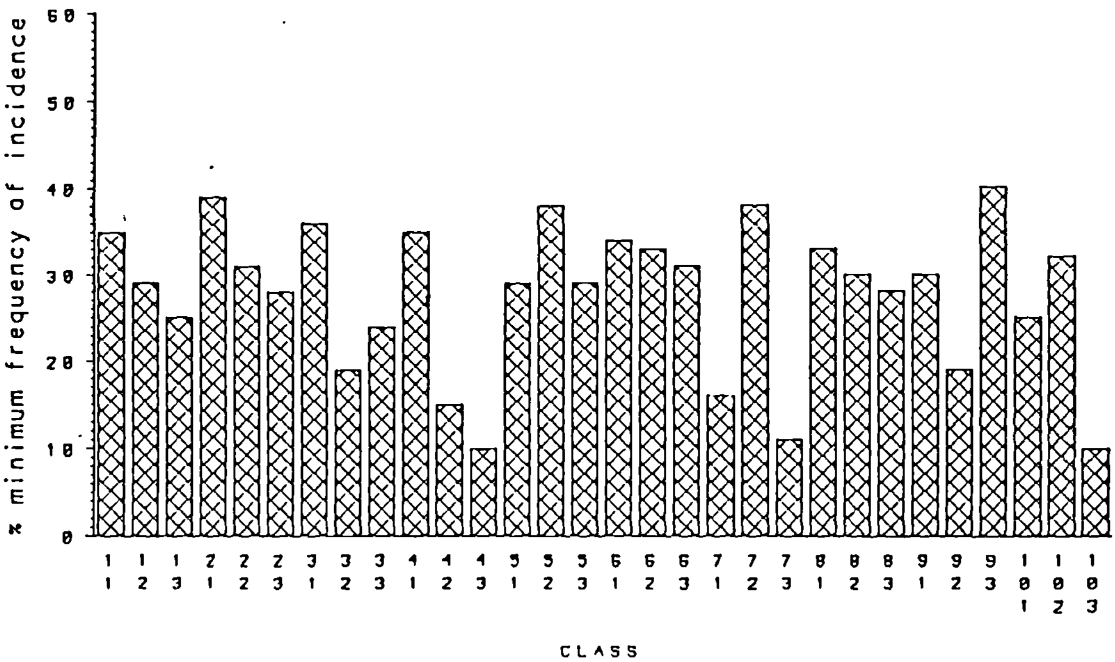


Figure 6.2

higher (37.5) than that of discussing observations (27.7). While it can be assumed that pupils would quietly make their observations and not necessarily discuss on each occasion all of their observations, one cannot also rule out the possible effect an observer standing close to children may have on their discussions, particularly in the case of shy children. Table 6.2 shows that the intended PSP materials for each class also provide for pupils to be involved in observations.

(ii) Discussing Interpretations:

Table 6.1 shows that the MPMFI for interpretations was 24.2. Figure 6.3 shows that pupils in all thirty classes were involved in making interpretations, which included examples of pupils making predictions and controlling variables in some instances. The use of the skill of interpretation was reflected in the intended PSP materials.

(iii) Discussing Hypotheses:

Figure 6.4 shows that six classes (code 13, 41, 42, 62, 81) were not observed to have children involved in this skill. Except for class 42, the intended PSP materials for the remaining five classes did not reflect the use of this skill. However, there were some classes where children were involved in this skill although the intended PSP materials did not reflect this. It appears that while most teachers involve their pupils in hypothesising where the intended materials call for it, there are occasions when teachers

Discussing interpretations

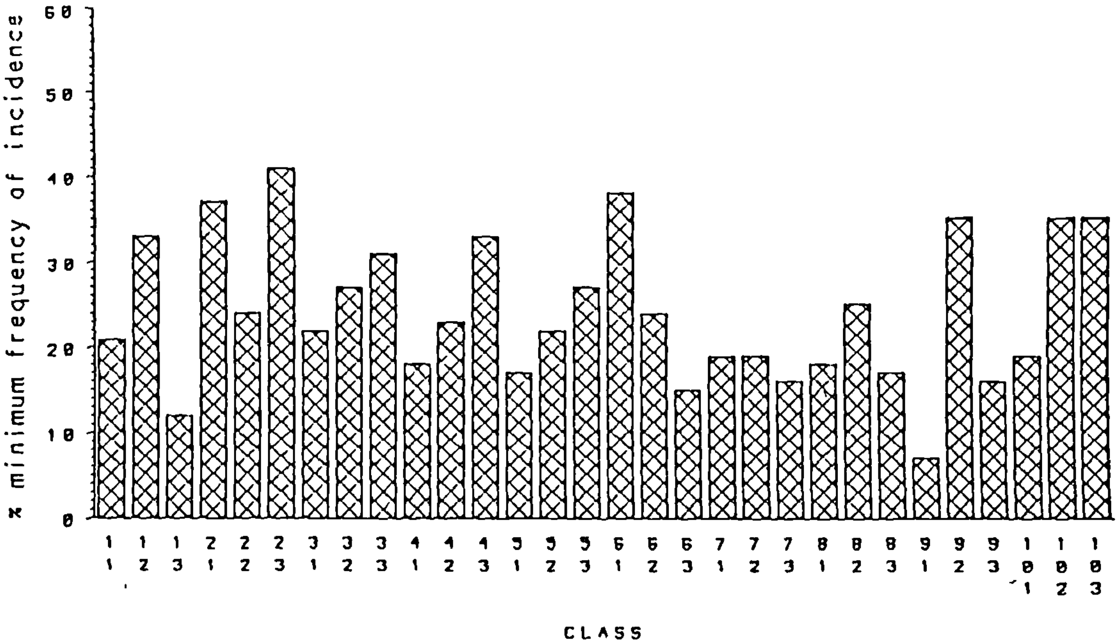


Figure 6.3

Discussing hypotheses

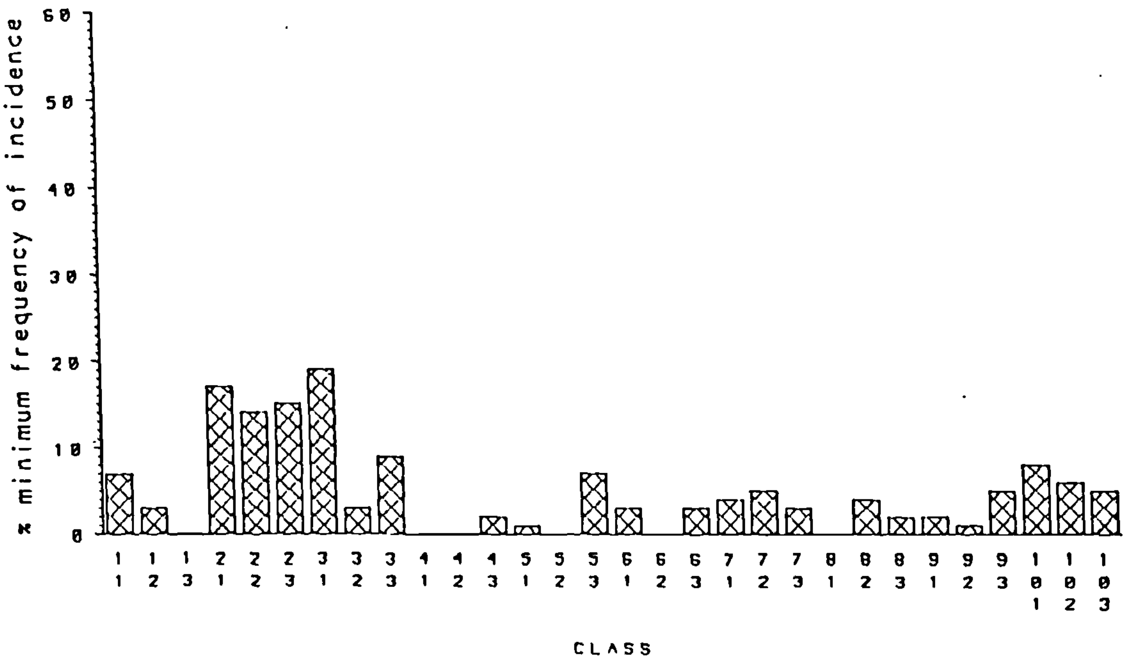


Figure 6.4

have provided pupils with opportunities for hypothesising on their own initiative. (MPMFI for this skill was 4.9).

(iv) Dialogue involving General Planning:

Figure 6.5 shows that only six classes were observed to involve children in this skill. The MPMFI for this skill across thirty classes was only 0.8. The intended PSP materials shows that at the P6 level there was some provision for this in the lessons for three classes. This was implemented in only one class (code 51). However, while this was not specified for the materials in class code 21 and 61, the teachers had on their initiatives involved pupils in some way in this skill. At the P5 level the intended PSP provided for it in four classes, but was implemented in only one class - code 71. In class code 22 the intended PSP did not provide for it but it was implemented by the teacher. No provision was seen in the intended lessons for the P4 level, though class code 23 did involve pupils in it.

(v) Discussing Specific Plans/Procedures:

Figure 6.6 shows that in all but three classes, children were involved in this skill. MPMFI for this was 8.1.

(vi) Discussing Measurements and Using Measuring Equipment:

The MPMFI for discussing measurement was 6.7 while that for using measuring equipment was 5.3. Referring to Figure 6.7 and 6.8 it

Dialogue – general planning

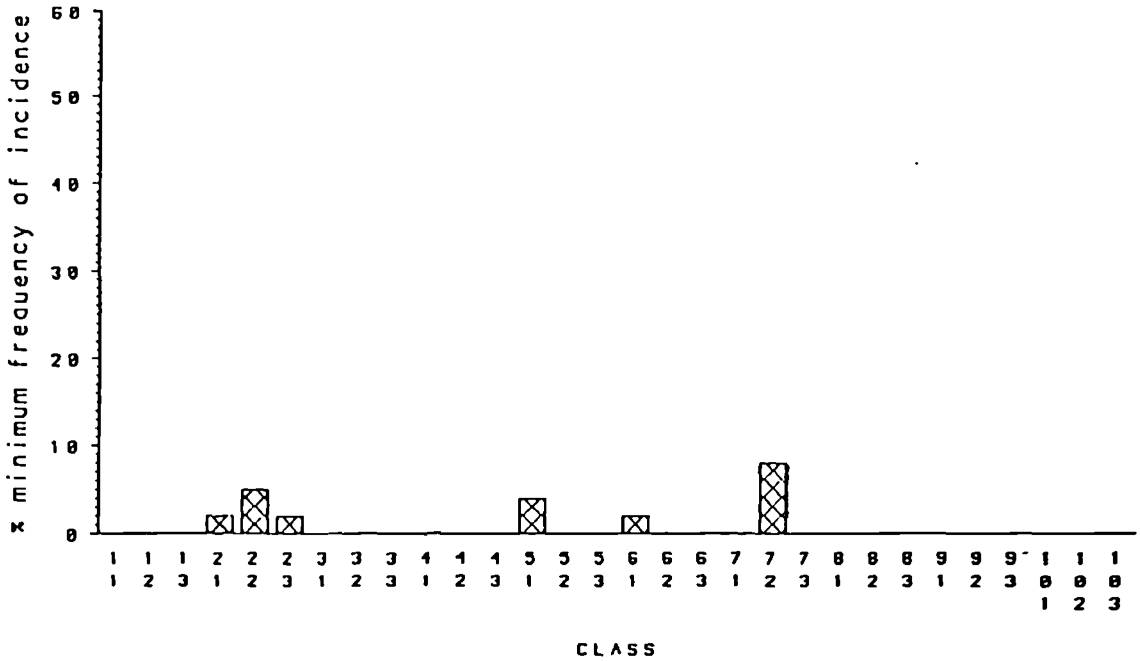


Figure 6.5

Dialogue – specific planning

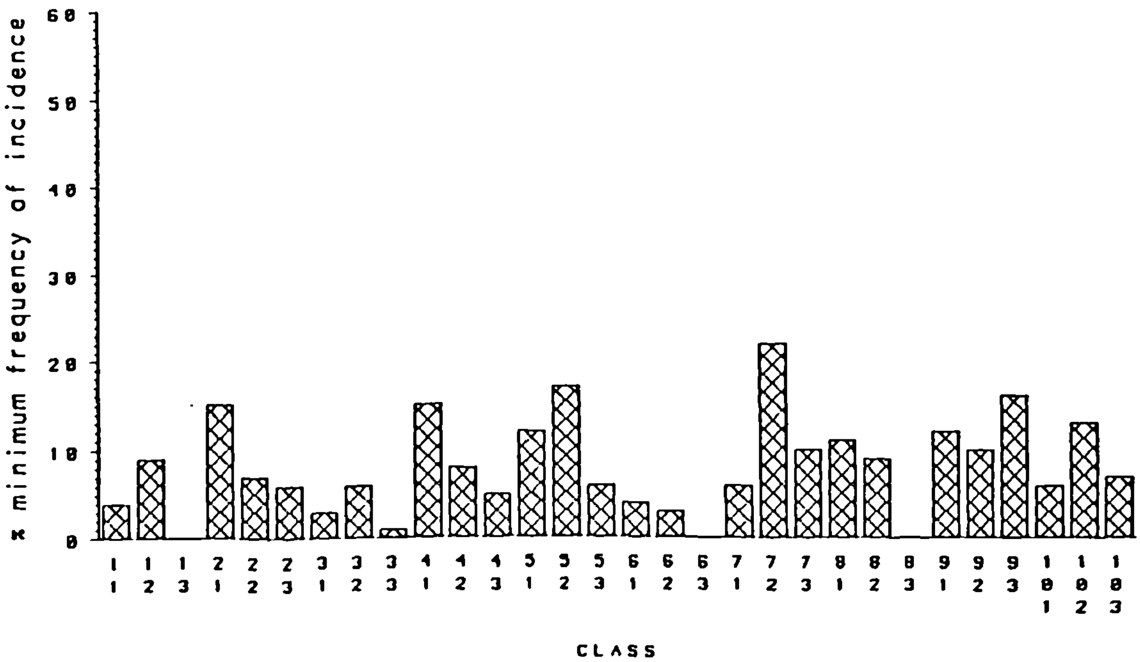


Figure 6.6

Discussing measurement

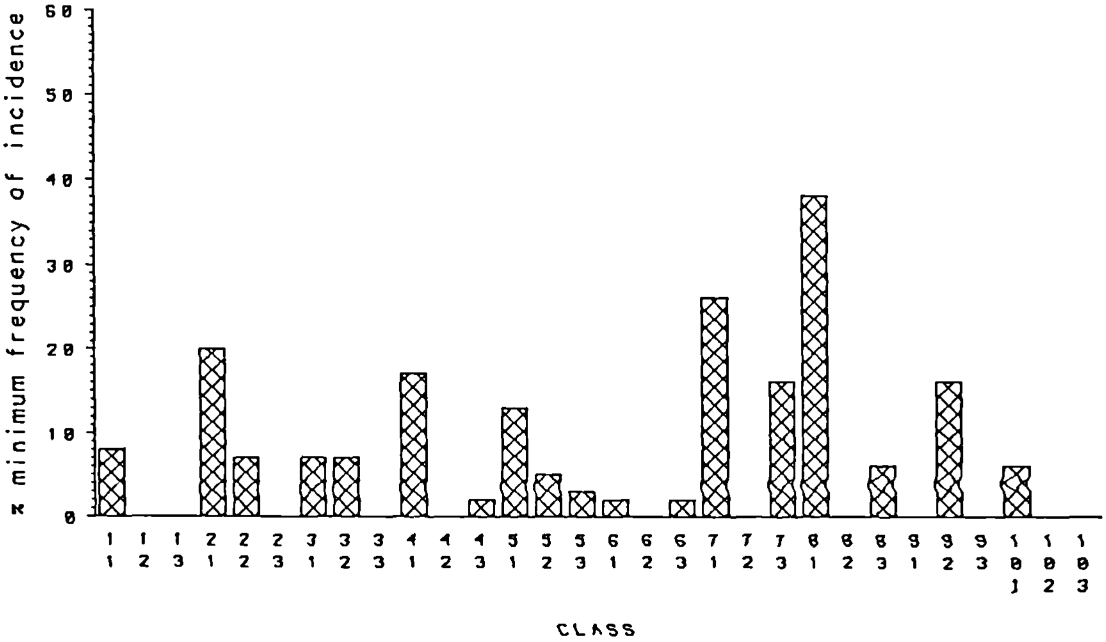


Figure 6.7

Using measuring instruments

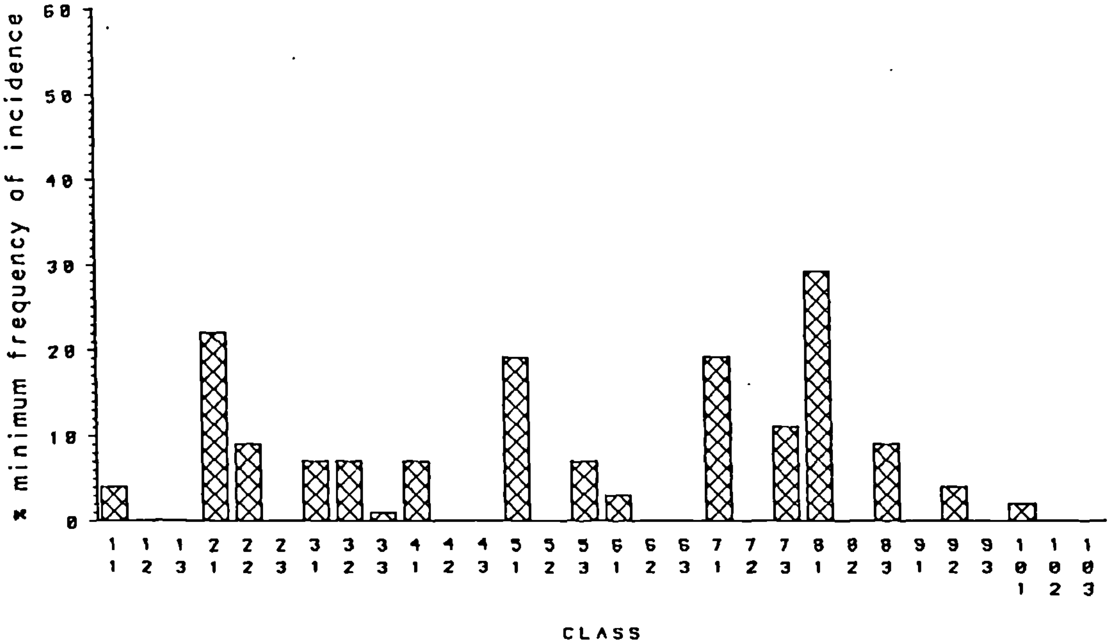


Figure 6.8

can be noted that except for one P6 *(code 91) class, the remaining* P6 classes involved children in this skill. The PSP materials used by class code 91 did not reflect this skill, while it was called for in the materials used by the other P6 classes. At the P5 level the intended materials for three classes required it. However, one of these classes did not involve children in it, while another class managed to involve children in measuring although it was not stipulated in the materials. At the P4 level again the classes for which PSP intended the skill did involve children in it.

(vii) Recording (Dialogue and Non Dialogue):

Figure 6.9 shows that 23 classes had children involved in discussing their recordings (MPMFI 5.9). However Figure 6.10 shows that all 30 classes had children involved in recording (non dialogue). The MPMFI for this was 14.6. This seems to indicate that pupils may make recordings without discussing them - that is, they make an individual response to their workbooks, where they make most of their recordings. The intended materials reflect this for all classes by virtue of having workbook exercises.

(viii) Raising Questions:

Figure 6.11 shows that 20 classes involved children in raising questions (MPMFI 2.5). If one notes the very low mean as well as the fact that only six classes involved children in planning, then it can be understood that while children did raise questions,

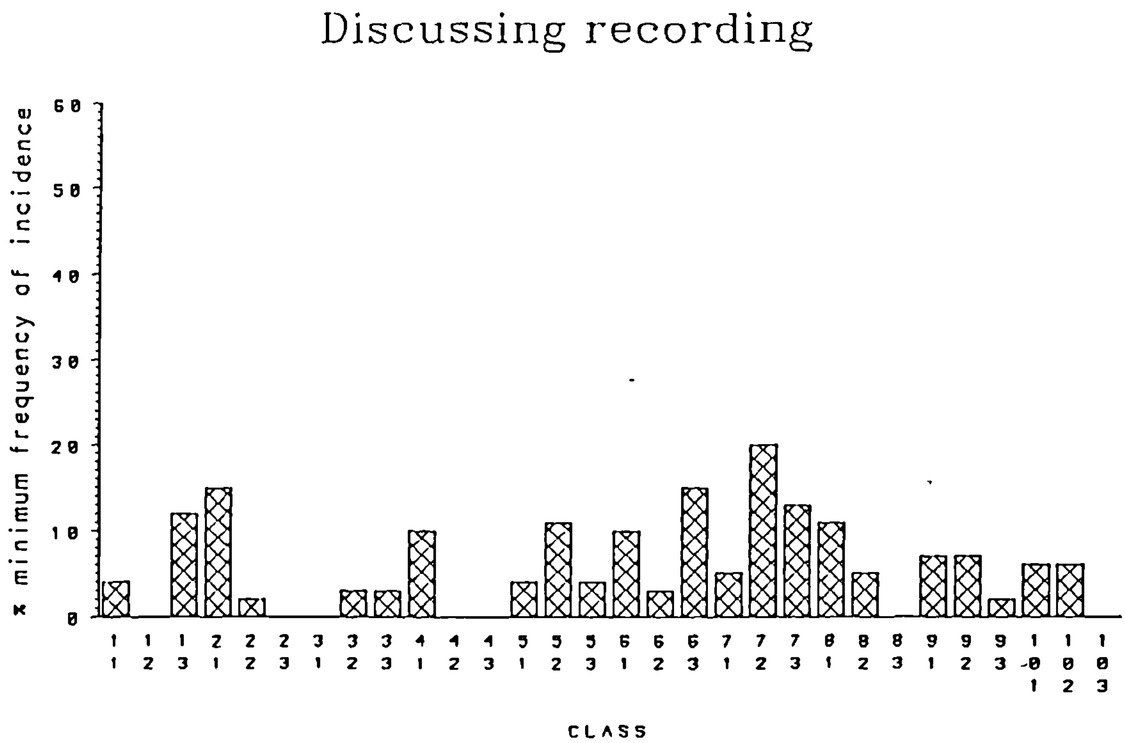


Figure 6.9

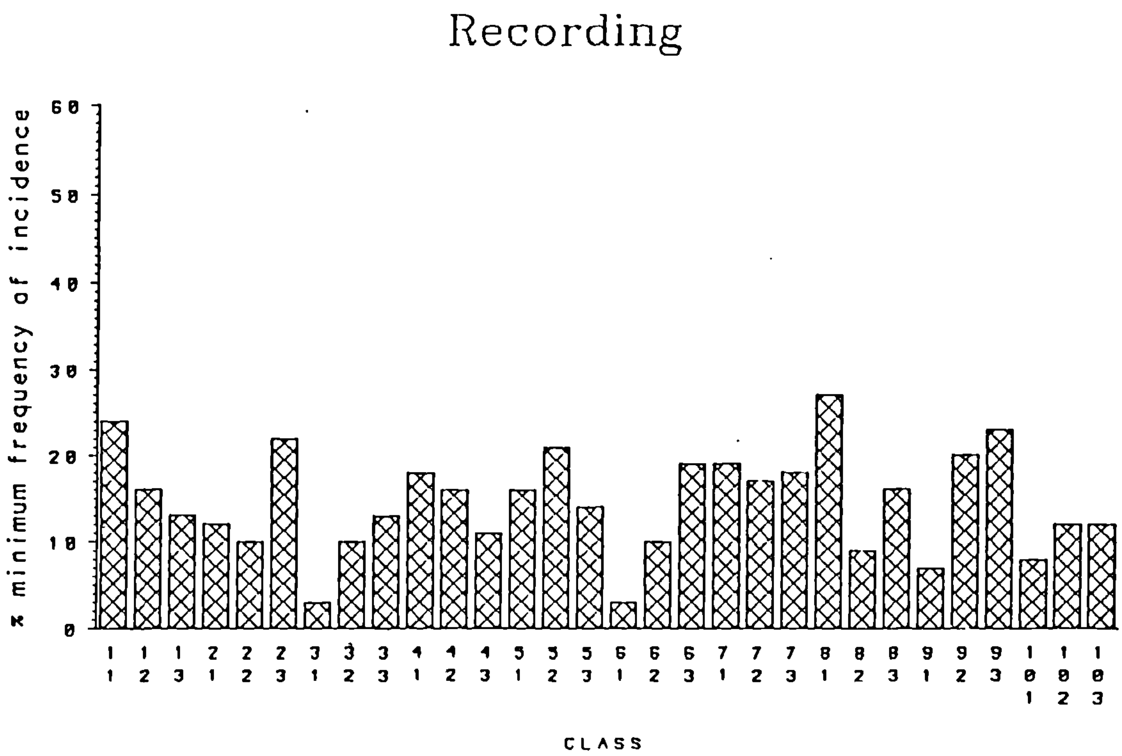


Figure 6.10

Dialogue – raising questions

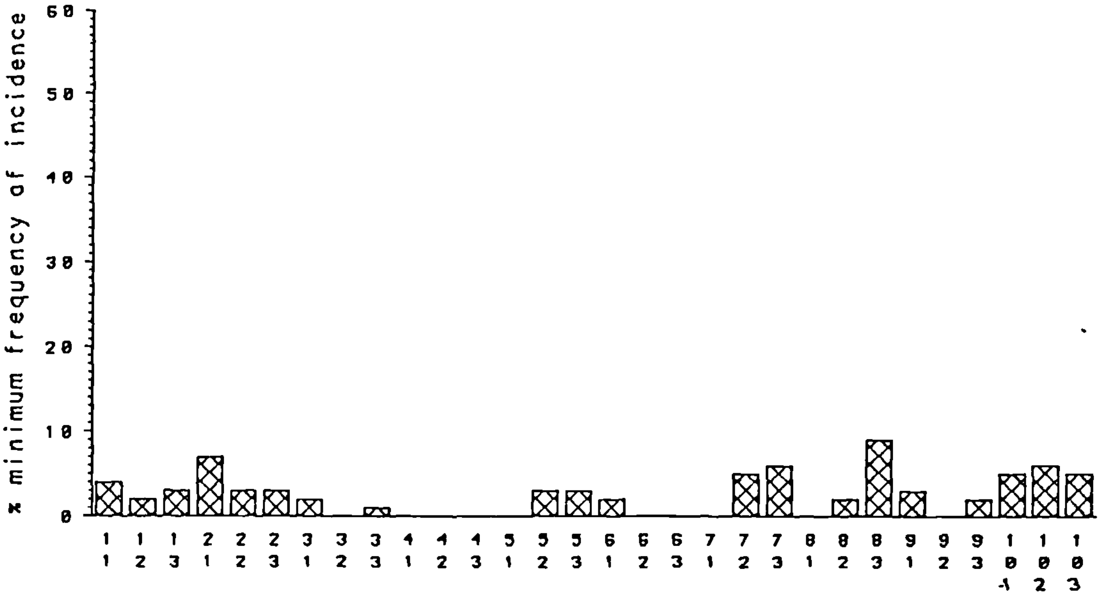


Figure 6.11

Dialogue – recall

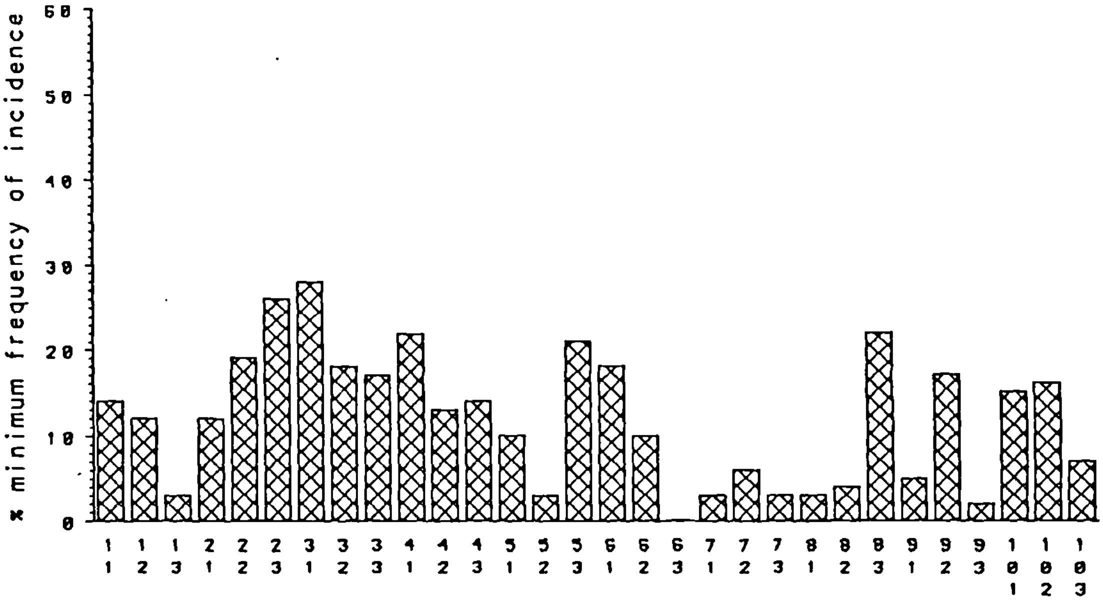


Figure 6.12

they were not ones that led to children working on their own questions. Had this been the case, the general planning category may have registered a higher mean. Further, it was difficult to discern the opportunity for this skill in the intended PSP. Also, a notable feature seen in Figure 6.11 is that in one school no class involved its children in this skill. This point will be taken up in Chapter Seven.

(ix) Recall (Dialogue):

Figure 6.12 shows that all classes except for code 63 involved children in recall situations (MPMFI 12.1). However, the analysis of the intended PSP shows that recall was specified only in 8 classes. This does reveal that in spite of curriculum intentions teachers are tending to involve their children in recall as a routine part of their lessons.

(x) Recap (Dialogue):

Figure 6.13 shows that 26 classes involved children in recap. The intended PSP materials specifically called for this in 4 classes. Again this shows that teachers tend to involve children in recap situations in spite of curriculum intentions (MPMFI 7.0).

(xi) Using Other Materials and Equipment:

Figure 6.14 shows that all thirty classes involved their pupils in using materials and equipment other than measuring equipment. PSP materials called for the use of materials in all lessons observed (MPMFI 25.2).

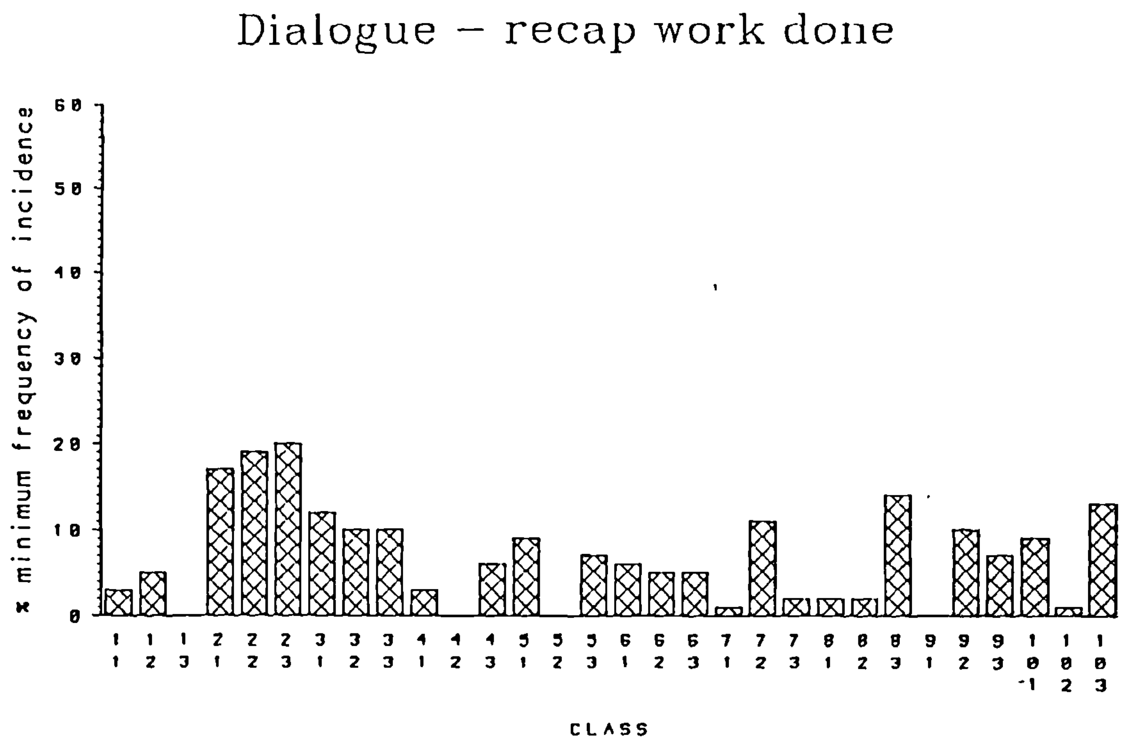


Figure 6.13

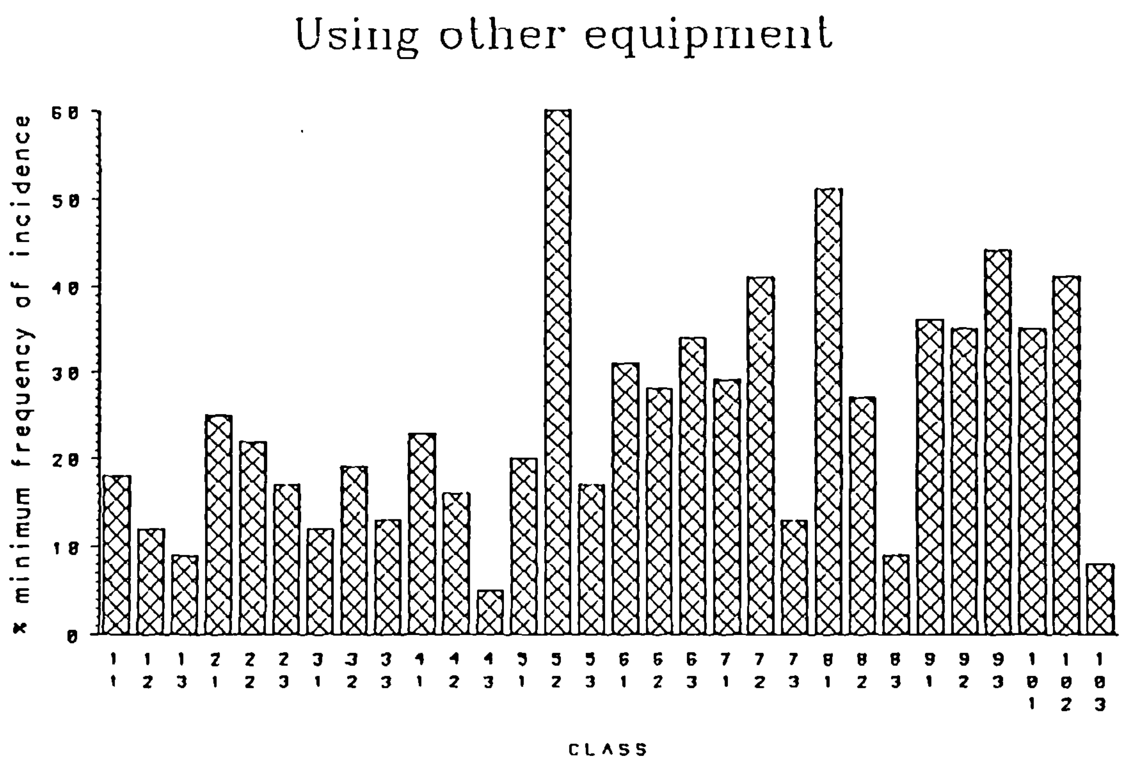


Figure 6.14

From the mean values for all the fourteen skills, it was possible to list in rank order the involvement in terms of minimum incidence the skills as implemented in all thirty classes. Table 6.3 shows this rank order. It shows that across the thirty classes, the more commonly involved skills were those requiring 'Observing', that is firstly making observations and secondly discussing observations. At the bottom end of the rank order list were the skills involving 'Raising Questions' (rank order 13) and 'General Planning' (rank order 14).

b) Extent of Use of Skills Across each Level :

Table 6.4 provides data concerning the means of the percentage of minimum frequency of incidence for each level. Figures 6.15 to 6.28 show graphically how each level involved its pupils in each of the skills.

The data which show the implemented PSP tend to suggest that while generally the P6 level tends to have 'more' of each skill occurring in the classrooms, one cannot make out a strong trend showing any progressive involvement of the implemented skills in the classes observed. An analysis of variance procedure was carried out on the data to test the significance of the difference between the means of each variable for the three class levels (ie. P6, P5 and P4). In particular, Scheffe's test was applied at the 0.05

Table 6.3 Observed (Implemented) Rank Order of 14 Process Skills across All Levels (N = 30 classes)

Rank Order	Process Skill Categories	% Minimum Frequency of Incidence (Mean)
1	Making Observations	37.5
2	Discussing Observations	27.7
3	Using Materials and Other Equipment	25.2
4	Discussing Interpretations	24.2
5	Recording	14.6
6	Recall (Dialogue)	12.1
7	Discussing Specific Plans/Procedures	8.1
8	Recap Work Done (Dialogue)	7.0
9	Discussing Measurement	6.7
10	Discussing Recording	5.9
11	Using Measuring Equipment	5.8
12	Discussing Hypotheses	4.9
13	Dialogue Raising Questions	2.5
14	Dialogue General Planning	0.8

Table 6.4 Observed Values (Implemented) for 14 Process Skill Categories Across 3 Levels (P6, P5, P4, N = 10)

Process Skill Categories	Level P6 (Aged 11+)	Level P5 (Aged 10+)	Level P4 (Aged 9+)	Scheffe's Test for Means Difference Significance
Discussing Observations	31.2	28.4	23.6	*
Making Observations	40.3	42.3	30.0	P5 differs sig. from P4
Discussing Interpretations	21.6	26.7	24.3	*
Discussing Hypotheses	6.1	3.6	5.1	*
Dialogue General Planning	0.8	1.3	0.2	*
Discussing Specific Plans/Procedures	8.8	10.4	5.1	*
Discussing Measurement	13.7	3.5	2.9	P6 differs sig. from P5 and P4
Using Measuring Equipment	11.2	2.0	2.8	P6 differs sig. from P5 and P4
Discussing Recording	7.2	5.7	4.9	*
Recording	13.7	14.1	16.1	*
Dialogue Raising Questions	2.3	2.1	3.2	*
Dialogue Recall	13.0	11.8	11.5	*
Dialogue Recap Work Done	6.2	6.3	8.4	*
Using Materials and Other Equipment	28.0	30.6	16.9	*

* No significant difference between the three age levels (P6, P5, P4)

Making observations

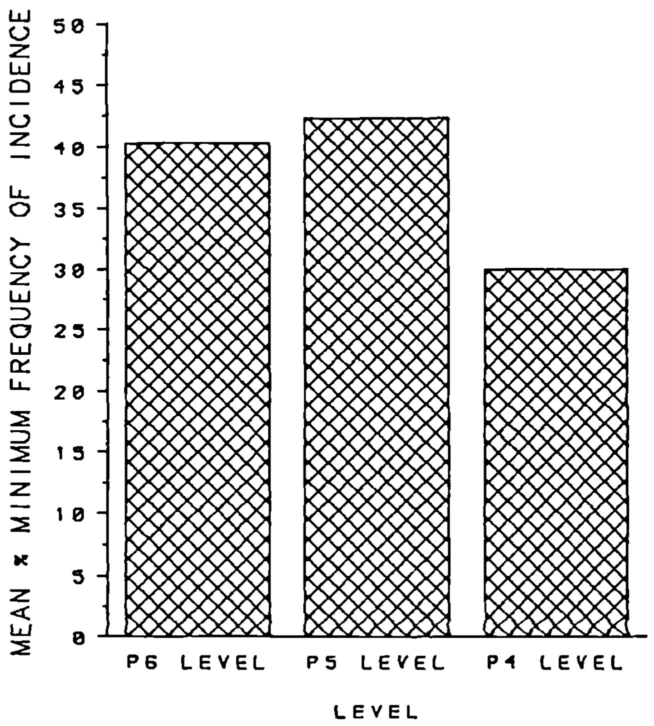


Figure 6.15

Discussing observations

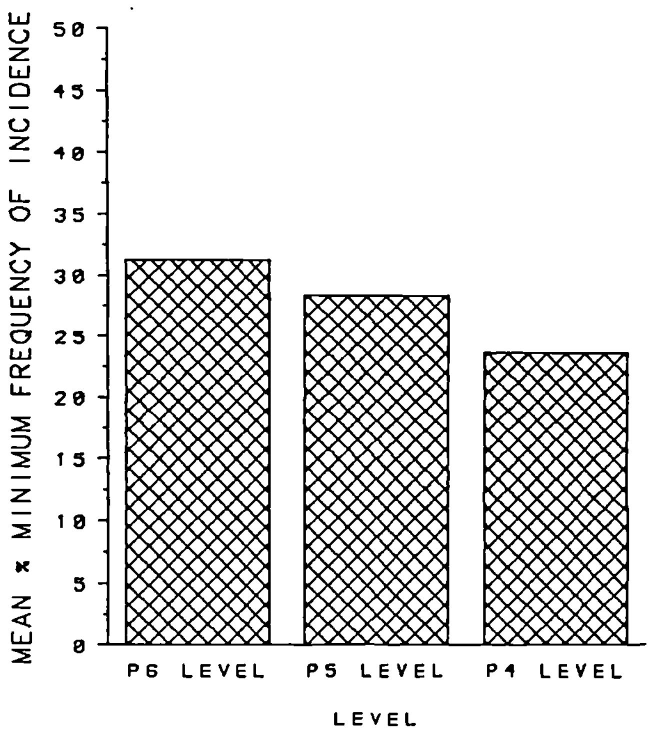


Figure 6.16

Discussing interpretations

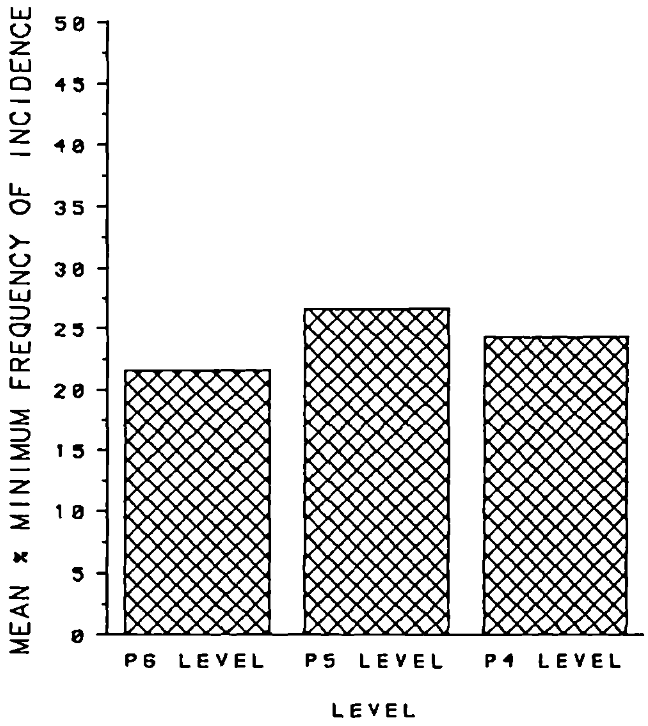


Figure 6.17

Discussing hypotheses

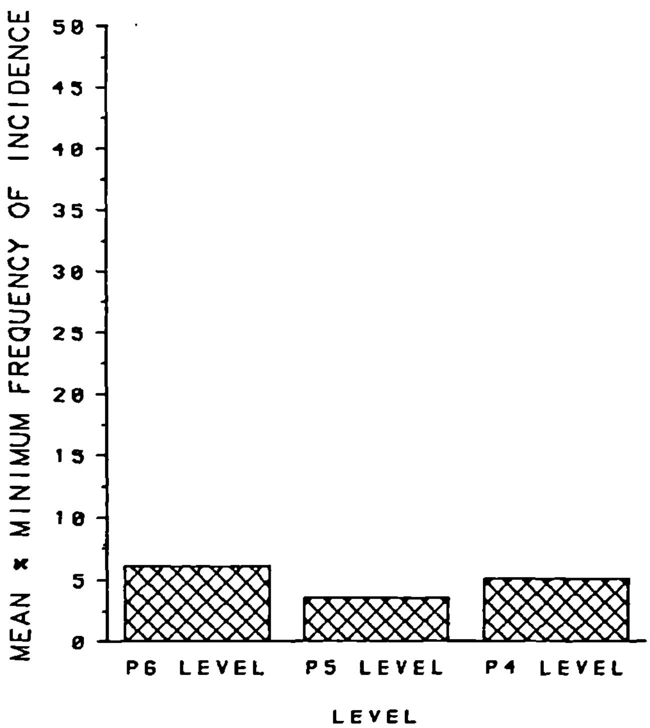


Figure 6.18

Dialogue – general planning

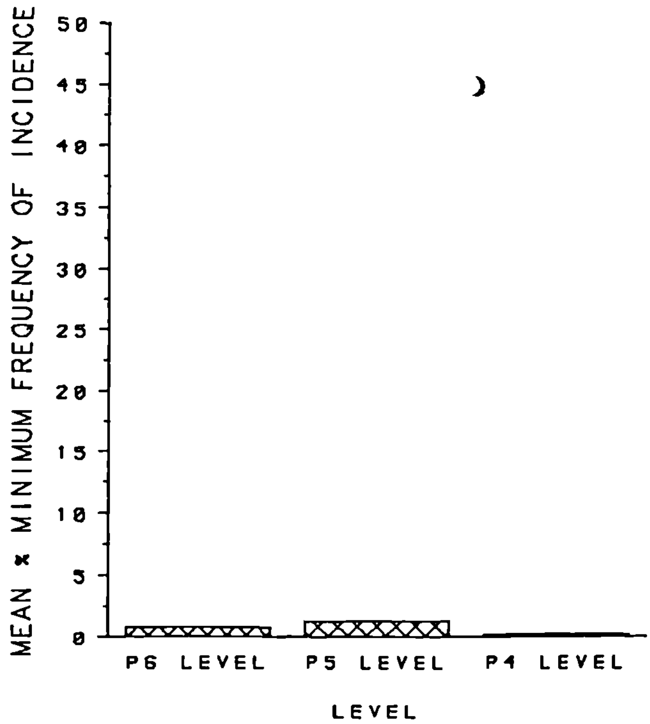


Figure 6.19

Dialogue – specific planning

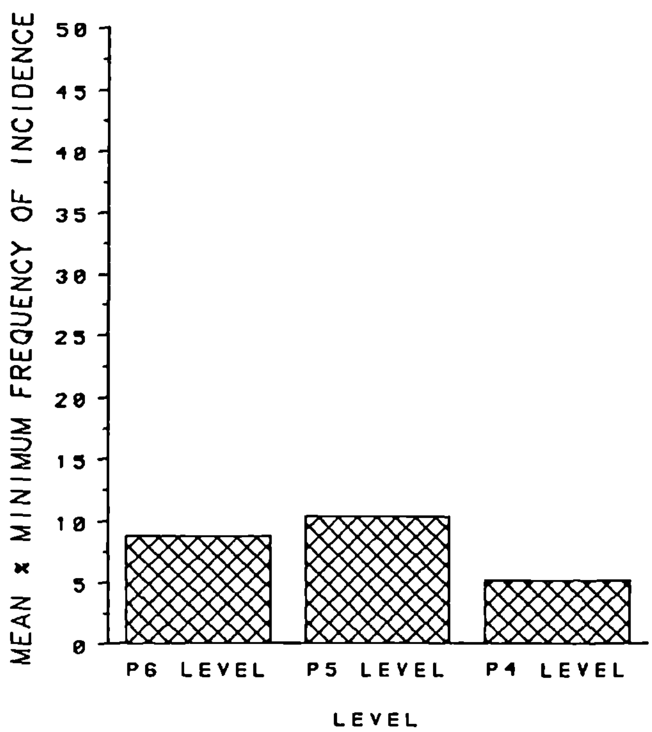


Figure 6.20

Discussing measurement

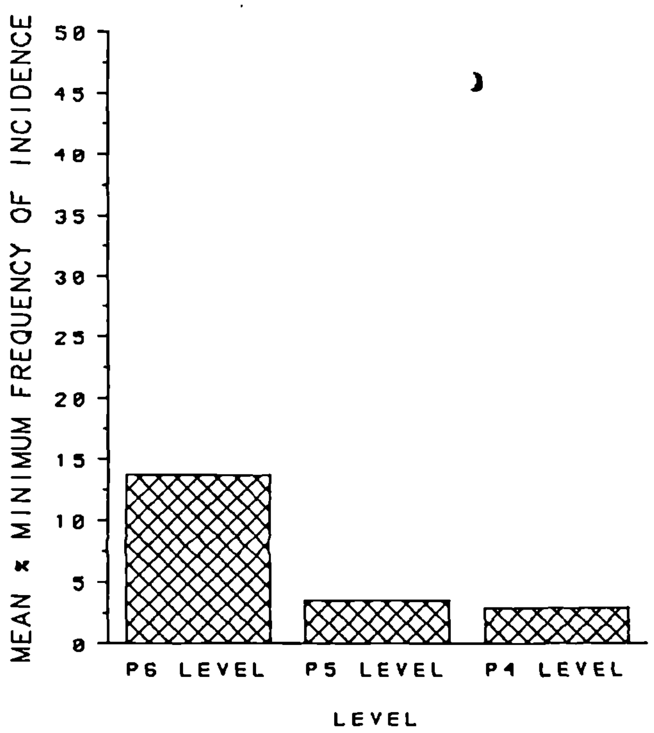


Figure 6.21

Using measuring instruments

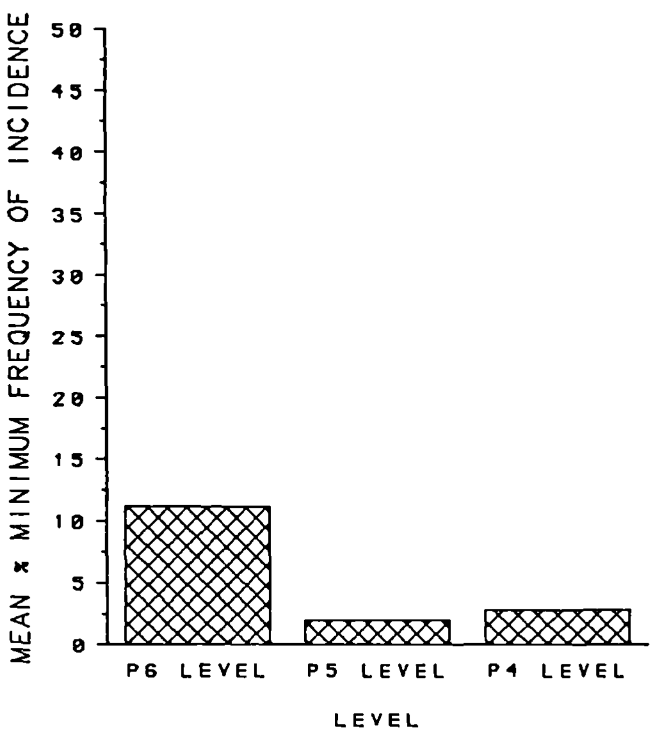


Figure 6.22

Discussing recording

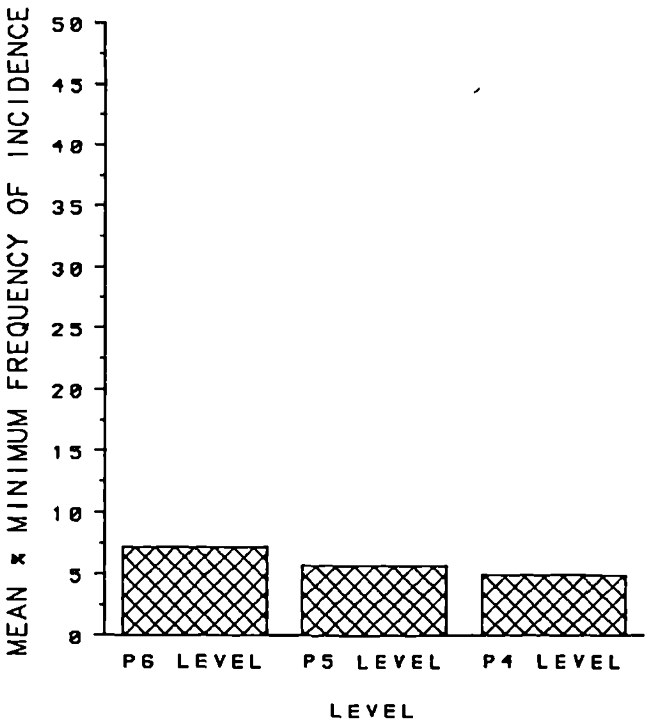


Figure 6.23

Recording

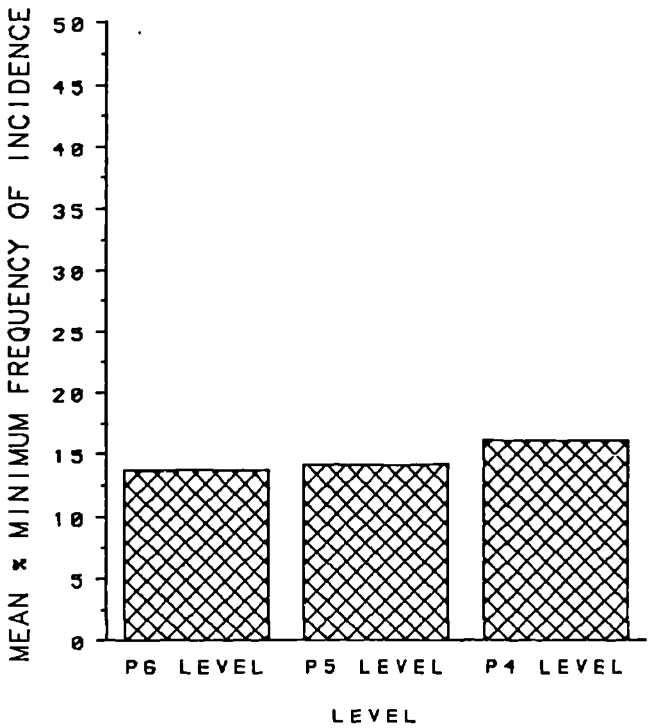


Figure 6.24

Dialogue – raising questions

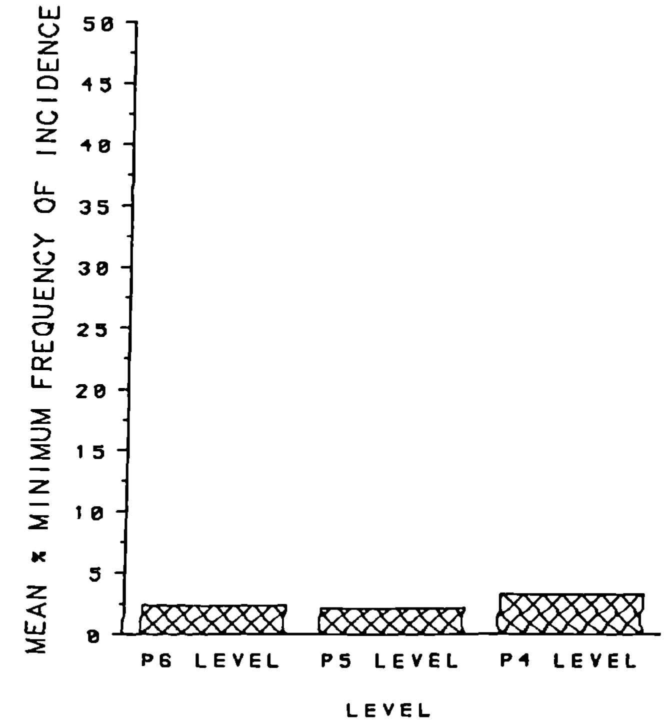


Figure 6.25

Dialogue – recall

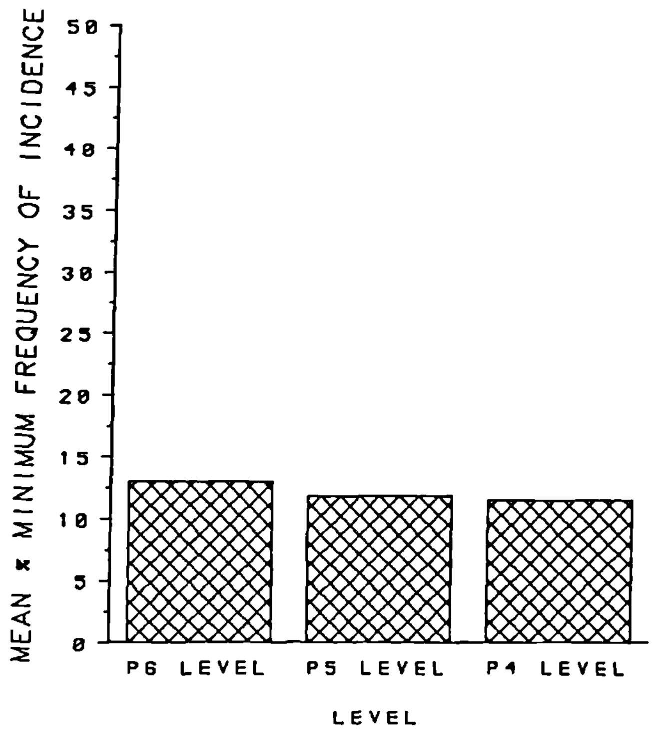


Figure 6.26

Dialogue – recap work done

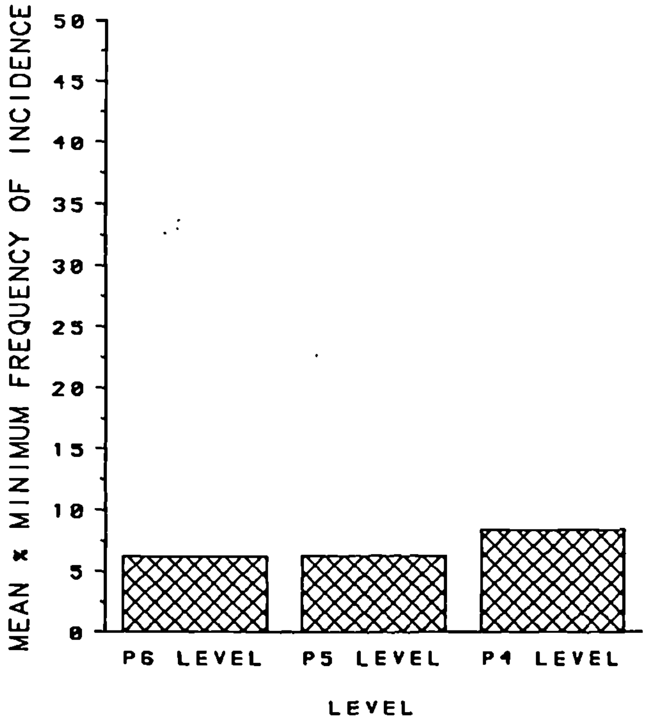


Figure 6.27

Using other equipment

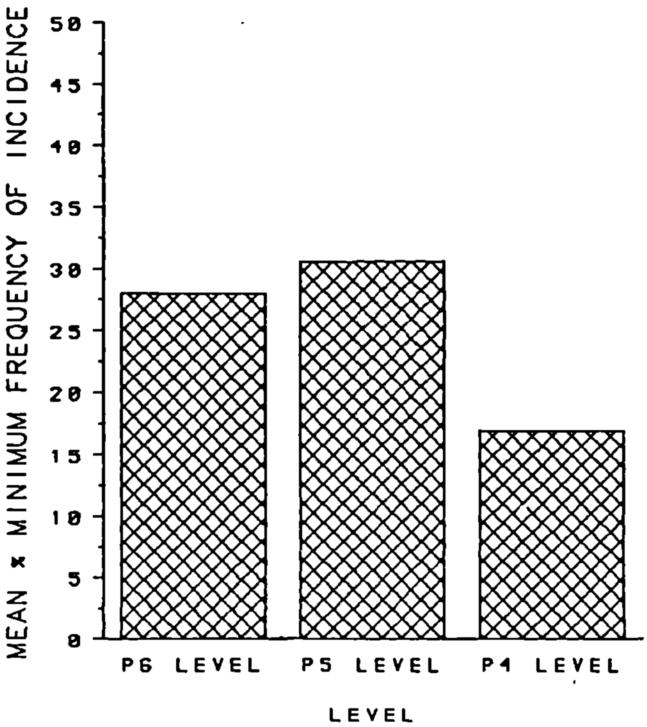


Figure 6.28

confidence level to see if the means for each variable differed significantly between each level. The results in Table 6.4 show that the means for each variable between the levels were not significantly different except for the following three variables.

(i) "Discussing Measurement" mean at the P6 level (13.7) differed significantly from the P5 (3.5) and P4 (2.9) levels.

(ii) "Using Measuring Equipment" mean at the P6 level (11.2) differed significantly from the P5 (2.0) and the P4 level (2.8) ($p <= 0.0078$).

(iii) "Making Observations" mean at the P5 level (42.3) differed significantly from the P4 level (30.0), but not the P6 (40.3) and P4 and P6 were not significantly different. Interestingly, (though not significantly different) 'raising questions' appears to be slightly higher in incidence at the P4 level than the other two levels. It does raise the question as to whether the younger children are more forthcoming in this aspect than the older ones. As might be expected, the use of measuring instruments and children discussing measurements which showed a marked higher incidence at the P6 level, was also well reflected in the intended curriculum materials for the P6 level. It would appear that at the P6 level greater provision is made for children to use measuring equipment.

The data from Table 6.4 and 6.1 were then sorted to provide a rank order of the use of the skills, first, across all classes

(N = 30) and then for each level (N = 10 at P6, P5, P4). The results are shown in Table 6.5. The following interesting features come through in these rank orders.

1. 'Making Observations' consistently occupied rank order position one for all levels. It would appear that teachers in implementing PSP have placed a high emphasis on the 'observation skill'. Close to 'making observations' is 'discussing observations'.

2. In conjunction with children making observations, teachers are involving their pupils in handling materials and equipment.

3. Across the levels, teachers are putting almost equal priority to 'recall' - which occupies rank order 6 - 7. In a list of 14 variables, a rank order of 6 or 7 would be a fairly high priority.

4. The use of measuring instruments takes a lower rank but this must be seen in relation to the topics covered. Measurements can only be provided for in a lesson that lends itself to this. Hence the lower rank order in itself is not a source of concern if across the levels it is a feature of the lessons in science children learn.

5. General Planning consistently across the levels occupies the lowest rank order position. This seems hardly surprising as children are also not appearing to involve themselves much

Table 6.5 Observed (Implemented) Rank Order of 14 Process Skill Categories for 3 Levels (P6, P5, P4)

Process Skill Categories	RANK ORDER All Levels N = 30	P6 Level N = 10	P5 Level N = 10	P4 Level N = 10
Discussing Observations	2	2	3	3
Making Observations	1	1	1	1
Discussing Interpretations	4	4	4	2
Discussing Hypotheses	12	12	10	8.5
Dialogue General Planning	14	14	14	14
Discussing Specific Plans/Procedures	7	9	7	8.5
Discussing Measurement	9	5.5	11	12
Using Measuring Equipment	11	8	13	13
Discussing Recording	10	10	9	10
Recording	5	5.5	5	5
Dialogue Raising Questions	13	13	12	11
Dialogue Recall	6	7	6	6
Dialogue Recap Work Done	8	11	8	7
Using Materials and Other Equipment	3	3	2	4

in raising questions for involvement. Hence the opportunity to plan their investigations for their own questions has certainly not been an established feature of the classrooms observed.

6. Children across the levels are making recording with the same degree of priority (rank position 5). However, this does not tie in well with them discussing their recordings - which takes a very much lower rank order. It would appear that children generally in the classes are making individual recordings. This may be linked with the fact that they have individual workbooks to complete and respond to these on an individual basis.

CORRESPONDENCE BETWEEN THE INTENDED AND IMPLEMENTED PSP

In order to see how the observed ranks for the fourteen skills corresponded with the intended, Table 6.6 was prepared. Table 6.6 reflects the Intended Ranks as established from the analysis of PSP materials. However, as explained in Chapter Five, it was not easy to establish a score for 'discussion of specific plans/procedures' and that for 'raising questions' - In the light of this, they were given a zero score and the ranks for the 14 skills computed.

Table 6.6 Rank Orders for the Process Skill Categories in the Intended and Implemented PSP across all levels (N = 30 classrooms)

Process Skill Categories	Intended Rank Order	Implemented Rank Order
Discussing Observations	1.5	2
Making Observations	1.5	1
Discussing Interpretations	5	4
Discussing Hypotheses	9	12
Dialogue General Planning	11	14
Discussing Specific Plans and Procedures	13.5	7
Discussing Measurement	7.5	9
Using Measuring Equipment	7.5	11
Discussing Recording	3.5	10
Recording	3.5	5
Dialogue Raising Questions	13.5	13
Dialogue Recall	10	6
Dialogue Recap Work Done	12	8
Using Materials and Equipment	6	3

From the results it appears that 'Making Observations' ranks as top priority in the intended materials and this has also been implemented with the same priority. 'Discussing observations' was ranked 1 in the intended as they were scored equally in the analysis of PSP materials. In the implemented they have held equally high in priority. Recording in the Intended has a high priority and is given a fair amount of attention in the implemented - although as discussed earlier, the discussion of their recordings takes lower place in the classroom. This may also be tied up with the approach taken by teachers to expect workbooks to be completed and handed in for correction.

'Recall' and 'Recap' show an interesting rating. The intended appears to indicate less need for this, but the implemented classroom situation appears to have raised its importance. The rank order for recall in the intended was position 10, but the implemented indicated it as position 6. It would appear that teachers are placing a higher priority for 'checking' that pupils are remembering what is being transacted in the classroom. It may also be a reflection of a more 'content' oriented classroom scene.

Looking at the intended, hypothesising opportunities appear to be limited in relation to the other skills. It has an even lower position in the implemented curriculum.

While the intended did show some opportunity for 'general planning', it occupied a very low rank, and the implemented situation appears to have further reduced its use in the classroom. This can be understood in a situation where 'raising questions' is not stipulated in the PSP intended materials. While it may not be easy for curriculum developers to put this into their materials, nor do all lessons lend themselves to pupils raising questions, indications of its value could be provided where possible in the teaching suggestions. This was clearly absent and may be seen as reflecting a lower priority on the part of the PSP developers for this skill.

Spearman's rank order correlation coefficients were computed in two ways to look further into the correspondence of the intended and the implemented PSP. Table 6.7 shows the computed data when correlation coefficients were calculated for each classroom (seen as a unit) between the intended (obtained from curriculum analysis) and the implemented PSP (observed values from SPOC data). These correlations were calculated for each class across all fourteen process skill/categories.

The results show that positive correlations ranging from $\rho = 0.2$ to 0.9. While many of these correlations may be statistically significant at the 0.05 level, one needs to look at it from its educational value. Thus, to get a clearer meaning for these correlations, the following was used as a rough and ready guide to the meaning of ρ. The table provided by Cohen and Holliday (1979, p. 98) offers a descriptive interpretation for ρ.

ρ	Meaning
0.00 to 0.19	a very low correlation
0.20 to 0.39	a low correlation

0.40 to 0.69	a modest correlation
0.70 to 0.89	a high correlation
0.90 to 1.00	a very high correlation

Based on this guide, the Spearman Correlations in Table 6.7 indicate that all 30 classes showed a positive correspondence between what was intended and what was implemented with regard to the fourteen process skills/categories . While these correlation values for ρ ranged from 0.2 to 0.9, based on the interpretation offered by Cohen and Holliday, 28 classes had a modest and above correlation. Of these nine were high and another very high.

In terms of significance among the modest and above correlations, they ranged from very significant at $p < 0.00$ to p being not significant at 0.16. If the acceptance level of significance was taken at $p < 0.05$, then 22 classes would have acceptable significance levels from the Spearman correlations. Table 6.7 thus appears to indicate that teachers are generally working closely with the PSP materials and showing the same relative importance to the process skills in accordance with the intended PSP.

Spearman correlations were also calculated between the intended and the implemented values for each process skill but across the values obtained from the 30 classes. Table 6.8 provides the calculated values. The results show the ρ values ranging from negative correlations, -0.4 to positive correlations of 0.8. However, very little significance can be attributed to the data, with only 3 indicating significance values acceptable at the 0.05 level.

Table 6.7 Spearman's Rank Order Correlation Coefficient (ρ). Correlation between Observed (Implemented) Values and the Intended (from Curriculum Materials Analysis) across all 14 Process Skill Categories in each class.

(Total 30 Classes)

Class Code	Spearman's ρ	Significant at	Meaning of Correlation
011	0.6	0.04	Modest
021	0.6	0.03	Modest
031	0.4	0.16	
041	0.6	0.03	Modest
051	0.6	0.03	Modest
061	0.5	0.10	
071	0.7	0.00	High
081	0.6	0.01	Modest
091	0.6	0.01	Modest
101	0.5	0.06	Modest
012	0.5	0.08	
022	0.4	0.01	Modest
032	0.6	0.04	Modest
042	0.8	0.00	Modest
052	0.8	0.00	High
062	0.7	0.01	High
072	0.7	0.00	High
082	0.6	0.01	High
092	0.7	0.01	Modest
102	0.7	0.01	Modest
013	0.8	0.00	High
023	0.5	0.05	Modest
033	0.7	0.01	High
043	0.4	0.14	
053	0.5	0.08	
063	0.9	0.00	Very High
073	0.8	0.00	High
083	0.2	0.40	
093	0.8	0.00	High
103	0.3	0.23	

Note: Correlation accepted as significant if $p <= 0.05$

Table 6.8 Spearman's Rank Order Correlation Coefficient (rho). Correlation between Observed (Implemented) Values for each Process Skill and the Intended (from Curriculum Materials Analysis). (N = 30 classes)

Process Skill Categories	Spearman's rho ρ	Significant at	Meaning of Correlation
Discussing Observations	-0.4	0.04	Modest
Making Observations	0.1	0.69	
Discussing Interpretations	-0.1	0.59	
Discussing Hypotheses	0.1	0.63	
Dialogue General Planning	0.2	0.42	
Discussing Specific Plans/Procedures	-0.1	0.69	
Discussing Measurement	0.8	0.00	High
Using Measuring Equipment	0.7	0.00	High
Discussing Recording	-0.1	0.78	
Recording	0.1	0.57	
Dialogue Raising Questions	*	*	
Dialogue Recall	0.2	0.29	
Dialogue Recap Work Done	0.2	0.24	
Using Materials and Equipment	0.2	0.29	

* Correlation cannot be computed.

Note: Correlation accepted as significant if $p <= 0.05$

In spite of this, the picture is one that says that the teachers, while they are working closely with the intended relative emphasis, they are not varying the emphasis they give within each skill on a day to day basis. The date from Table 6.8 could be interpreted to say that teachers are tending to keep to a mean in terms of the extent to which pupils are given experiences with the process skills. It could mean teachers are not relating according to the demands of the content of the intended and they have a set approach and are not varying their teaching approaches for the use of the process skills.

TEACHER'S UNDERSTANDING OF THE INTENDED PSP IN TERMS OF ITS PHILOSOPHY, OBJECTIVES OR RATIONALE RELATING TO PROCESS SKILLS.

To obtain information about the understanding teachers have of the PSP's philosophy and its objectives, the transcript of the interviews conducted with the teachers was studied for their comments on this matter. The transcripts showed that all teachers perceived PSP as being a more 'activity oriented' programme. Teachers were not able to discuss the rationale nor the philosophy behind the project. However, they were very forthcoming on how they perceived the objectives of the new materials and what the use of PSP materials was to mean for the science classroom. Their perceptions can best be encapsulated by presenting a selection of their views on the objectives of PSP. Their comments are presented verbatim.

> "I think it is now more activity oriented. This is good. Not so much chalk and talk."

> "It is better than what we had long ago. At least now it's more hands on activities. The project is trying to get the children to observe and to know the importance of keeping certain variables fixed in experiments. Process skills would lead to content, but there must be some pre-knowledge given to children so that they are not working with nothing at all."

> "I do not know because I have very conflicting thoughts about them. Ideally I would like to think that it is to create more investigative minds; it will take them to a point where they will know that if they want to know something, they will have to plan an experiment. Discovery learning. But, realistically, I think it is just to gear them towards a wider science knowledge."

> "Discovery method. Teacher taking the back seat."

> "More activities. They are trying to encourage observation and the process skills."

> "It is to make children more aware of the environment, to think for themselves, to observe. Now we are changing towards process skills and the children are getting used to it."

> "It is making them think rather than memorise facts."

> "I think it is not rote learning. It is more practical."

> "More freey, not so guided."

> "To introduce science in a more creative way - through observation and the use of process skills."

> "Involved in activities - to make their own apparatus."

> "It is for an inquiry mind. Not what the teacher puts in."

> "What they went is to teach pupils to observe - process skills, but unfortunately we are not doing that well."

> "Reasoning. What they want is for children to apply."

From the sample of the teachers' view on what implementing PSP means for the science classroom, it appears that generally teachers are aware that it has 'something to do with process skills'. But it appears that they articulate this generally in terms of 'observation'. This may explain in one way why 'Making Observations' is ranked one in the implemented curriculum.

Also coming through in the teachers comments is that they see PSP as advocating an activity approach - 'hands on' science. Again this view appears to have influenced their teaching PSP - with children using materials and equipment (other than measuring instruments) taking the next order of priority after observations.

A significant feature for this study is noted when the teachers comment that they see PSP science moving away from rote learning, and directed towards science learning being more creative and encouraging an inquiry approach. However, they were not able to say how this might be achieved apart from using the phrase 'process skills' science.

INFLUENCE OF THE NATIONAL SCIENCE SYLLABUS

The teachers in their comments on how they perceived the influence of the national syllabus on their teaching of PSP offered some clear indication as to what they felt about a content as well as process skills oriented science programme like PSP.

Again a sampling of their comments on the national syllabus will help to more clearly convey their sentiments. Their comments are provided verbatim.

> "We are still very much content oriented. This new PSP is an improvement but the syllabus wants content learning."
>
> "Our programme is still very content oriented - we test on it."
>
> "National Syllabus restricts some of the things we as teachers may wish to teach."
>
> "Problem is completing the syllabus."
>
> "Completing the syllabus - we feel that we have to follow exactly what is given to us otherwise we would be accused of not carrying out our work."
>
> "Present syllabus has process skills - but we are teaching the process skills as content."
>
> "I know we are going for process skills. But we are a long way away. I am going for the exams and process skills are only there if I can make time for it."
>
> "Process skills - it is important for scientific thinking. But the syllabus content is important - without basic concepts how are they going to design experiments and think in further depth."
>
> "For my class - I would say to develop skills is more important than tell them the facts. But we are still a long way away. The exams - we have to work within the constraints of the syllabus."

It would seem that the last comment says in spirit how the teachers generally see the national syllabus influencing their teaching and implementation of PSP. In Chapter Seven this will be explored further when the constraints teachers perceive in implementing PSP are discussed.

TEACHER'S UNDERSTANDING OF THE PROCESS SKILLS

The approach taken to establish this was discussed in the section under teacher interview in Chapter Five. Essentially it was a matter of teachers identifying examples of children in the video programme involved in using the process skills.

Because it was a video, teachers were able to see the children progress through their interactions with the materials, through their interactions with each other and finally to their written communication by way of their recordings. The following are some examples of the children's work that was part of the evidence on which teachers were asked to respond to the following task - Identify as you watch the video the skills you think the children are involved in.

Example 1.

This shows the evidence for children having carried out observation, measuring, raising questions and recording (communication). In the course of carrying out this activity they would have handled materials and equipment (including measuring equipment). It also shows evidence of group work and hence pupil - pupil interaction.

Example 2

This is an example of observations that led to pattern finding.

Example 3.

This is an example of children making a prediction as to the number of washers required to sink block B. It is a follow up of an earlier activity in which they had established the weights of the blocks. The group went on to provide the teacher with the following hypothesis as to their prediction.

> "Block 'B' is 60 grams
> Block 'A' is 40 grams ...
> Because Block 'A' is lighter than
> Block 'B' and Block 'C' is heavier
> than Block 'B' ....

Examples 4, 5, and 6 show three different attempts by children at raising their own questions and planning an investigation. It provides evidence of children listing their equipment and providing the steps to be taken as well as the way in which they would collect their data.

Example 1

Height 4cm Length 5cm
Weight 3g
The snail leaves a sticky trail behin
When the gets onto the glass and you lift the glass up you can see its foot:
It climbs up the ruler
The eyes and feelers go in and out.

Gary Brady.
Anthony Boygan.
Elizabeth Hardwick.
Rachel White.
Catherine Herd.

What part is male and what part is female?
How big is the foot?
What it eats?
What colour is the inside of the shell?
How far it goes in 6 hours?

Examp'e 2

The pattern is the lighter it is the better it floats. and the heavier it is it dosent float as good.

Example 3

BLOCK	FLOAT WASHERS	WEIGHT	ALTOGETHOR WEIGHT		SINK
BLOCK A	1 BIG 10 LITTLE	78g	158g	139	2 BIG 61g
BLOCK B					
Block C	1 BIG 19 LITTLE	70g	150g	131g	2 BIG 61g
BIOCK D	3 BIG 10 LITTLE	130g	159g	262g	4 BIG 122g
	WE Predict Block B will need				

BLOCKB 2 BIG

Example 4

HOW DOES the snail cope with other animals?

ants worms earwigs ~~Centipede~~ Millipede
beetles woodlice caterpillar spider.

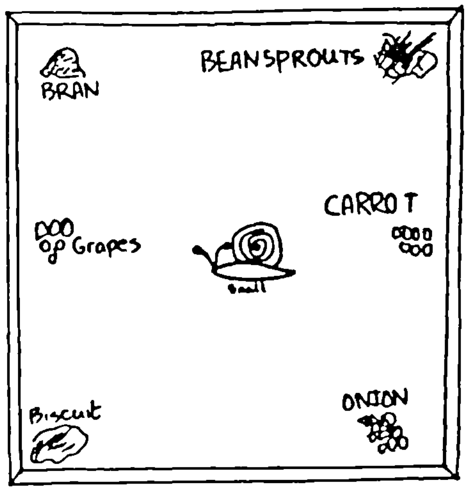
big tray. leaves and grass. round edges. snail in the middle. spread animals around it. what the snail does, and animals do. see if the animals go nearer or farther.

Example 5

What Does It Eat?

We will need - sheet of glass, Bran, Bean Sprouts, Onion, Biscuit, Carrot, Grapes.

This is what we think a snail would eat.

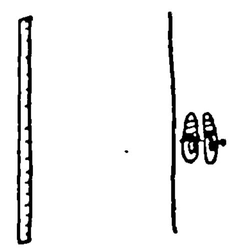


Put the snail on the glass, put all the food around it. See what it goes to first and write it down on your paper.

Example 6

How Many Turns Does It Take To Go 1 metre?

We will need. 1 clockwork toy. some string, a metre ruler.



We give the toy some turns and see if it goes 1m. To measure we put it by some string and when it gets as far as it can go we measure the string.

Result ~~10 turns ½ metre~~ x 10 turns ½ metre
9 turns

Example 4.

"How does the snail cope with other animals" shows a non pictorial presentation of their plan. However, their choice of animals shows an understanding of the snails' natural environment. It is selected here as an example of an investigation that does not have a 'right' answer - an important aspect for teachers who are steeped in the thinking that science lessons must always have 'right' answers to appreciate.

Example 5.

"What does it Eat?" This shows a more sophisticated pictorial presentation as well as evidence at attempting to control a variable - the distance of the snail from the food choices (circle would have mean more accurate). It is also a question based on a hypothesis 'this is what we think a snail would eat' which the children are wishing to test. It also provides evidence of a different way (pictorial) children have chosen to communicate their ideas.

Example 6

This is another attempt at a pictorial method of communicating. It shows children being able to advance a specific procedure of collecting their date - the use of string to measure the distance travelled by their toy. Through this activity evidence came through of an investigation that had a possible 'right' answer.

Through these and other situations in the three topics in the video programme, the teachers would have had occasions to identify and comment on the following skills:

Making observations

Discussing observations

Using equipment (including measuring equipment)

Making interpretations - including pattern finding and predicting.

Hypothesising

Raising Questions for involvement

Planning

Communicating - dialogue as well as recording (non dialogue)

From the teacher's spontaneous response to the skills as she viewed them and listed them, it was possible from the transcripts of the interviews for the researcher to list the skills each teacher was able to identify.

The following are some examples of how the teachers responded to the video and identified the skills as they viewed the tape.

"The skills observed were observation, measuring ... that is a good prediction."

"I think it is the beginning of a kind of hypothesis and when they design their own experiment."

"Yes, they have made a good plan."

From remarks such as these the researcher was able to make a summary of the number of teachers who recognised correctly a skill in the video tape programme and responded by way of comment accordingly. The summary at each level for each skill is provided in Table 6.9.

From the data in Table 6.9 it can be seen that all teachers are familiar with recognising children involved in observing and measuring. They were also able to respond to children planning. Although planning is not a skill that was particularly used in their classrooms, the way in which the science sessions came through in the video tape and the written examples of teachers had available to them were sufficient for them to understand what planning involved. However, the teachers found more difficulty in identifying examples connected generally with children interpreting and hypothesising, although predicting they were able to identify easily as the term was used specifically by the teacher and the children.

Table 6.9 Number of Teachers recognising video-taped examples of the process skills (N = 30 teachers)

Process Skill Categories	P6 Level	P5 Level	P4 Level	Total (N = 30)
Observing	10	10	10	30
Measuring	10	10	10	30
Interpreting	6	6	3	15
Controlling Variables	7	7	5	19
Predicting	9	9	9	27
Raising Questions	8	7	8	23
Hypothesising	7	6	6	19
Planning	9	9	9	27
Communicating (Dialogue)	5	5	3	13
Recording (free)	10	8	9	27

SUMMARY

In this chapter, the data collected were used to look at the extent to which each of the process skills referred to in this study were used by PSP pupils. It was possible to establish through the data a ranking of the skills in terms of the minimum frequency of incidence - which does reflect the priority attached to the skill by the teachers on a day to day treatment of PSP.

Generally, there was correspondence between the intended use of the skills by PSP and the implementation in the classrooms. There was insufficient evidence to say that a particular level was exposed to a particular skill for more than another level.

The teacher's seem to have a view of PSP as being generally, a 'hands-on' activity oriented project. While they recognise the trend for process skill development, they have a perception of the national syllabus demands being still very content oriented and hence limiting the extent to which the process skills can be experienced by children in their science lessons.

In terms of the teacher's understanding of the process skills, they are more familiar with observations, measuring skills to some extent, the control of variables and predicting. These are situations that they have themselves provided opportunities for in their classrooms. They were however, less familiar with other aspects of interpretations and hypothesising-a reflection of the less frequently observed skills in their classroom.

The next chapter will look at the constraints teacher s expressed in fully implementing PSP. In discussing the issues raised, some of the observations made by the researcher on the kind of classroom interactions that took place (non empirical information) will also be provided.

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CHAPTER SEVEN

RESULTS AND DISCUSSIONS PART 2

This chapter looks at the analysis of data concerning:

A the personal and social constraints on the teacher;

B the physical and organisational constraints on the teacher;

C additional information collected by use of the SPOC instrument during classroom observation;

D teacher priorities.

A. PERSONAL AND SOCIAL CONSTRAINTS ON THE TEACHER

The data itself were collected mainly from the teacher interviews, which followed the viewing of the video tape of children involved in working with process skills in science. The procedure used in analysis was to go through the transcripts of the interviews, and, from the statements made, to score a teacher on the opinions she had on various issues pertaining to the model of implementation of PSP discussed in Chapter Five. Aspects of the school background such as school scores in the 11+ examination (PSLE) and language background of pupils in the school were obtained from the school principals in the study.

Reference is also made to a survey carried out by the Curriculum Development Institute of Singapore (CDIS) which was administered during October, 1986 at the time the researcher in this study was carrying out data collection in Singapore schools. The survey carried out by CDIS sought feedback on the PSP materials from teachers in fifty primary schools selected at random. Relevant sections from the data collected by CDIS will be referred to in this chapter. Although the data do not specifically refer to the teachers in this study; however, because of random sampling, they would be representative of the teachers in the P4 to P6 class population.

Finally in this section of the chapter, reference will also be made to the responses given by science co- ordinators when they attended a workshop session conducted by the researcher and organised by the Ministry of Education (Curriculum Branch). Science Co-ordinators in Singapore schools take on the task of subject co-ordination (see chapter 4) in addition to their teaching duties.

The 141 science co-ordinators are teachers from primary schools and their responses were made after viewing the videotape that was used in the teacher interviews.

The categories under the personal and social constraints on the teacher will now be considered.

(i) Pre-service and In-service Training of teachers using PSP

The range of years of teaching experience of the teachers in the sample for this study was from 2 years to 30 years. The average teaching experience was 18.3 years. As PSP materials were first introduced into schools in Singapore in 1982, the majority of the teachers in the sample would thus have not had any exposure to PSP in their pre-service training. 2 teachers in the sample did have some pre-service training in PSP, but 28 did not. Of these 28, there were 10 teachers who had in recent years undergone in-service programmes on PSP materials and teaching methodology, while the remaining 18 had not had any formal exposure to PSP. As the number of teachers in the sample for the present study who had some training in PSP was small it was not possible to see if this factor had in any way influenced the classroom situation in pupil use of the science process skills. An interesting comment made by one teacher was that she felt she could 'manage' teaching PSP without any in-service training.

The CDIS survey looked at the courses teachers have attended since 1983. Generally there have been four types of courses - single session workshops, courses less than 10 hours duration, courses between 10-30 hours, and a one year full time in-service course at the Institute of Education. These courses were conducted by the Ministry of Education (CDIS and Curriculum branch), the Institute of Education, the Science Centre and other institutes such as the

Science Teachers Association (STAS), the Regional Science Centre (RECSAM) and other school-based workshops.

The data showed that in the fifty schools surveyed and for teachers involved with class levels P4 -P6, in all 100 teachers had attended courses by the Ministry of Education, 21 at the Institute of Education, 97 at the Science Centre and other similar institutions. The total number of respondents at the P4, P5 and P6 levels was however 147.

It would thus appear that some of these respondents had attended more than one of the courses mentioned. Further, it would appear that the main source of in-service training is the Ministry of Education.

In order to see to what extent teachers felt confident about the PSP materials, they were using, the following questions were used as foci in analysing the interview data. The questions in connection with teacher confidence and the PSP materials were

(a) Did the teacher have any difficulty in conducting lessons involving any of the PSP experiments?

(b) Would the teacher be willing to teach without a teacher's guide?

(c) Would the teacher be happy to work without pupil workbooks?

(d) Would the teacher feel at liberty to omit exercises in the pupil workbook?

(e) What was the teacher's reaction to the set of

SIO's the school provided for her to work with in science?

(f) Did the teacher have any view on the level of prescription of PSP materials, and did she view the PSP materials as in any way limiting free enquiry by pupils?

The teacher responses are as follows.

(a) Did the teacher have any difficulty in conducting lessons involving any of the PSP experiments?

16 teachers in their interviews said Yes, while 14 said No. A t-test was carried out to see if the pupils from the two groups differed in their use of the fourteen process skills categories obtained from the SPOC data. No significant differences were observed between the mean scores of two groups. (Appendix 5 Table 1.a)

This seems to indicate that although some teachers claimed to have difficulty in carrying out some of the experiments, they were eventually able to carry out the lessons as far as the pupils were concerned without their anxieties affecting their pupils. It also suggests that teachers who said they had no difficulty were not particularly showing themselves to be any more competent in the exposure they were giving their pupils to the science process skills.

It may also be the case that teachers who had difficulty often said so because of the biological experiments where 'success' in an experiment dealing with living things cannot be guaranteed. In the course of the data collection, most classes had already completed these biological experiments. Most teachers were involved with experiments in physics which they all claimed they found easier to handle.

Difficulty in carrying out experiments does however, link itself to some extent to the issue of teacher confidence. The CDIS survey asked for responses on a 7- point scale on how confident teachers were about teaching PSP.

Appendix 4, Table 1a showing the data from the CDIS survey on teacher confidence seems to suggest that generally teachers are claiming to be fairly confident with teaching PSP. If one takes into account the kind of pupil involvement with the process skills categories discussed in Chapter Six, there seems to be a case of teachers believing they are doing a fair job in exposing their children to all the process skills. However, the low scores obtained in many of the skills seems to once again indicate that to teachers, PSP is more a 'hands on','activity oriented', 'children observing' type programme rather than one of enquiry.

(b) Would the teacher be willing to teach without a Teacher's Guide?

Only 3 teachers said Yes, while 27 maintained that they would not be confident enough to teach science without a teacher's guide which in the case of PSP they found very useful.

The following are some of the comments teachers made during their interviews on the role of the teacher's guide.

> " I find the teacher's guide very useful, but I would like it to give still more information Sometimes I don't feel very confident about the answers."

> " Without a teacher's guide I will have to find may own resources. I prefer to have a teacher's guide. "

Most teachers in their interviews tended to give comments similar to the first one indicated here. Teachers feel obliged to carry out 'successful' experiments with 'right' answers. However, the second comment does hint that there could be some who prefer taking an easier approach with the materials being provided rather than them having to exercise some professional judgement in their selection of materials. The data from the interviews seems to tie in with how the CDIS survey teachers responded to the issue of the Teacher's guide. While the CDIS survey did not offer an alternative to the teacher's guide but rather probed into possible shortcomings of their project materials, the data in Appendix 4, Table 1b does indicate clearly that teachers looked to the teacher's guide for ideas, content information, teaching strategies and methodology. Such a dependence on prescribed approaches cannot help achieve a classroom situation where creativity is sought and where children's questions are valued.

(c) Would teachers be happy to work without pupil workbooks?

14 teachers in their interview said Yes, while 13 said No. The remaining 3 said they were unsure. Teachers in their interviews made some of the the following comments.

> "Pupils would be lost without workbooks"
>
> "I would be very lost in some topics without a pupil workbook"
>
> "Without a workbook, it would affect both the confidence of the teacher and pupil. The workbook acts as a guide, I think, to the teachers as well as the children."
>
> "The workbook is more as a guide, sort of tells us what to look for . I think for our Singapore schools we need the workbook orientation. It tells us exactly what to look out for."

It would appear from the interview data that Singapore primary science teachers see the pupil workbook as a confidence giving crutch. The CDIS survey data shown in Appendix 4 Table 1c shows that generally the teachers find the pupil workbooks as helping them by providing the necessary exercises for concept and process skills acquisition.

(d) Would the teacher feel at liberty to omit exercises in the pupil workbook?)

This question explained the teacher's willingness to be selective of exercises within the workbook.

12 teachers said Yes, but 18 said No. The teachers who did omit exercises often remarked that it was because they found the exercises too simple and substituted their own worksheets which they felt would prove more interesting to their pupils. However, amongst the group that said No, the argument was often one of teachers feeling

obliged to complete all exercises because of parental pressure or demands of their principals. This later reference is highlighted by one teacher when she said,

> "Not in my case. My Principal is enlightened and supports us. We told him that certain things are not relevant - he does not object to us leaving them out."

As explained in Chapter Three, Singapore teachers are also provided with a detailed set of Specific Instructional Objectives (SIOS) in each subject area they teach. The following questions was asked during the interviews to establish teacher reaction to these SIOS.

(e) What was the teacher's reaction to the set of SIOS the school provided for her to work with in science?

4 teachers expressed a positive acceptance of the SIOS but 26 teachers reacted negatively to the SIOS. Of the 4 teachers who were happy to work with the SIOS they linked it to the examination situation and remarked;

> "SIOS help in a way. For our school when we set the exam paper, we have to look at the SIOS."

However, most of the teachers who were not happy with working with SIOS tended to echo the following sentiments,

> "I find the SIOS are in some ways repeating what is in the Teacher's guide - but I prefer to work with the objectives in the Teacher's guide. The SIOS are too rigid. I do not understand why the Ministry came up with them. In fact many teachers do not follow them. We just write it down to please the Principal."

It must be added here that generally the teachers did feel that it was important to plan their lessons and work with some objectives, but they did not want to be tied down to the very specific form of objectives that they perceived to be demanded of them. As one teacher remarked,

> "I would rather not be guided by the SIOS. So long as I have the syllabus, I will be able to come up with my objectives."

(f) Did the teacher have any view on the level of prescription of PSP materials, and did she view the PSP materials as in any way limiting free enquiry by pupils?

18 teachers found the PSP materials very prescriptive and limiting free enquiry by pupils, while 12 did not. Often, it appeared to the researcher that teachers wanted the teacher's guide and workbooks, yet admitted to these being highly prescriptive and limiting their teaching style and pupil enquiry. Examples of their comments are as follows;

> "Our workbook is very stilted and structured. It does not give much opportunity for children to ask their own questions and discover new things."

> "If we did not have workbooks and SIOS, I think I would have a lot more freedom. Before the PSP was introduced I was teaching science and we had lots of activity cards for children and that gave us more scope."

But other teachers felt that there was still room for teachers to use the materials with freedom, stressing PSP was only a guide.

> "It is up to the teachers to decide whether they want to follow it to the letter or adapt it. Teachers will have the freedom to adapt it if they feel it is necessary."

If teachers do choose to be less dependent on the workbooks, then what did they feel about children being allowed to record their findings in their own style and format, without prescription form either the workbooks or the teachers?

On free form of recording many teachers saw their pupils as not being able to record their findings without the guidance that the workbooks give. They acknowledged however that allowing children to record findings without the prescription of the workbook will

> "make children think about what they are writing. Our kids know exactly what to write because all they have to do is to look at their workbooks and then fill in the information asked. But in the video, the children do a lot of discussing before they record their work."

Other teachers pointed out,

> "The way PSP presents the work to children, it is very prescriptive and limiting. I feel that when children record without any guidance there is a better chance that children might record more facts than what the workbook asks."

> "If you train pupils from P4 then by the time they reach P6 they should be able to do it on their own. Now we spoon-feed them so they can not show much initiative in recording without guidelines. However, as a teacher, I can not work without a workbook. Perhaps the 'pupil' workbook should be only for the teacher as a guide. You do not need it for pupils."

From these comments one tends to notice a mis-match of what teachers see PSP materials providing by way of confidence for them and their pupils, yet acknowledging such an approach as limiting the potential of the child. The pre-service training and in-service training of teachers will need to look particularly at this aspect as a constraint towards full implementation of PSP.

(ii) Science Co-ordinator's Support

How did the teacher view the role of the science co- ordinator?

18 teachers responded with the view that they sought the assistance of the science co-ordinator sometimes, while 3 said they sought the help of the co-ordinator often. Against this there were 4 teachers who said they seldom went to the co-ordinator for assistance and 5 of the teachers in the sample for this study were their schools' science co-ordinators. Responses from the teachers included,

> "I go to the co-ordinator only when I am in need of something or when I do not understand something. I expect the science co-ordinator to know more than we. I do not think she is an expert, but I know that if I were to go to her I know that she would be able to give me the answer. I have not been for any process skills course but the science co- ordinator has."

It would appear that teachers generally see the science co-ordinator as being there to assist them in specific problems, not so much to develop a long term programme for the school. One of the teachers who was herself a science co- ordinator appears to confirm this when she said,

> "When the teachers need things they come to me. So far they do not see me for other things. I make sure the teachers have apparatus, check to see if anything is broken and get it replaced. Most teachers I think do not see the co-ordinator as qualified to conduct workshops."

It would appear that generally the science co- ordinator is looked upon as someone whom science teachers can approach for assistance with regard to some of the duties listed in the role of co-ordinators discussed in Chapter Four. However, it would appear that some of the other professional roles such as that of developing a continuous programme within the school to assist teachers in their professional growth seems yet to be implemented.

Further data on the science co-ordinators becqme available when the researcher was in Singapore for data collection. The Ministry of Education (Curriculum Branch) invited the researcher to conduct a workshop for primary science co-ordinators so that they could view the video tape on process skills used in the teachers' interviews. 143 science co-ordinators attended the workshop. They were invited to respond to the video tape, as well as complete a questionnaire on their teaching priorities. Their comments were revealing. The science co-ordinators seemed to raise doubts about the possibility of the process skills being implemented to the extent that the pupils in the video tape were displaying. They raised the following as constraints.

- Need to complete the syllabus for examinations
- Insufficient time to allow children to plan and raise questions for involvement
- Pupils not fluent in English to express themselves
- Class size was too large for a teacher to give groups attention
- Space in a classroom was not sufficient for many activities
- The level of noise would be too high.

There were, however, aspects that they liked, such as the relaxed classroom atmosphere, the initiative that children showed in making their recordings, the use of the easel board that allowed children to share in each group's work and children raising their questions and interacting with each other.

If however, science co-ordinators feel the constraints are insurmountable then full implementation of PSP will be affected, especially as the science co- ordinators are seen as subject leaders and the source of liaison between the teacher, the principal and other Ministry of Education Officials.

(iii) The 11+ Examination

Five questions were covered in this section.

- Did the teacher see the demands of the examination affecting her teaching style?
- Did the teacher see the PSP materials as process skill orientated?
- Did the teacher see the PSLE examination as process skill orientated?

- Did the pupils use the workbooks as a source of examination preparation?

- Did the teacher see the giving of notes as essential?

The thirty teachers in the sample were very emphatic in their replies when they said that the pressure of the 11+ examinations affected the way they went about their work. Their main concern was completing the syllabus for the PLSE examination.

On whether the PSP materials were process skills oriented,) 12 teachers said yes, it was, 13 felt it was only a little oriented towards process skills and 5 teachers said it was not process skills oriented. On whether the PSLE examinations was process skills oriented, 14 teachers said it was not, 10 felt it was a little and only 6 said yes, it was.

Amongst the three groups of teachers, that is those who saw the PSP as process skills oriented, those who said it was a little and those who said no, an analysis of their pupils' use of the process skills categories was made. A similar analysis was made of the three groups who responded likewise to the PSLE being process skills orientated or otherwise.

An analysis of variance procedure was carried out to test if there was a statistically significant difference of the means observed for each of the 14 process skills categories referred to in the SPOC classroom observation schedule for pupils from the

3 groups of teachers. The test showed that the pupils of the groups responding to whether the PSP materials were process skills oriented did not significantly differ in the use of the process skills at the 0.05 level (Appendix 5 Table 1.b). In the second case referring to whether the PSLE was process skill oriented, the only case where there was a significant difference between the three groups wasfor the skill of interpretation.(Appendix 5 Table 1.c) In this case, Scheffe's test showed that the pupils of the group of teachers who said the PSLE was process skills oriented had a higher incidence of use of the skill than the other two groups (probability $<=$ 0.05). This may be because the teachers who think the PSLE is process skills oriented allow for more interpretation in their classrooms as they perceive the examinations as setting a fair number of questions on interpretation.

However, generally it appears that teachers, irrespective of how they perceive the PSP materials and the PSLE in terms of process skills, have not made any discernible adjustment in the extent to which they allow for the skills to be used in their classrooms. This is not to say that process skills are not used, but again tends to confirm an earlier analysis that teachers are not varying their teaching approaches to any significant difference to cater for the skills.

This finding does not seem unusual when one looks at the comments teachers made on the PSP materials and the PSLE in terms of process skills. The following are some of the comments made.

> "Process skills are now meshed into the exams. Teachers inform me that process skills are being tested."

> "The PSLE is still content oriented. I do not pay much attention to process skills. I am concerned with the exams. Also parents may ask why in daily work you do not pay attention to the things required in the exams."
>
> "If we emphasise process skills in science lessons we might not be helping our children to score in the PSLE. For process skills our children should be tested in the classroom situations, and teachers will have to do the assessment."
>
> "I think we will not make much progress until there is a drastic change in the PSLE. Main change must be in the style of the questions - where not too much content is required."

These comments show that generally teachers still feel that these is no strong congruency between the materials advocating process skills and the PSLE examination questions.)

An attempt was made to see if this perception of the teachers with regard to the PSLE examination questions was a correct one. As the examination questions set in the PSLE are confidential, there was no direct way in which the researcher could confirm this. However, each year the Ministry of Education, Singapore (Testing Branch) sends out to schools its guidelines for the different examinable subjects at the PSLE. An analysis of the guidelines was made to see to what extent the examination had kept in touch with the changing emphasis on process skills.

The PSP materials were first introduced into schools in 1982. The cohort of children in P3 in that year were the first cohort of children to be exposed to PSP materials in each succeeding year, thus being the first cohort of children to be examined at the PSLE on the new materials in 1985.

An analysis of the guidelines or examination specifications shows that there was no change in the specifications until 1985. In the 1985 specifications, for the first time a more detailed specification of the process skills aspect of the examination was provided. The following comparisons of the 1984 specifications with that of 1985 will help to show the changes made in the direction of process skills.

	1984 PSLE Examination Specifications	1985 PSLE examination Specifications
Skills to be tested	(i) Remembering	(i) Recall
	This category requires the pupils to recall, reproduce or perform routine manipulations of facts, rules, procedures or any other materials which has been presented to them in the course of instruction.	This category of items requires pupils to recall facts, rules, procedures or any other materials that have been presented to them in the course of instruction
	(ii) Understanding and Thinking	(ii) Understanding & Application of Knowledge which includes process skills.
	This category of items requires the students to make use of higher order skills such as applying known principles to completely new situations, recognising freshly presented information as pertaining to known principles or theories interpreting and understanding data, classifying and the like.	This category of items requires the pupils to make use of higher order skills such as using generalisations, applying known principles to new situations and using process skills such as observation, classification, communication, inference, prediction, planning and

		conducting experiments and interpretation of data
2. Categories of questions	a) Remembering 52 marks b) Understanding & thinking 48 marks	a) Recall 46 marks b) Understanding & application; process skills 54 marks
	Total 100 marks	Total 100 marks

It would appear that the PSLE examination has made some attempt to take cognizance of the move towards process skills in PSP. While the change may be small, for example reducing recall questions by 6 marks , and increasing application and process skills by 6 marks, the fact that process skills are specifically mentioned is a first step. Further, the specimen questions provided in the specifications provides examples of questions on process skills, for the first time in the 1985 specifications. Perhaps, to convince teachers of the need to allow for more process skills opportunities for their pupils, the examination questions in PSLE have to lead the way in an examination oriented situation with a more obvious emphasis on process skills.

Did their pupils use the workbooks as a source of examination preparation?

28 teachers said Yes, while 2 said No. This would indicate why teachers generally were hesitant to work without pupil workbooks. To them the workbook was seen as a record of what had been covered (see Table 6.3) as well as a source for examination revision. Did

the teachers see the giving of notes as essential? 21 teachers said Yes, while 9 said No. Teachers' feelings are summed up in the following:

> "The pupils use the workbook and some notes which I give them to revise for the exams. The notes I give are not detailed but what we think are not in the textbook. We feel that it is something extra which the pupils may need."

(iv) Pupil Background

This was not investigated directly for the children whose classrooms were observed as it was not possible in the time available. However, in the Singapore context, the data on the school's profile can, within limits, be taken to be generally characteristic of pupils attending a given school. Two aspects were considered.

1. Language background : Data obtained from school principals provided information on the percentage of children using English as the most commonly used home language.

2. PSLE examination grades : Data obtained showed the percentage of children in the school who scored A-star (i.e. 91 per cent and above) and A grade (75 - 90 per cent) in the 1986 PSLE examinations.

The following were examined

a) The percentage of children in the school with English as a home language was examined against their science performance in the PSLE (1986) examinations.

b) The influence of the home language on pupil use of the process skills.

Language background

Science is taught in English in all schools in Singapore. However the home language may not be English. 8 teachers raised this as a problem for them in the classroom especially as they felt their pupils were not able to express themselves freely and clearly. 18 teachers however said language was not a problem while 4 teachers found it gave them some problems.

A Pearson Correlation was carried out to see if the percentage of pupils in a school using English as a home language had an influence on the incidence of pupil use of any of the process skills categories. No significant correlation was obtained, thus indicating that the home language, in spite of what teachers perceived, was not influencing the incidence of the use of skills as measured in this study. (Appendix 5 Table 1.d). However, it must be pointed out that in the classroom observations, some teachers certainly had to spend more time explaining words to children.

Some examples of how pupils used language that teachers felt needed correcting are:

"The iron is used to make cloth straight" (a lesson on heat) (Teacher explained it was to remove creases)

"A toaster is for cooking bread - to make bread hot"

Teachers in such classes had to spend time explaining words like advantage, disadvantage, contract, expand, insulate, positive, negative, attract, repel. In other classes observed for similar lessons, pupils who come from homes where English was spoken did not need as much time spent on explaining the meanings of words. An interesting situation arose when in one class some Chinese pupils found it difficult to understand why a bulb in a circuit lit when the teacher said the circuit was closed. They insisted it should be the other way round.

After some time it was realised that for the child translating from his dialect; when the bulb in his home lights up, he would say he has 'opened the light' - hence he now felt it should be to open the circuit. Perhaps this is the kind of language misunderstanding that does affect children working in a language which is not their home language.

PSLE Grades and Language

To investigate any evidence of a link between high grades at the PLSE and pupil use of English as a home language, the correlations between the percentage of the use of English at home and the percentage of A-star and A grades were examined. These were found to be highly significant (p <= 0.0001 for both correlations). (Appendix 5 Table 1.e). While this issue cannot be analysed further with the available data in this study, it does indicate a need for some research into language issues in Singapore schools.

Parental Pressure

Did the teacher feel any pressure from parents that might affect her teaching style?

13 teachers said Yes, they did feel parental pressure, 15 said No, and 5 said they felt a little pressure. Often those who said they were under pressure said that parents wanted to see their children 'learn facts' and quoted as an example that parents would not be happy if pupils did not have completed workbooks as evidence of work covered. Even project work the teachers felt that, while it may benefit pupils, it may not provide the tangible evidence that parents look for. Teachers expressed their views as follows:

> "Parents would ask, where is the written work and things like that. Our parents of pupils are very exam conscious. I am in favour of a more relaxed approach as in the video programme - I do that in some of my English lessons. But I do not think parents would take too kindly with that in science. Parents want to see what their children have done in schools. They check their workbooks."

> "The end result is more important to parents than the approach I take. I am expected to teach them content so that they can answer questions in the exams."

However, one teacher said,

> "I think parents would accept children working on their own projects - it is a more enjoyable way. When the new science books first came out there were lots of complaints from parents who help their children in their work at home because they say there is nothing factual in the book. But now they are beginning to accept that these activities in science are actually the right approach to learning."

This mixture of responses does indicate that to some teachers the concern of producing results for parents is more strongly entrenched in their activities than for others who either disregard parental pressures or feel that parents can be brought round to a new attitude to learning for their children.

vi Teacher Perception of Pupil Ability

Based on what teachers saw of pupils in the video programme using the various process skills, they commented on how they perceived their own pupils would be able to do likewise. Their comments were then classified and scored as responses to the following questions:

1. Did the teacher see her pupils using the skill satisfactorily?

2. Is sufficient opportunity provided in the PSP materials for each skill to be developed?

3. Should the skill be encouraged in children?

4. Does the teacher see her pupils improve in the skill through more opportunity being provided?

The skills that the teachers commented on related to those that they had seen in the video programme. They were,

- Observation
- Using measuring equipment
- Interpretation — Predicting / controlling variables
- Raising questions
- Planning of experiments
- Explaining/Hypothesising
- Free format recording (i.e. children recording without the prescription found in the workbooks).

Table 7.1 provides information on the number of teachers who responded in each category, based on their perception of their pupils.

Table 7.1 Teacher Perception of Pupil Ability

Process Skill	Number of Teachers Responding in Each Category									
	Pupil Use of Skill			Opportunity for use of skill provided for in PSP			Pupils will improve with opportunity		Skill to be encouraged	
	Can	Not all	Cannot	Yes	Some	No	Yes	Some	Yes	Conditional
Observation	28	2	-	30	-	-	30	-	30	-
Using Measuring Instruments	27	3	-	29	1	-	30	-	30	-
Predicting	22	5	3	23	6	1	30	-	30	-
Controlling Variables	12	11	7	17	7	6	27	3	30	-
Raising Questions	-	12	18	-	14	16	20	10	30	-
Planning	3	1	26	2	3	25	16	14	19	11
Explaining/ Hypothesising	10	17	3	4	22	4	23	7	30	-
Free format recording	3	2	25	1	4	25	18	12	30	-

The discussion that follows is based on the data from Table 7.1 as well as from notes made by the researcher during classroom observations of the science lessons.

Observation

28 teachers felt their pupils could make observation to the same extent as the pupils in the video. 2 said not all their pupils would be able to do as well. However all teachers felt that observation was a skill that PSP materials provided opportunity for and that it was a skill that their pupils would improve in with more exposure and that it should be encouraged in children. The P6 level teachers were concerned about observations made from an exam point of view as well. The following interaction took place between teacher and pupil that illustrates this concern.

Pupil (describing a picture of an orange) : The orange is juicy.

Teacher : How do you know that?

Pupil : I have tasted it before

Teacher : You can't say what you don't see .....

Using Measuring Equipment

27 teachers felt that their pupils would be able to use measuring instruments, while 3 felt not all their pupils would be able to.

They found PSP materials did provide for the skill, that their pupils would improve with more opportunity, and that it should be encouraged. A good example of children showing keen interest in the measuring equipment they use and accuracy of measurement is seen in the following interaction:

1st Pupil to 2nd Pupil	How can you get 250 grams when the spring balance you have only goes up to 200 grams?
2nd Pupil replies	We took the weight printed on the milk packet. We did not weigh it (Milk packet however did not show the weight but volume - 250ml).
Teacher intervenes	You are not correct. Volume of milk is not the same as the weight.
3rd Pupil	I told the group that but they would not listen.

Prediction

22 teachers perceived their pupils as being able to make predictions, 3 felt some of their pupils may be able to, while 5 teachers felt their pupils would not be able to. In terms of provision in PSP, 23 teachers said there was, 1 said there was a little and 1 said she did not see any provision. All teachers however felt their

pupils would improve with opportunity and that the skill should be encouraged in children.

The researcher did observe examples of pupils involved in exercises involving predictions. Pupils appeared to enjoy making their predictions and then testing them. They were excited when they found their predictions to be correct. Examples were also seen of some teachers providing opportunity for predictions even though the materials did not specifically call for them.

Controlling Variables

12 teachers said their pupils would be able to control variables, 11 said some of their pupils would be able to, while 7 teachers did not perceive their pupils as being able to. Seventeen teachers saw PSP materials as providing opportunities for this skill, 7 saw some opportunity but 6 did not see any opportunity being provided in PSP materials. Generally teachers saw their pupils improving with more opportunity and all felt the skill should be encouraged.

A good example of pupils contributing their ideas about how the variables could be controlled is seen in an experiment they were carrying out on making an electro-magnet with batteries, wire, nail and showing its strength by using it to pick up some paper clips, and making group comparisons.

Teacher Let's design a fair test. What must we do for a fair test.

Pupils' suggestions We must make sure the power is the same. Some girls have brought old batteries, others are new, that's not fair. We must have the same size battery. Same make battery. Batteries must not be leaking or rusty . We must have the same length of wire. Same type of paper clips. Same type of wire.

Teacher (Demonstrating coiling the wire round the nail) asks: What do you remember about this?

Pupil Number of turns. We must keep the same number of turns.

Raising Questions

Only 2 teachers said their pupils could definitely raise questions that could be used for investigation. 12 teachers however said some of their pupils may be able to , while the majority, 16 said they did not think their pupils could. These 16 teachers said PSP materials did not provide opportunity for this skill, while 14 said there was some provision. However, while all teachers said the skill should be encouraged, 20 teachers felt sure their pupils would improve with opportunity, while 10 teachers were of their opinion their pupils would not be able to do so. Their often quoted reason was the language fluency of their children being a handicap. The nature of questions the pupils were observed to ask were, for example;

Why is the flame blue?

Why is ash white?

Do all things in this world have a shadow.

This scissors handle is plastic, it can not be magnetised. How should I classify the scissors?

Planning

3 teachers said their pupils could make plans, 1 felt her pupils may be able to, whilst the majority, 26 said they felt their pupils would not be able to. This was clearly related to the fact that only 2 teachers saw PSP as providing opportunity for this, 3 felt there was some provision in PSP, while 25 saw no opportunity being provided. 16 teachers saw their pupils improving with opportunity, while 14 teachers did not see this happening. Again, only 16 teachers were willing to 'say it should be encouraged. 11 teachers said it should be encouraged, conditional to them having more time, there was no examination stress, and their pupils were more proficient in English.

Hypothesising

Only 10 of the teachers saw their pupils as being able to hypothesis or provide some explanations. 17 felt some of their pupils may be able to, while 3 said they would not be able to. Only 4 teachers saw PSP materials as definitely providing for this skill, 22 said there was some provision, while 4 saw no provision in PSP. However teachers felt with opportunity their pupils would improve and that this should be encouraged. An example of the level of hypothesising that was observed is seen in the following hypothesis which could be tested.

Teacher Why do people make things of metal.

Pupil Because it is strong ... can be used for a long time. Cannot break it, but we can break plastic.

Free format recording

This is when pupils are given the opportunity to make their recordings, perhaps using an easel board so that the rest of the class can follow the recordings, but primarily not giving the kind of prescription found in worksheets.

3 teachers said their pupils would be able to make such recordings, 2 felt some of their pupils may be able to, while the majority, 25 said their pupils would not be able to. Only 1 teacher saw PSP allowing for children to record in their own style. 4 said there was some opportunity in PSP but the majority said PSP was too prescriptive in their workbooks to allow for this. All teachers felt however it was a skill that should be encouraged as it allowed pupils to communicate in their own way, and they felt that with the opportunity their pupils may improve.

Other reactions from teachers

During the course of viewing the video, some teachers volunteered their opinion on how they perceived the children in the programme approaching their work, as well as the approach of the teacher. The following is a summary of these comments.

10 Teachers said they found the children in the video programmes very independent.

11 Teachers described the children as confident.

7 Teachers described the children as working creatively.

7 Teachers found the children very responsive.

15 Teachers found the children very willing to express their views.

12 Teachers found the teaching approach enjoyable.

27 Teachers said it was a non-restrictive method, allowing for much interaction between pupils as well as the teacher and pupils.

12 Teachers commented on productive group work.

11 Teachers described the use of the easel board as a good idea.

Some of their comments are as follows :

> "The way the children in the video work on their own - I think that is really marvellous. They are left to discover for themselves."
>
> "I like the idea of the easel board - it allows children to share their work easily with others."
>
> "The children have initiative. They are independent."
>
> "The way the children move around and touch the things - there is no restriction - there is no worry about noise - such an approach will also improve the children's vocabulary. But language is a handicap in our schools."

While not all teachers volunteered their comments the summary does show that there are teachers who are very keen to be less prescriptive and have a more relaxed teaching learning environment for their pupils.

vii Teacher Interest in Teaching Science:

Did the teacher like to teach science? In the sample, teachers had been teaching science from one year to thirty years. The mean number of years of science teaching experience was 10.2 years. 25 teachers said they liked to teach science, while 5 said they did not.

A t-test was carried out to compare sample means i.e. to see if the group which said they liked to teach science had pupils involved in the process skills categories significantly different from the group that said No. On all skills the t-test showed no significant difference between the two groups indicating that teacher attitude to the subject did not appear to have an effect on the incidence of their pupils using the process skills.

Did the teacher favour the idea of a specialist science teacher? Would the teacher herself like to specialise in science?

12 teachers said they would like to specialise while 14 did not want to. Four teachers said it would be conditional to them only having to teach at no more than two age levels, or being able to combine science teaching with mathematics. Those teachers who advocated specialisation felt it would help them develop their knowledge of the subject with long term interests and that their pupils would benefit from their experience.

B. PHYSICAL AND SOCIAL CONSTRAINTS ON TEACHERS

Class size

The most common class size of the teachers in the sample was 40 pupils, while the most common group size was 6. Teachers in response to the video and observing the way children went about their work were quick to comment that such activities were possible only with the small size of the class which in the case of the video programme was 20, in groups of 5.

Teachers when asked what their ideal class size would be said on the average they would find 25, pupils per class ideal (the smallest size mentioned was 15, while the largest was 35). Their ideal group size was 5 (one teacher however said she did not like group work).

Teachers who raised the class size as a major constraint said it also affected the noise level and the attention the teacher could give pupils. They were also convinced that large class sizes would make it difficult for teachers to work with children's ideas and questions. They also felt that it would mean having more children per group or more groups, both of which would weaken the inter-group interaction.

Classroom space

18 teachers in the sample had access to a science room while 12 teachers did not. In the interview, 22 teachers felt having a science room was important while 8 were of the opinion it was not essential. However, teachers did comment that pupils enjoyed working in the science room. The arrangement of the desks and the extra space in a science room made it more conducive to experimental work. For teachers, it meant that all apparatus was in easy reach. It must be pointed out that teachers in the sample did utilise locations other than their classroom and science room when necessary. Some teachers used the school canteen, corridors, and

playground. Most teachers working in their own classrooms were able to effectively move furniture around without much loss of time.

Timetabling

21 teachers felt that time was a problem. The total amount of time per class for levels P4 - P6 was two and three quarter hours, per week. This is stipulated by the Ministry of Education. Principals then work this out to either single periods or double and single periods. Teachers found having double periods important. The teachers who found time insufficient suggested a figure of 3 double periods per week - ie. approximately an extra 30 minutes per week.

Equipment and Resources

Generally teachers were quite satisfied with the equipment and materials they had access to. Only 8 teachers expressed some concern about obtaining some of the materials required for the experiments. Often these were the biological specimens recommended in the teacher's guide. In some cases teachers did not have enough weights for all groups and this modified the exercises to suit the situation or did a demonstration. 6 of the 10 schools had an ecological pond that helped teachers in their teaching of ecology. 5 of the 10 schools had an ecology garden. In the course of the interviews 20 teachers voiced the opinion that having the equivalent of a laboratory attendant that secondary sciences teachers have would help them tremendously where obtaining and setting up the materials for the science lessons was concerned.

C. OTHER ASPECTS OF THE CLASSROOM SITUATION

From the remaining categories of the SPOC schedule it was possible to make the data analysis presented in Table 7.2 - 7.7 It shows the mean values of percentage of minimum frequency of incidence for each category mentioned and covers the following areas :

a) Pupil Talk Variables (Table 7.2)
b) Non Talk Pupil Variables (Table 7.3)
c) Teacher Talk Variables (Table 7.4)
d) Non Talk Teacher Activity Variables (Table 7.5)
e) Audience Interaction of Target Pupil (Table 7.6)
f) Teacher Interaction (Table 7.7).

Whilst the means provided in the tables show small differences between groups, it must be pointed out that an analysis of variance procedure carried out to see if the group means were statistically different showed that there was no significant difference between the groups on the variables at the 0.05 level except for children waiting for other pupils. (Appendix 6 Table 1. a-f)
A summary of the more relevant aspects is discussed.

Table 7.2 Other Pupil Talk Variables
% Minimum Frequency of Incidence
Means at 3 Levels (P6, P5, P4)

Variable	All levels N = 30	P6 Level N = 10	P5 Level N = 10	P4 Level N = 10
Reporting	5.8	5.3	5.2	6.0
Reading out/ Discussing Instructions	1.0	0.5	1.5	1.0
Discussing Meaning of Words	3.2	2.4	3.7	3.4
Asking for Help	2.3	1.8	2.7	2.3
Organising Task	4.4	7.5	3.7	2.0
Non-Task	1.2	1.6	0.8	1.2

Table 7.3 Non-Talk Pupil Activity Variables
% Minimum Frequency of Incidence
Means at 3 Levels (P6, P5, P4)

Variable	All levels N = 30	P6 Level N = 10	P5 Level N = 10	P4 Level N = 10
Collecting/Cleaning Equipment	4.8	5.4	3.5	5.6
Reading Book/ Worksheet etc.	16.8	15.8	19.2	15.4
Copying from Book/ Worksheet/Board	2.0	3.5	0.6	1.8
Waiting for Teacher	7.0	5.9	5.6	9.6
Waiting for Other Pupil(s)	3.7	7.3	1.7	2.0
Attentive to Teacher	27.8	32.9	24.0	26.6
Attentive to Other Pupil(s)	11.3	19.6	8.7	11.6
Non Attentive to Task	1.5	1.0	1.6	1.8
Organising for Group Work	1.7	2.4	1.1	1.7
Moving to Another Location	1.4	0.9	0.3	2.9
Watching Film/ Video	1.1	1.8	0	1.5

Table 7.4 Teacher Talk Variables
% Minimum Frequency of Incidence
Means at 3 Levels (P6, P5, P4)

Variable	All levels N = 30	P6 Level N = 10	P5 Level N = 10	P4 Level N = 10
Giving Information (Task)	11.2	10.4	11.2	11.9
Giving Instructions (Task)	25.1	23.6	24.5	27.1
Commenting on Pupils' Answer (Task)	10.5	11.1	10.4	10.1
Asking for Account of Progress	7.8	9.6	8.7	5.1
Questioning	27.6	25.5	27.5	29.8
Non-Task	4.4	2.5	3.4	7.3

Table 7.5 Non Talk Teacher Activity Variables
% Minimum Frequency of Incidence
Means at 3 Levels (P6, P5, P4)

Variable	All levels N = 30	P6 Level N = 10	P5 Level N = 10	P4 Level N = 10
Collating Pupils' Ideas	17.9	19.3	15.1	19.4
Demonstrating Activity	10.7	9.5	13.2	9.3
Listening to Pupils	0.2	0	0.2	0.3
Writing on/Correcting Pupils' Work	0.1	0.4	0	0
Collecting Pupils' Work	0.4	0	0.6	0.5

Table 7.6 Audience/Interaction of Target Pupil
% Minimum Frequency of Incidence
Means at 3 Levels (P6, P5, P4)

Target Pupil's Audience	All levels N = 30	P6 Level N = 10	P5 Level N = 10	P4 Level N = 10
Pupil - Pupil	0.5	0	0.2	1.3
Pupil - Teacher	0.1	0	0.1	0.2
Pupil - Group	39.8	43.7	45.9	29.8
Pupil - Whole Class	55.2	55.1	48.5	62.1
No Audience	3.9	2.2	4.4	5.1

Table 7.7 Teacher Interaction
% Minimum Frequency of Incidence
Means at 3 Levels (P6, P5, P4)

Teacher Interaction	All levels N = 30	P6 Level N = 10	P5 Level N = 10	P4 Level N = 10
Teacher Monitoring	5.2	4.8	5.1	5.8
Teacher Interacting	68.2	64.0	67.1	73.6
Teacher Not Present	25.9	29.8	26.9	21.0

1. In Table 7.3, 'children waiting for other pupils' category at the P6 level was found to be significantly higher than that at P4 and P5 (Scheffe's test, p<= 0.05). This may be explained by the fact that more activities involving children measuring occurred at the P6 level and children had to take their turns at the limited weights and measuring instruments.

2. In some classes in the category of 'discussing meanings' some teachers had to spend more time explaining the meanings of words to their pupils (Table 7.2). This to some extent may have a link to the pupil's home language background.

3. Table 7.6 shows that most interaction in the class took place during group work and when the teacher and pupils were in whole class situations. The latter would be when the teacher was collating pupil findings.

4. Table 7.7 shows that teachers do not tend to monitor pupil interactions - more of a tendency for them to interact and be involved. This may not be a useful practice if it means that during the interaction teachers tend to provide answers to pupil queries, and not leave the children to work things out for themselves.

5. It appears that classrooms are still tending to follow the traditional pattern of teacher dominance as the rather high means for the minimum percentage frequency of incidence for 'teacher

giving instructions' and 'questioning' (Table 7.4) and 'pupils attentive to teacher' (Table 7.3) indicate.

As a comparison of teacher activity and pupil activity the incidence of 'teacher giving instructions' and 'questioning' appears to be as high as pupils 'making and discussing observations' (see Table 6.1).

ANALYSIS OF TEACHER QUESTIONNAIRE ON TEACHING PRIORITIES

The questionnaire was presented in Chapter Five. Teachers were asked to list the top three statements of a list of six statements that affected them on a day to day basis in their present situation and secondly on an ideal basis. To analyse their priorities, a rating scale was used. For each statement selected as priority 1 a score of 3 points was given. 2 points was given for priority 2 and 1 point for a statement selected as priority 3. From the total that each statement gained a mean was calculated, with number of cases equal to 30. The data are presented in Table 7.8. From the data analysis, it can be seen that the highest priority presently is in the official syllabus. This is closely followed by the use of the process skills. It would appear that concept development has come to take a lower priority to that of process skills.

Table 7.8 Teacher Priority: Present and Ideal (N = 30 Teachers)

	STATEMENT *	*Present* Priority Mean Value	*Ideal* Priority Mean Value
1.	What I think the students in my class will need when they leave school	0.2	1.0
2.	The official curriculum or syllabus	1.9	0.1
3.	Prescribed text books	0.5	0.0
4.	What the students will need in the next grade/course	0.4	0.4
5.	Developing the ability of the student to think scientifically and to use the process skills	1.8	2.7
6.	Helping the students to acquire a systematic knowledge of scientific concepts	1.2	1.7

* Statements taken from IEA study 1984

Table 7.9 Science Coordinator Priority: Present and Ideal (N = 143)

STATEMENT *	Present Priority Mean Value	Ideal Priority Mean Value
1. What I think the students in my class will need when they leave school	0.2	1.2
2. The official curriculum or syllabus	2.3	0.3
3. Prescribed text books	0.9	0.1
4. What the students will need in the next grade/course	0.5	0.2
5. Developing the ability of the student to think scientifically and to use the process skills	1.2	2.5
6. Helping the students to acquire a systematic knowledge of scientific concepts	1.0	1.6

* Statements taken from IEA study 1984

In the ideal priority list, process skills are the first priority. The mean score is much higher here than that for priority one in the present priority list. It shows that more teachers are convinced of the importance of process skills and would like to make it their first priority. Concept development takes second place in their ideal priority list and interestingly, pupil needs when they leave school is third. Further, in an ideal situation teachers have rated the official syllabus as only fifth in their priority listing.

The responses on priorities from the 143 science co-ordinators were also analysed in a similar manner. Table 7.9 provides the results of this analysis. Again for present priority, the official syllabus takes first place while developing process skills comes a close second and developing concepts third. In their ideal priority listing, in first place is process skills development and concept development comes second. Similarly as for the results in the ideal priorities for the teachers the science co-ordinators also placed the needs of their pupils when they leave school as third and placed the official syllabus in fourth place.

These results show that in a way Singapore teachers in the sample are not presently working in what they would term an environment where their ideal teaching objectives are being exercised. It seems to be a case for attention that the constraints they face may be less of a personal disinterest or low value of process skills, but more of being in a situation where they perceive there are other tasks expected of them. Generally this seems to point in the direction of examination grades and the stresses that arise from that.

In the final chapter, some of the mere salient features arising from the findings of Chapter Six and Seven will be considered.

CHAPTER EIGHT

SUMMARY AND CONCLUSIONS

OVERVIEW OF STUDY'S ORIENTATION

This study set out to make an investigation of the science process skills in the intended and implemented PSP of Singapore. The science process skills were the focus of the investigation since the national primary science syllabus set out as one of its four aims the need for schools to help each pupil to acquire the ability to use the science process skills. The science syllabus went on the first premise that pupils learn best by doing, actively manipulating the materials and by sharing the experiences with their classmates. The second premise the syllabus went on was that content learning is secondary to process learning. In this respect it looked towards the teacher as the facilitator of the learning rather than as a dispenser of science facts. The teacher's guide carefully points out that the materials are to be seen as a guide and not as pre-scriptions advising that the development of communication skills will be hampered if teachers do most of the talking.

In the course of working towards a research design some curriculum evaluation and curriculum implementation models were reviewed in Chapter Two. The review looked particularly at Tyler's objectives model, Cronbach and later Stufflebeam's decision-making rationale as a basis for evaluation, Stake's model on the congruence between the intended and the actual and the illuminator's model. This study did not, however, base its evaluative work of PSP on any specific model.

An eclectic methodology has been adopted. The objective of the PSP programme has not been ignored. In a centralised system such as in Singapore, where there is hundred percent uptake of PSP, it was possible during classroom observations to directly link each lesson observed with a specific exercise set out in the teacher's guide and pupil workbook. The objectives in this case referred not to the content or the concepts of the lesson but to the process skills the science lesson lent itself to, and which were evident from an analysis of the PSP materials. It was however necessary to establish the criteria and for each process skill category that was to be observed and scored, the criteria for deciding how a skill would be recognised was determined before observations were carried out.

Stake's model of the congruence between intended and actual outcomes related to this study to the extent that what was observed (outcomes) was then matched with what was intended by way of an analysis of the PSP materials, and the extent of congruence between the two established.

This study then went on perhaps in the style possibly of the illuminative evaluation to look at the implementation of PSP in terms of its process skills from as wide an angle as possible. It has attempted to provide information which portrays the innovation in the context of a recognisable reality and to document a broad spectrum of teacher responses. This was possible from the teacher interviews, the linking of field notes to the observed data and the inclusion of survey data by CDIS. This study cannot claim to have worked in a judgement free context. The information itself that can be presented cannot be considered to be value free. Inevitably the selection of what data to collect, the method of analysis and its reporting, have been based on the researcher's own values and possible biases.

An issue arising from the review of evaluation models in Chapter Two was one of decision making and who should be the decision maker. In this study, certainly the findings do indicate that some decision making will be necessary. However, as often is the case in a centralised education system, decisions are taken at different levels. To that extent, the data that are available from this study can provide a guide to necessary decisions. However, on the issue of teacher training and the nature of pre-service and in-service course content, it will be possible for the researcher to have some influence. To that extent, perhaps, in an evaluative study such as this, the evaluator can also be a decision maker. In actuality, this was a strong motive for the researcher to embark on this particular study.

In Chapter Two, there was also the reference to barriers to change. These have been identified in this study by the thirty teachers in the sample, and modelled on the Schematic Process of Classroom Implementation of PSP that has been described in Chapter Five.

Chapter Three looked at various primary Science Curriculum projects. Against the background of these projects, PSP was seen as a prescriptive curriculum that attempted to embrace both the pursuit of skills and concept goals. A fair amount of commonality was observed between the four themes of PSP and the broad themes suggested by Harlen (1978), the Oxford Primary Project and SCIS. This does give the confidence that generally curriculum developers seem to be agreed on the broad areas of children's work in primary science. However, the centralised system in which PSP operates and the prescribed nature of the materials tended to make it different from the more informal approaches of projects in England. The inevitable question became what effect the prescription of PSP would have on children raising their own questions - a point now very much in the focus of the kind of science that is being advocated for primary children.

Chapter Four outlined the impact of the implementation of PSP and identified the process skills categories for the study and the criteria for recognising the skills. Against these criteria the process skills as used by the pupils during the classroom observations were identified that would be scored as a percentage of minimum frequency of occurrence. The outline of the schematic process of classroom implementation of PSP developed for the study was presented. This model provided the backdrop against which teacher interviews were conducted.

Chapter Five discussed the research design and methodology. The main instruments for data collection were the SPOC classroom observation schedule and the use of the video programme prepared especially as a focus for the teacher interviews. The data collected were analysed and presented in Chapters Six and Seven. The extent to which the process skills were used by the pupils of PSP was discussed, together with the teacher's understanding of the skills in Chapter Six. Chapter Seven focused mainly on the constraints identified and the teacher's priorities in their present teaching compared with what might be their ideal priorities.

FINDINGS OF THIS STUDY

The following is a summary of the findings of this study.

(i) The classroom observations revealed that in most classrooms, only a select number of process skills in science are being provided for, to any extent, in classroom practice. These tend to be in observations, interpretations, using materials and equipment, using measuring equipment - where PSP exercises particularly required it, recording and recall.

(ii) The findings tend to indicate that there is no significant variation in the use of the process skills by pupils across class/age levels (P4, P5, P6). Hence the notion of a hierarchy existing with the higher class levels using more of the 'integrated skills' as

PSP states in the preface of the teacher's guide was not substantiated in this study.

(iii) Using the arbitrary rank orders of the process skills from an analysis of PSP materials and looking for correspondence of that rank order with the rank order of the observed use of skills, it was found that a close correspondence did take place between what was intended and what was implemented in most of the process skills. Observations were highly ranked in both the intended and implemented, but children raising questions and planning investigations were of low ranking in both the intended and implemented.

(iv) Spearman correlation coefficients showed that all thirty classes had a positive correlation between what was intended and what was implemented with regard to the fourteen process skills categories. Most of these correlation coefficients were significant. However, Spearman correlation coefficients for each skill across thirty classes showed few significant correlations. These correlations, taken together tend to indicate that while teachers are working closely with the PSP materials and giving the same relative importance to the process skills overall in accordance with the intended PSP, they are not relating according to the demand of the content of the activity. Instead the teachers have a set approach and are not varying their teaching approaches in relation to the encouragement of process skills.

(v) In terms of how teachers perceive the objectives of PSP it would appear they see it as a "hands-on" activity oriented project and with "something to do with process skills".

(vi) Teachers in the study appear to be more familiar with the use of observation and measuring skills, less familiar with that of hypothesising, children raising questions and planning investigations. No discernible difference was observed on children's use of the skills and the pre-service or in-service training of teachers which included PSP materials as compared with teachers who had no training in the use of PSP materials.

(vii) No discernible difference was noted in the pupil's use of the process skills in the group of teachers who said they had difficulty with PSP materials as compared to those who said they had no difficulty with PSP materials. It would appear that teachers generally have as their main objective a successful lesson which to them means satisfactorily completing an experiment and pupils being able to complete the workbook exercise for the lesson.

(viii) Teachers are very dependent on the teacher's guide and to some extent the pupil workbooks to carry out their teaching. There did not appear to be any attempt by the teachers to reduce their dependence on these materials.

(ix) In spite of feeling dependent on the materials which teachers themselves described as prescriptive, they expressed the view that their pupils would benefit if there was less dependence on pupil workbooks and more provision was given to working with children's ideas and allowing them to raise their own questions and design their own investigations.

(x) The value teachers hold for their pupils experiencing the process skills is expressed in their rating of their present priorities in science teaching compared with their ideal priorities. The science syllabus which takes first priority in their present rating takes only fifth place in their ideal rating, but process skills which is currently a second priority, moved to first priority in their ideal rating.

(xi) Completing the syllabus appears to be directly linked to one of the constraints identified for full implementation of the process skills - that of the 11+ examination (PSLE). All teachers in the sample expressed experience of stress from the demand of the examination and felt that the schools were being judged by their success in this national examination.

(xii) Generally teachers felt PSP materials were tending towards a process skills orientation but few saw the PSLE examination being skills oriented. Generally teachers in the sample perceived little congruence between the objectives of PSP and what PSLE purported to test. They saw the PSLE examination as still content oriented.

(xiii) To prepare pupils for the content orientation in the examination teachers felt the need to complete most, if not all the exercises in the workbooks and to give additional notes where necessary.

(xiv) Teachers of some of the classes observed considered their pupils' lack of fluency in English to be a handicap for their pupils to communicate orally and in their recordings. It was noted in this study that schools with a high percentage of pupils with English as a home language performed significantly better at the PSLE examinations.

(xv) Teachers experienced parental pressure towards them in some schools in the sample and felt this affected their teaching style.

(xvi) Teachers generally perceived their pupils as being able to use most of the process skills but expressed less confidence over the use of skills involving hypothesising, raising questions, planning experiments and recording their plans and findings in their own style without the format provided in workbooks.

(xvii) When shown a videotape of children working with process skills some teachers expressed admiration for pupils they saw in the videotape whom they described as working independently, willing to express their views, and working productively within their groups. These teachers also described the teaching approach as allowing for a more creative teaching learning situation which could result in a more enjoyable classroom atmosphere.

(xviii) Most teachers in the sample liked teaching science. About half the sample of teachers would like to specialise in science teaching, expressing the view that it would mean they could develop the subject with a long term view and become themselves more proficient.

(xix) One of the major obstacles perceived was the class size. Teachers in the sample felt that reducing it to about *twenty-five* pupils would certainly result in more gains for their pupils.

(xx) Teachers also expressed the view that having an extra period (forty minutes) more each week would give them more time to develop their science lessons with more opportunity for pupils to use their process skills.

(xxi) Classroom space and resources were not perceived to be a problem.

(xxii) Science coordinators generally mentioned teaching constraints similar to those that teachers in the sample raised.

(xxiii) Teachers in the sample generally tended not to monitor their pupils or listen to them involved in interaction with each other. Rather, teachers were often involved in the interaction themselves.

DISCUSSION OF SELECTED ISSUES AND CONCLUSIONS

From the results highlighted in this chapter, six issues are discussed because of their relevance to the Singapore situation. These are

- PSP's content orientation as perceived by teachers
- Teacher dependance on the teacher's guide and pupil workbooks
- Language issue
- Class size
- Teacher interaction
- Parental pressure

PSP's Content Orientation as perceived by Teachers

The centralised national science syllabus and the pressures of preparing pupils for an examination-orientated system appears to be a major issue for primary science teachers in Singapore. To the extent these teachers perceive the examination to be content orientated, it will continue to be a constraint for teachers and will raise doubts as to whether there will be a greater opportunity for pupils to work more with process skills. While concept acquisition in itself is not being challenged, a reduction in specifying the extent of the content to be covered on each topic in the syllabus and a major re-look at the examination questions to create a more process skill orientated examination may be a step forward. Harlen and Dahar (1981, p. 119) give their experiences of their encounters with teachers in Indonesia when they write,

> "It would be no use urging teachers to pay attention to process skills development whilst the central syllabus imposes goals which require a great deal of content to be covered"

In referring to a workshop experience in Indonesia, they recalled

> "the amount of content which could reasonably be covered in a lesson in which pupils were able to observe, question, plan and carry out investigations was about one quarter of that which teachers could cover by 'telling'. Existing teaching methods also tended to be preserved by the assessment applied by teachers and by external examinations... "

There needs to be a concerted effort made by those responsible for the PSLE examinations and by officials who make appraisals of schools and indirectly therein on teachers to recognise the effect they have on the teacher's day to day teaching of science lessons. Otherwise the hesitation that teachers have to create more opportunities for children to work with process skills, particularly with children's ideas, will remain. Teachers ultimately need to feel they are working in a non-threatening context.

Teacher dependence on teacher's guide and pupil workbook

Kelly (1970, p.91) points out that the relative roles of the teacher and curriculum materials vary with the stage of the innovation. He sees in the development stage "teachers continually seeking guidance on what is intended by the development team, the curriculum materials as a primary source of communication." He goes on to make the observation that

> "... at this stage the students', rather than the teachers' materials are used by teachers as guidelines ... despite encouragement for individual initiatives, the work tends to be a rigid reflection of their content ... As teachers put it -- 'they represent a good security blanket'."

How true this appears to be of the way teachers are currently responding to the PSP materials. It may well be that the developmental stage is longer than we think for PSP materials have been in Singapore schools for 5 years. It also indicates that it may take a while for teachers to 'internalize' the new materials and the philosophy behind the project.

Producing new curriculum materials does not by itself produce curriculum development. Eisner (1985, p.367) makes the point that any attempt to create teacher-proof materials rests on a mistake. He suggests that new curriculum materials should stimulate their ingenuity rather than materials to which they are to be subservient. He adds

> "Although different teachers may require different amounts of detail in the curriculum materials they use, the ultimate aim of such materials is to minimize the teacher's dependency on them, to offer to the teacher materials that will foster a

> sense of competence both in pedagogical matters and in the context to which pedagogy is directed. In short, well designed curriculum material is to free the teacher to teach with ingenuity, flexibility and confidence."

In a CDIS Newsletter (October 1981, para 6) it was stated "the textbook contains all the important facts required by the syllabus." It goes on (in para 7) to say "the teacher's guide provides direction for preparing and conducting the lessons ... Teachers can use any approach that suits the ability and need of their pupils as long as they are convinced that the lesson objectives can be achieved."

The PSP team has obviously chosen to move with great caution when it set out to create a curriculum package for primary schools. It would appear that the team has aimed at providing sufficient support for teachers to involve the pupils in practical activities. The results in this study show that certainly teachers have moved from the 'chalk and talk' method of the past to an activity orientated, 'hands-on' approach to primary science. However, a stage must come for the dependance on textbooks and the teacher's guide to be reduced. When pupils have the right answers in their textbooks the challenge may not be there for pupils to use the process skills in science to work out solutions for themselves nor will teachers encourage children to voice alternative ideas. Teachers need to work with materials that are not highly prescriptive if they wish to use practical work to make children think.

The argument may be put forth that the teacher's guide and any other prescriptive materials back up the lack of teacher knowledge. Dobey and Schafer (1984) in their study of how teacher knowledge affected science teaching looked at three groups of teachers in an experimental study. They involved teachers given very little knowledge in the topic they were teaching, ~~a second were teaching~~, a second group given some knowledge and a third group given much more knowledge.

They found that

> "'no knowledge' teachers allowed fewer student ideas to be investigated and exercised more direct control over the activities than did teachers with an intermediate level of knowledge, but not teachers with a high level of knowledge " (p.48)

He explained that the 'no knowledge' teachers expressed lack of confidence in their teaching and suggested that they exercised control to keep student activity within the scope of their limited knowledge. On the other hand the 'high knowledge group' teachers tended to interrupt pupils' activities when they were concerned that the pupils were doing something 'wrong'.

Perhaps the whole issue of teacher confidence and use of the teacher's guide and workbook will need to be looked at in in-service courses. One way to give teachers greater confidence may lie in the experience Kelly (1970, p.96) describes referring to his experience with the Nuffield Junior Science Project. He says that adoption and implementation is greatest when a pair of teachers in a school is involved. He adds " the isolation of teachers is one of the major inhibiting factors acting on curriculum innovation." (p. 97). It may be that teachers need to have the opportunity to share their experiences and be able to observe each other in their respective classrooms. An in-service course that builds into its programme the opportunity for teachers to do this may prove beneficial. Usual in-service programmes have tended to be more instructive rather than allowing teachers to be reflective of their work. Perhaps visits to each other's schools, (seeing other teachers in practice trying out new ideas), followed by discussions, may give teachers confidence.

Language Issue

For those teachers who experienced a constraint with children who did not have much familiarity with English, classroom observations showed that they did need more time to give pupils the opportunity to express themselves. A study was carried out by Mori, Kojima and Tadang (1976) on the effect of language on a child's concept of speed involving Thai and Japanese children. They found that Thai children's concept of speed was further advanced than that of Japanese children. They attributed this to the Thai language which uses vocabulary that accelerated the Thai children's acquisition of the concept of speed while the Japanese language affected the Japanese children's development of that concept. This study does not have the data that could throw any further light on this matter with regard to Singapore children. However, later in this chapter it will be shown that with encouragement from teachers, children in spite of a limited vocabulary, are capable of expressing their ideas when opportunity is provided.

Class Size

Singapore teachers raised this issue as a constraint on them. In a survey by Fletcher and Payne (1982) which was an empirical study reporting stress factors on UK teachers, 54% of the teachers responding to the survey ranked a reduction in class size at the top of the list of factors which would reduce job pressure. In the (1984) IEA survey for the UK the results of which were published recently (Keys, 1987) the mean science class size in the primary school was given as about 28 (p.50). In a recent Ministry of Education (Singapore) report titled 'Towards Excellence in Schools' (1987) the recommendation was made for a teacher-pupil ratio of 1 to 15 (p.4). Such a ratio, the report suggested, would lend itself to an interactive form of teaching, where all pupils were encouraged to participate actively. Although the report referred to secondary school classes, perhaps a determined effort to bring class size in the primary schools to at least 25 pupils, as suggested by the teachers in the sample, would certainly help towards removing one of the constraints teachers face implementing more pupil use of the process skills in science.

Teacher Interaction

Shymansky and Penick (1981) carried out studies on students in hands-on science classrooms to find out how much and what type of teacher intervention is needed for children in an activity centred classroom. The 'teacher structured' (TS) group of teachers were highly directive while the 'student directed' (SS) group of teachers were highly non-directive, allowing students to pursue and evaluate their own ideas. The SS teachers spent more time observing students working on activities and asking questions relating to students' work. The research findings also showed that students of the TS groups exhibited increased levels of disruptive behaviour, showed more dependance on the teacher and tended to have children thinking that science was one thing for the scientist and another thing for them personally. Students in the SS group however tended to have a more "congruent view of themselves and scientists". They saw themselves "attacking problems the same way as a scientist would, by active investigation" (p.417)

The authors also found that students appear to stay on-task more when the teacher interacts less -- that "teacher interactions with students actually sometimes may have a stifling effect." (p. 418). There may be the need for Singapore teachers to look at their interaction patters with their pupils to see to what extent these findings are reflecting their own classroom situations.

Parental Pressure

In a speech by the Education Minister, Singapore on 'Economic Change and the formulation of Education Policy' (Tan, 22/7/86, para. 51) it was pointed out

> "Each parent would have his own priorities but generally it is undoubtedly the fact that most parents place the enhancement of their children's future career and employment opportunities above all other rationale for education when they enrol their children in schools. One of the key factors which must guide our education system in future years must therefore be to ensure that our education system remains relevant to the type of environment in which our children will have to find employment when they leave school".

The Minister went on to say that Singapore will need "creative, imaginative people" (para 51), who will be able to think critically and imaginatively, communicate, be flexible and adaptable. Certainly the children beginning school at this time will be joining the work force in the 21st century. While content knowledge is important the sole pursuit of content will not bring about the flexible and adaptable adult. However knowledge acquisition with that of greater ability to use the process skills to solve problems will certainly help towards developing in children the ability to think more critically and communicate their ideas more freely.

While it may be true that parents are concerned with examination results a recent letter by a parent to a national newspaper (Straits Times, Singapore, 8/8/86, Forum Page) may yet be an indication that there are parents who are also concerned with how their children learn. One parent wrote commenting on his children's science lessons which he thought were not up to how he expected science to be taught, He said,

> "An effective lesson must include experiments and other such activities so as to provide an environment for learning through concrete experience... Am I wrong, therefore, to suggest that science lessons require the teacher to provide the class with every possible opportunity to use the five human senses -- to observe, listen, feel, smell and taste -- as a stimulant to drawing conclusions?"

If this is an example of how parents are beginning to feel about how their children learn, then the concern of teachers that parents are only concerned with examination results may not be totally correct.

HOW CAPABLE ARE SINGAPORE CHILDREN IN USING THE PROCESS SKILLS?

Perhaps this thesis can be brought to a close with an attempt at answering this question. Although it was not intended as part of the design for this study, during the course of the data collection in Singapore the showing of the videotape of the children in a Liverpool school working with the author eventually included making a similar tape with Singapore children. It became an interesting idea to see to what extent children of the same age group would be able to handle similar activities and to show to what extent they were able to use the process skills when given the opportunity as well as the encouragement. This was especially valuable as Singapore teachers in the sample had expressed positive views towards how they saw children in the videotape work.

A class which was part of the sample in the study co-operated by coming for 'additional' lessons conducted by the author. The following is a summary of the experiences the author had with this class on one of the activities -- SNAILS. The videotape containing two lessons, namely, on snails and clockwork (spring) toys is submitted as Appendix 3 in this study.

The process skills that I was interested in focusing on can be broadly categorised under the following headings:

a) observation
b) interpretation of information
c) raising questions
d) hypothesising
e) devising investigations
f) communicating

The children worked in groups of 5 and each group was provided with an easel board and paper for making their recordings. Because of the larger size the easel board gave the members of the group and the rest of the class the opportunity to read easily what was recorded. The groups were left to appoint their own 'recorder' and a 'spokesperson' but as the lessons progressed I was happy to note that these jobs were shared by group members.

Lesson one involved the children in the following stages:

1. Observing snails, including measurement of their mass and size and recording their findings,

2. Sharing the observations with the class in open discussions

3. Listing questions the groups would like to ask about their snails.

4. Selecting one of the questions from the list from each group so that the groups could devise investigations to find the answer(s).

Here are some examples of the children's work relating to the processes used.

Observation

2

1. The mass of my snail is 10 grams.
2. The length of my snail is 6 cm and the width is 2.5 cm.
3. The snail moves 11cm in 1 minute.
4. When the snail crawls out of its shell, the shell is empty.
5. The two dots on the feelers are the eyes. Because the eyes move away from bright light just like human beings.
6. The colour of the snail is brown.
7. When we touch the ~~feelers~~, they go in.

Group 2

When Group 2 presented their report and pointed to the upper two feelers to show the eyes, the following interaction occurred:

Boy from Group 3 to Group 2: What makes you think the eyes are on the top? To me it is the bottom feelers.

Boy from Group 1 to Group 3: I think the eyes are even lower than that.

At this stage I (as a teacher) stepped in and suggested that they do some library research after the lesson and report to the class in the next lesson what they had found out about the parts of the snail and any other interesting information.

Raising Questions

Group 2

2
1. Will it die when we put it in water?
2. How many kinds of snails are there?
3. Do snails by eggs? Where?
4. Do they feed their young when they are born?
X

Raising Questions

Group 3

1) What types of food does the snail likes to eat?

2) What is the texture of the snail?

3) Why does the snail stick to the surface of the styrofoam?

Group 4

1) Does snails have sex?

2) How do snails give birth?

3) Do they sleep when night-time?

4) Do snails have teeth?

5) Do snails eat leaves only?

6) Do snails have their own ~~tang~~ language?

Devising Investigations (Planning)

The children were told to make sure their experiments were 'fair' (although the words 'controlling variables' were not used). They were expected to write out the stages of their experiment and how they expected to come to their conclusions. Before the lesson ended they had to work out within the group the tasks of obtaining the items required and provide me with a list of equipment they needed me to provide.

Lesson 2

The second day's lesson involved the following stages:

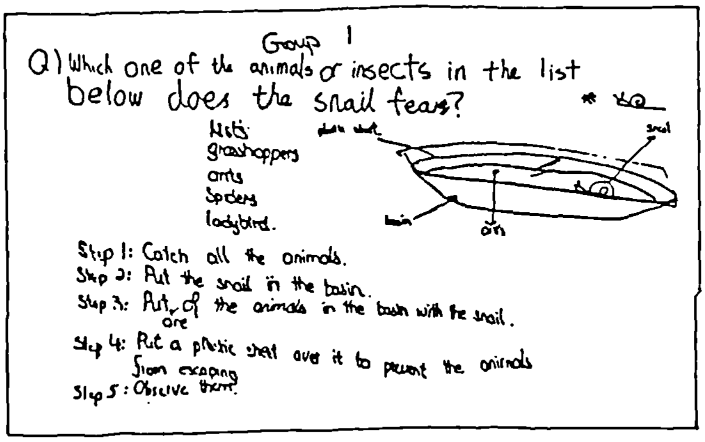
1. Presenting their experimental plans to the class and answering questions on the procedure.

2. Carrying out the experiments and recording their data and/or conclusions.

3. Presenting their findings to the class followed by open discussion.

Presenting their Plans

Group 1



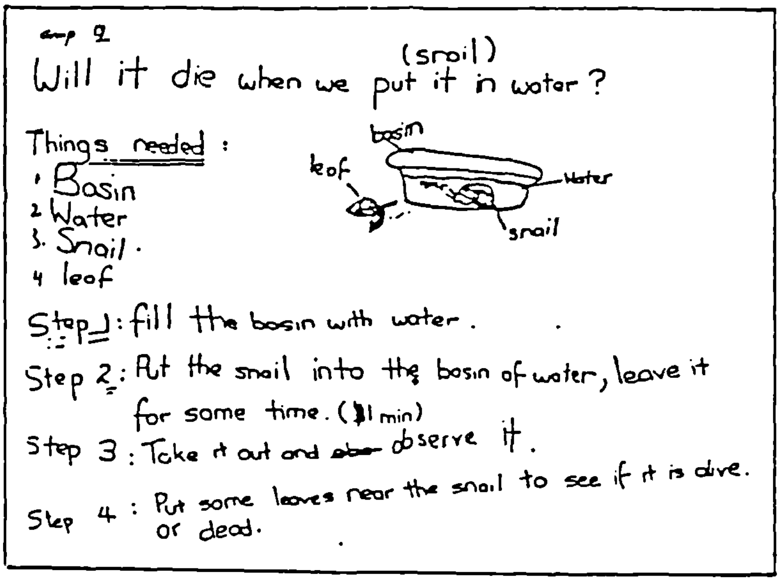
Notice the precautionary detail of Step 4!

When this group presented their plan they were asked:

Boy from Group 3: How will you know if the snail is afraid?

Boy from Group 1: If the snail goes in the opposite direction, that means the snail wants to escape and it is afraid.

Group 2



The questioning here showed concern for animal life:

Girl from Group 1 to Group 2: Youŕeexperimental - you can't let the snail die.

Boy from Group 3 to Group 2: Your experiment is killing the snail!

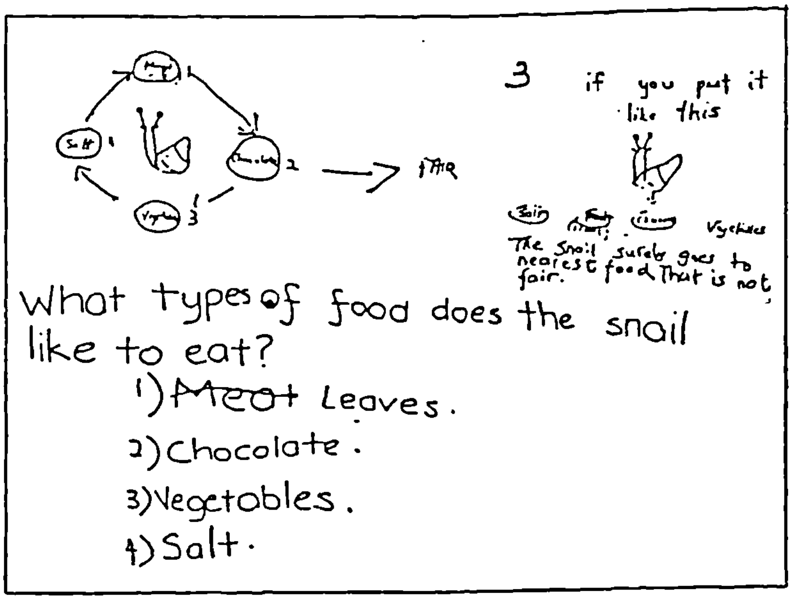
Boy from Group 2 (replying): The snail is a pest.

Boy from Group 1 to Group 2: Even though it is a pest you can't destroy them completely - killing all of them.

Boy from Group 2: I did not say I would kill all of them.

Boy from Group 1 to Group 2: If you do this experiment all the time, you'll make them extinct.

Group 3



Note the control for the variable - distance and their explanation by the side. There was however some concern expressed as to whether even this was fair enough.

Boy from Group 2 to Group 3: It is still not fair - the snail can't see the food at the back.

Girl from Group 4 (replying): But the snail has a sense of smell also .....I think.

Reporting Groups' Findings

Each group in turn presented their findings and it was interesting to note how open the children were to comments while trying to defend their observations. The children were supportive and helped each other in their argument, as can be seen in the following situation.

Group 3

> 3
>
> 1) The snail eats the cabbage.
>
> 2) ~~The~~ It also eats the ~~coulife~~ couliflower.
>
> 3) When we put the food around the snail, it turned around to see which food it would like to eat.
>
> 4) It ~~does~~ ~~not e~~ neither eats chocolate nor salt.
>
> 5) It also didn't eat the green peas

Group 4

> Gp.4
> 1) The snail eats chocolate.
> 2) The snail did not eat the garlic because we think the smell of the garlic is too strong for it.
> 3) The snail eats a little bit of sweet cuttle fish.
> 4) The snail eats candy.
> We think that the snail likes to eat sweet things.

Note that statement 4 from Group 3 and statement 1 from Group 4 appear to contradict each other. Quick to note this, the children were involved in the following interaction:

Girl from Group 3: Our snail didn't eat chocolate

Girl from Group 4: The snail is a plant eater. How can it eat chocolate?

Girl from Group 4 (defending): The chocolate also belongs to the plant

Boy from Group 1: Chocolate is a mixture of animal and plant ... some of it comes from the cocoa plant.

I should point out that Group 3 and Group 4 worked on slightly different questions:

Group 3: What type of food does the snail like to eat?

Group 4: Do snails eat leaves only?

Subsequently they had different experimental procedures and arrived at different findings.

The discussion with the children went on with them eventually suggesting that perhaps Group 4's snail was 'hungrier' and that when given a choice it would eat leaves as they are 'used to it' in the garden.

Library Research Reporting

This allowed for clarification of various questions that children had raised (including the position of the eyes). They brought along their reports with diagrams and the class was informed about the parts of the snail, that each snail had both male and female parts, that there are land and sea snails as well as information about the African Giant Snail.

The experience I had with this class showed that when the opportunity was provided for, the children did show ability to use the process skills. They went on and chose different forms of communication as they saw appropriate - verbal and written, pictorial and descriptive.

Their interaction with their peers as well as with me was both enjoyable and informative. Some of the experiments may not have led to the 'right' answers, but this was not the only objective. Different investigations in science lend themselves to different possibility. What was intended here was for the children to be given the opportunity to observe freely, raise questions, devise investigations, collect data, record their findings and communicate.

To this extent the children have proved their ability and answered the question - are Singapore children capable of working with the science process skills? The experiences with the children show that they are capable of using the process skills, and more importantly, that they can be analytical, critical and able to communicate their ideas when the opportunity can be provided for them. This does not however mean that all science lessons should take on such an approach. Firstly, not all topics in science lend themselves to children raising questions. In such cases the teachers would certainly have to be directive and give children the questions they need to work with. Teachers will undoubtedly also need to understand the need for experimentation and not carry out such experiments with children out of a feeling of some external compulsion. As has been shown in the examples provided, and as Symington and Osborne (1985, P.22) point out

> "primary science education needs to affirm that pupils' ideas should be investigated in the most appropriate way. Frequently this will involve 'hands-on' investigation, but not invariably. Asking ... Mum or Dad because she or he is an expert, or finding out from books, should not necessarily be considered as second rate scientific activities".

The children in the video programme show how the facilities of a school library in this instance could be utilised. While in this video programme, group work was advocated and used, good science learning need not always necessitate small groups of pupils interacting with materials. As pointed out by Symington and Osborne (P.23) in appropriate circumstances a teacher demonstration can provide the basis for worth while pupil learning. They also share their opinion that there is a place for teacher - led whole class discussions. Such discussions as shown in the video, can help focus children's thinking.

The video tape submitted as Appendix 3 also shows how a lesson from the P5 materials (Teacher's Guide P5) was adapted, so that pupils could be given the opportunity to raise their own questions. In this example, the teacher's guide for the lesson on clockwork toys, provided teachers (and pupils) with the question to be worked on. The researcher however gave the children in the video programme the opportunity to raise their own questions on the clockwork toys. It was not coincidence that one of the questions raised by the children was identical in spirit to that raised by PSP developers. The children worked on the questions enthusiastically because they felt they were working on their own questions.

It may be the case that within the constraints teachers face, they do not always find the classroom situation conducive to the approach as for example in the video programme. Yet PSP materials can be adapted, despite the perceived prescriptiveness, to lessons which do not miss out on capitalising on children's ideas. Teachers and teacher educators need to find appropriate ways of entering into the world of children's thinking about natural phenomena.

In the Singapore context we have, with PSP, moved from chalk and talk experiences of the past to one where children are certainly involved in hands-on scientific activities. This is an important achievement. The move may have been a cautious one. To have moved too quickly may have put far too many pressures on teachers. However, many teachers have shown both the ability and the willingness to take further steps forward in working towards a more meaningful experience for our children. Let us, at the same time, guard against the danger of underestimating what our children are capable of.

REFLECTIVE COMMENTS ON THIS STUDY - POINTERS FOR FUTURE RESEARCH

This study set out to look at the extent to which pupils in Singapore were using the process skills and to provide a general account based on the sample schools used. It did not propose to look at individual children nor the development of the process skills in the pupils over a given period of time. Had this been the issue, the target pupils observed in a class on each occasion would have had to be the same. This was not the case in this study. However, as a consequence to this study, it would be a useful study to observe the development of the process skills in individual children. Such a study will throw light on how best the acquisition of the science process skills can be enhanced.

A second feature of this study that needs comment is that the scoring system only allowed for a recoding of the minimum number of times a process skill was observed to be used by the pupils. This did limit the extent to which the data could be used. For example, no comment can be made in the study of actual durations of any event. For such analysis the recording system would have required vary small time intervals. However, as explained in Chapter Five, the scoring system for this study has served to show the use of the process skills by primary children in the sample observed.

A third feature of this study is that for each class the data was summed over a number of lessons observed. This was certainly a sufficient way of analysing the data for the specific research questions raised. However, an alternate procedure would have been to work on the data for each lesson. This would have allowed the researcher to look at the relationships of the variables listed in the SPOC schedule more closely. It would have also been possible to look at differences in performances between boys and girls.

Fourthly, no particular trend could be observed across the three class levels (P4, P5 and P6) observed. However it cannot be assumed that such an observation would hold true had the opportunity been possible for more classes to be used in the sample.

Fifthly, the role of the school principal was not investigated. This is no way reflects his role as being unimportant. On the contrary, the quality of the principal makes a major difference to the character of a school, and more specifically, to the development of the various subjects offered in the curriculum. In the Singapore context, the principal's role is being recognised as being of increasing importance. A research study that can throw light on how such leadership can enhance the development of the various aspects of a curriculum should be explored.

A sixth point to be made is that this study did not look at the achievement of children. This study only set out to look at the implementation of PSP with regards to the process skills that pupils in class levels P4 - P6 use. To look at the achievement aspect of these skills is in itself a major research project. In an examination oriented system, however, such a study could show ways in which assessment of the process skills can be considered.

However, as a final comment, this study has attempted to use a multiplicity of different kinds of data to provide as clear a picture as is possible of the classroom situation with regard to the process skills. Only through looking at the classroom context in different ways can one begin to understand the roles of the various individuals both inside and outside the classroom who may affect the life within the classroom. For the researcher, this has been an experience from which much has been gained that will find its way into the training of primary science teachers in Singapore.

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APPENDIX 1

CLASSROOM OBSERVATION SCHEDULE (SPOC)

School Code :
Class Size :
Teacher Code :

Lesson/Topic :
Time :

Date:

			Remarks
1.	TARGET		
	1.1 male = M. female = F		
2.	AUDIENCE/INTERACTION - p = ind. pupil; t = teacher; o = other; g = group; w = whole class, n = none		
3.	TEACHER INTERACTION – m = monitoring; i = involved, n = not present		
4.	CURRICULUM AREA – = science; x = non-science		
5. DIALOGUE INVOLVING PUPILS IN	5.1	discussing observations	
	5.2	interpretation	
	5.3	hypothesising	
	5.4	general planning	
	5.5	discussing specific plans/procedures	
	5.6	measurement	
	5.7	recording	
	5.8	raising questions (for inv.)	
	5.9	reporting	
6. OTHER PUPIL TALK	6.1	recall of previous learning	
	6.2	recap of work done	
	6.3	reading out/discussing instructions	
	6.4	about meaning of words	
	6.5	asking for help	
	6.6	organising task	
	6.7	non-task	
7. NON-TALK PUPIL ACTIVITY	7.1	making observations	
	7.2	using measuring instruments	
	7.3	using other materials/equipment	
	7.4	collecting, clearing equipment	
	7.5	reading book/worksheet, etc.	
	7.6	recording (not copying)	
		copying from book/worksheet/board	
	7.8	waiting for teacher	
	7.9	waiting for other pupil(s)	
	7.10	attentive to teacher	
	7.11	attentive to other pupil(s)	
	7.12	non-attentive to task	
	7.13	organising for group work	
	7.14	moving to another location	
	7.15	watching film/video, etc.	
	7.16	not classifiable	
8. TEACHER TALK	8.1	giving information (task)	
	8.2	giving instructions (task)	
	8.3	commenting on pupils' answer (task)	
	8.4	asking for account of progress	
	8.5	questioning	
	8.6	non-task	
9.	NOT INVOLVED WITH CLASS		
10. NON-TALK TEACHER ACTIVITY	10.1	collating pupils' ideas (on blackboard, OHP, chart, etc.)	
	10.2	demonstrating activity/what to do	
	10.3	listening to pupils	
	10.4	writing on/correcting pupils' work	
	10.5	collecting pupils' work	

APPENDIX 2

With the modifications referred to in Chapter 5 the text that follows is as produced in Draft Four of the STAR project.

1. SUGGESTED OBSERVATION PROCEDURES

1.1 Observation intervals are of two minutes, and all the behaviours occurring in each of these intervals coded, except where stated.

1.2 Pre-selected target pupils are identified and observed in the pre-arranged order, each for two time periods (i.e. 4 minutes) before passing on to the next. The order of observation of the targets must be randomly selected for each visit.

2. CODING AUDIENCE

Audience means person(s) with whom the target is an interaction, whether or not being addressed by the target. Thus silent co-operation on a shared task would be coded as having an audience, as would the target silently watching a child or group. The audience may be an individual pupil, the teacher, a group of two or more pupils, the whole class or none at all. If an adult other than the teacher is involved e.g. a parent or ancillary, then code "OTHER" and specify who. Only one audience type should be selected for each observation interval. If the audience changes from one to another within the same time interval, code the one which occupies the majority of the time interval.

3. TEACHER INTERACTION.

Monitoring

The teacher is monitoring by observing the target pupil or the group or class of which the target pupil is a member.

Involved

The teacher is involved in the interaction in which the target pupil is either engaged or is part of the audience. This could be through class teaching, group teaching, or individual attention.

Not present

The teacher is not involved with the target pupil. He/she might be housekeeping or involved with pupils not in the target pupil's audience.

4 CODING CURRICULUM AREA (TEACHER)

Only one curriculum category should be coded for each time interval. The teacher's attention may be directed towards "SCIENCE", some "OTHER" curriculum area e.g. when group work is taking place, some groups may be non-science, or "NON" e.g. housekeeping.
If the curriculum area changes during the time interval, code the area which occupied the majority of the time interval.

5. DIALOGUE INVOLVING PUPIL(S) IN:-

Discussing Observations
Refers to description of characteristics of objects or situations which children have directly perceived through their senses. May involve comparisons between objects or events, such as similarities and differences. Includes descriptions of the order in which events took place. Includes descriptions of observations in which a pattern exists ("the biggest went the furthest, then the next biggest and the smallest went the smallest distance") as opposed to a description of the pattern ("the bigger they are the further they go").

Examples

e.g. P. "When you push the blocks down they all float back up"

T. "Does everyone agree with that ... when you push them down they all float back up."

P(s)"Yes."

e.g. T. "Now, what have you found out that's the same about you blocks?"

P.1 "... they all float level."

P.2 "... they don't dip over ... like that." (gestures with hands)

T. "That's a lovely observation, anything else..."

e.g. T. "Look very closely at the way the blocks float and their weights ... can you see any pattern there?"

P. "They're all in the same order."

T. "Can you say anything else ... can you put that another way?"

T. "What can you tell me about the weight of the block and the way it floated?"

P. "The lightest block floated best ... and the heaviest block was the worst floater."

T. "Does everyone agree ... do you think it has something to do with weight?"

5.2 Interpretation

Drawing a conclusion or inference for which there is some (thought not necessarily sufficient) evidence on the children's findings.

Identifying a pattern linking observations or data. Interpolating/extrapolating from observed data whether or not the pattern which justifies it is stated.

Examples

e.g. T. "Here's a graph showing how fast the soluble aspirin dissolved at different temperatures. Tell me then what is the connection between temperature of the water and the time for the aspirin to dissolve?"

P. "As the water gets hotter, the aspirin dissolves quicker."

5.3 Hypothesising

Suggesting an explanation for an event, pattern or finding. It must be more than giving a name ("It's condensation"), possibly taking the form of an associated factor ("It's something to do with air") or a suggested mechanism ("It's because the air gets cold on the side of the can.") It is different from interpretation in that conceptually based reasons are proposed to account for what is observed. Further evidence is likely to be necessary to test the suggested explanation.

Example

e.g. T. "Now why is D the best floater?"

P.1 "Got more air in it."

P.2 "Got more air."

(P.1 takes block D out of the water and looks more closely at it.)

P.2 "It's lighter."

5.4 General Planning

Indicating the essential nature or general design of the plan, i.e. What it is about, what is to be changed and how any result of that change will be observed. Concerned with indicating the broad range of the plan rather than the details, but indicates what sort of enquiry is intended. Includes discussions of controlling variables for a fair test.

5.5 Discussing Specific Plans/Procedures

Concerned with the details of carrying out a general plan (how much of this; where does that start from, etc.). Includes discussion of in what order; deciding what quantities to use and what quantities to measure; how results are to be observed and measured. Discussion of the measuring process or the measurements taken are included in 5.4; here the concern is with deciding how they are to be taken.

5.6 Measurements

Refers to the discussion of the process of measuring whilst it is taking place, the description of how it was carried out, and the discussion of the measurements subsequently.

Examples

e.g. That one looks longer than the other one, doesn't it.

e.g. It is 7cm long.

e.g. The measure is in millimetres.

e.g. The graph is too small.

5.7 Recording

Refers to discussion about writing notes, taking down results or drawing either during a practical activity or afterwards. Also refers to children talking about the form of record they are making or have made of results. (The content might be reported either as observations or interpretations.)

Examples

e.g. Put the title at the top

e.g. Write down the measurement. It was 7cm.

e.g. The graph is too small.

5.8 Raising Questions

Refers to questions about the subject or content of the activity (not interpersonal relations in handling it). Questions which request information, suggest enquiring further, or challenge statements. Not to be confused with hypotheses expressed as questions.

Examples

e.g. T. "Are there any other things you would like to find out about balloons?"

5.9 Reporting

Pupil at request of teacher presents findings orally to the group/class. Includes providing teacher with data for teacher to collate on chalk board.

6 OTHER PUPIL TALK

6.1 Recall of Previous Learning

Refers to facts, principles, relationships which do not emerge from the current activity, but have to be recalled from memory. Includes names of objects, phenomena, etc, where these words are recalled but not discussed (if they are recalled in order to be discussed the coding 6.4 would be used).

Examples

e.g. T. "Does anyone know what this is?"

P. "A fossil."

6.2 Recap of Previous Activities

Recap of what was done or found out in a previous lesson, or earlier in the present lesson.

Examples

e.g. T. "What did you find out from your investigation last lesson?"

e.g. T. "Did your group do it a different way (last time)?"

6.3 Reading out/discussing instructions

Refers to the clarification of the task(s) as described orally by the teacher or given in writing. Also to reading out part of written instructions.

Examples

e.g. P. "What does this mean (referring to a written step)?"

T. responds

e.g. P. "Miss, what are we meant to be writing down?"

T. responds

e.g. P. "It tells you to weigh them first.

6.4 Meaning of Words

Refers to the discussion of meaning of words and the clarification of pupil suggestions (as distinct from 1).

Examples

e.g. P.1 "They stay up, they don't go right under."

T. "What's another word we could use to say they stay up?"

P.2 "Horizontal."

T. "Would you agree they all stay horizontal?
"Do you know what we mean by all stay horizontal?"
"Show me which way ..."
"... so instead of the word level we could have the word horizontal

6.5 Asking for help

The pupil is seeking guidance from the teacher about the organisation of the task.

Examples

e.g. P. "Where can I find a measuring jug?"

e.g. P. "Which shall I do first?"

6.6 Organising Task

Refers to general organisation concerned with doing the task such as who will fetch what.

Examples

e.g. Mary will get the paper while I stick the newspaper.

6.7 Non-task talk

This relates to any talk which is not related to the task in any way.

Examples

e.g. P. "Did you watch the T.V. last night?"

e.g. T. "Put your things away now."

7. NON-TALK ACTIVITY

7.1 Making observations

The target pupil is observing what happens during an event or the reactions of objects, creatures, etc. in test situations. Can also refer to pupils looking at two or more objects, pictures for the purpose of comparison.

Examples

The pupil has a bowl of tap water with a weighted object floating on the surface, and a bowl of salt water with a similar weighted object. The pupil is observing the differences. This may be followed by "interpretations" or "hypotheses".

7.2 Using measuring instruments

Activity using a measuring device e.g. rule, litre jug, trundle wheel, scales.

7.3 Using other materials/equipment

Actively using materials or equipment other than for measuring e.g. paper, scissors, sand, water, leaves, shells.

7.4 Collecting/clearing equipment

The pupil is collecting or putting away equipment such as scissors, measures etc. but is not using them.

7.5 Reading book/worksheet

The pupil is reading to him/herself from a book or worksheet rleated to the task. It could be a reference book or book related to a work-scheme.

7.6 Recording (not copying)

The pupil is writing or drawing to record what he/she did or learned during an earlier activity. It relates to his own work and is not copied from any source.

7.7 Copying

The target pupil is copying from a book, blackboard, worksheets, etc.

7.8 Waiting for teacher

The target pupil is waiting to interact with the teacher. He/she might be in a queue or sitting at a table with his/her hand up. Also refers to waiting for the teacher to continue an interaction already started e.g. in group- teaching a teacher might be interrupted by a non-group pupil. Refers to when the pupil cannot continue with his task until an interaction with the teacher has taken place.

7.9 Waiting for other pupils

The target pupil cannot continue with his task until another pupil has done something or interacted with the target. e.g. a construction task may require scissors leaving the target waiting while his her partner fetches some.

7.10 Attentive to teacher

The target pupil is listening to or watching the teacher working on a task related to science.

7.11 Attentive to other pupils

The target pupil is listening or watching other pupils working on a science task.

7.12 Non-attentive to task

The target pupil is day-dreaming, disruptive, or engaged on activities not related to his task. Includes watching the teacher or a pupil working on a non-science task.

7.13 Organising for group work

Pupil involved in re-arranging furniture to sit in group.

7.14 Moving to another location

Pupils moving to T.V. room, science garden etc to continue lesson.

7.15 Watching film/video etc.

7.16 Not classifiable.

8 TEACHER TALK

This section is only coded if SCIENCE is the curriculum attention.

8.1 Gives Information

Indicates the teacher has provided facts or information about the content relating to the process or product of the investigations. Includes telling how to use equipment or measuring instruments. Can be in the form of a statement or of a question which contains information.

Examples.

e.g. T. "The name of the force which is slowing down the cars is friction."

e.g. T. "You should keep the slope of the ramp the same while you are changing the weight of the cars."

e.g. T. "Did you notice how the sugar all dissolved when you stirred the water?"

8.2 Giving Instructions

Refers to teacher instructions about how to carry out an aspect of the task, as distinct from giving information about content.

Examples

e.g. T. "So divide your page into two and on the left hand side say what is the same and on the right hand side list all the things which are different."

e.g. T. "You must read through the worksheets carefully ... choose one person in your group to be the recorder."

8.3 Comment on Children's Answers or Actions

Refers to the teacher's evaluative remarks about the children's responses or about what they are doing and have done.

Examples

e.g. T. "I'm very pleased with your work.
You've all worked very scientifically.
You have kept to the task but you did
carry the experiments further on ..."

8.4 Asks for Account of Progress

Indicates the teacher's request to a pupil, group or whole class to say what they have done or found.

Examples

e.g. T. "How are you getting on."

8.5 Questioning

Teacher puts questions to class/group/individual on task.

8.6 Non-Task Talk

Any statements from the teacher which are of a general nature and not specific to the task in hand e.g. "Make sure you move your table back to where they usually are before you leave the room."

e.g. "Stop it Wayne, get on with your work."

9. NOT INVOLVED WITH CLASS

The teacher may be out of the room, administrating, or talking to a non-class member.

10 NON-TALK TEACHER ACTIVITY

10.1 Collates Pupils' Ideas

The teacher is involved in bringing together ideas or results from several groups or presenting one group's work for others to see. Generally in whole class context, but could involve a few groups only or even one group where the teacher is acting as a means to help bring results together

10.2 Demonstrates Activity/What to Do

Teacher carries out part or whole or a practical activity to show how to use the equipment for the particular purpose in hand. May be demonstrated to whole class, group or individual.

10.3 Listens to Pupil(s)

In general refers to the teacher listening to pupils talking to each other rather than when in dialogue with the teacher.

10.4 Reading/Writing or Collecting Pupils' Work

Either at pupils' table or teacher's table, when teacher looks at and may correct children's written work.

10.5 Collecting pupils work

Teacher collects individual pupils/group written record.

APPENDIX 3

A videotape accompanies this thesis and is referred to as Appendix 3. It contains videofilm showing children of age 10 in a Liverpool school and in a Singapore school using the Science Process Skills in their different science activities. The programmes in the video programme are:

a) Process Skills in Primary Science
   A Documentation - Liverpool

b) Process Skills in Primary Science
   A Documentation - Singapore

Appendix 4

Table 1.a Teacher Confidence in Teaching PSP

Data from CDIS Survey 1986, October (Normal classes)
Number of Teachers Responding on a 7-point scale

Statement	Class (Age) Level	Strongly Disagree	Disagree	Tend to Disagree	Tend to Agree	Agree	Strongly Agree	No Response	Total/Level
I have confidence in	P4		1	6	5	21	13	4	50
teaching science at	P5		2	2	9	30	7		50
this level	P6			4	6	20	17		47
I have good knowledge	P4		1	4	15	21	9		50
of the subject matter	P5		2	5	12	26	5		50
	P6			3	13	21	10		47
I am familiar with	P4			4	19	20	6	1	50
the methodology/approach	P5		3	3	13	29	1	1	50
advocated by the	P6			3	12	25	7		47
project team									

Appendix 4

Table 1.b Teacher Opinions on Teacher's Guide

Data from CDIS Survey 1986 October (Normal classes)
Number of Teachers Responding on a 7-point scale

Statement	Class (Age) Level	Strongly Disagree	Disagree	Tend to Disagree	Tend to Agree	Agree	Strongly Agree	No Response	Total/Level
The objectives of the chapter are clearly stated	P4			1	7	30	12		50
	P5			1	6	33	10		50
	P6				5	25	17		47
The suggested teaching strategies facilitate the achievement of the objectives of the chapter	P4			1	8	34	7		50
	P5			1	7	35	7		50
	P6				5	30	12		47
The suggested teaching strategies are consistent with the methodology/ approach advocated by the project team	P4				11	32	7		50
	P5				10	33	7		50
	P6			1	9	28	9		47
The suggested teaching strategies are easily carried out	P4	1	1	7	17	20	4		50
	P5			2	18	23	7		50
	P6			4	17	24	2		47
The Teacher's Guide provides adequate guidance in teaching the subject	P4	1	1	4	7	27	10		50
	P5			4	14	22	8	2	50
	P6			3	7	26	11		47
The background information provided is useful	P4				4	26	20		50
	P5			1	9	26	14		50
	P6				3	24	20		47

Appendix 4

Table 1.c Teacher Opinions on Pupil Workbooks

Data from CDIS Survey 1986 October (Normal classes)
Number of Teachers Responding on a 7-point scale

Statement	Class (Age) Level	Strongly Disagree	Disagree	Tend to Disagree	Tend to Agree	Agree	Strongly Agree	No Response	Total/Level
The workbook provides written exercises to consolidate what pupils learnt in the textbook	P4				11	26	13		50
	P5				10	36	4		50
	P6			4	10	25	8		47
The excercises are relevant	P4			1	12	27	10		50
	P5		1		11	33	4		50
	P6			1	12	29	5		47
Exercises for application of concepts are provided	P4			3	13	28	6		50
	P5			2	12	32	4		50
	P6		1		12	28	6		47
Exercises for application of process skills are provided	P4		1	3	13	28	5		50
	P5			2	14	31	3		50
	P6		1	1	13	29	3		47
Exercises incorporate different levels of skills	P4			7	25	14	4		50
	P5		1	3	18	28			50
	P6		1	7	17	21	1		47

Appendix 5

Table 1.a t-test values: Teacher difficulty with PSP experiments and Pupil use of process skills (See Text p. 226) (Accept as significant if $p \leq 0.05$)

Process Skill Categories	t value	2-Tailed Probability
Discussing Observations	-0.07	0.94
Making Observations	1.53	0.14
Discussing Interpretations	1.09	0.29
Discussing Hypotheses	-0.07	0.95
Dialogue General Planning	0.75	0.46
Discussing Specific Plans/ Procedures	0.36	0.72
Discussing Measurement	0.47	0.64
Using Measuring Equipment	0.76	0.45
Discussing Recording	0.75	0.46
Recording	-0.88	0.39
Dialogue Raising Questions	-1.11	0.28
Dialogue Recall	0.75	0.46
Dialogue Recap Work Done	0.15	0.88
Using Materials and other Equipment	0.09	0.93

Appendix 5

Table 1.b One-way ANOVA for comparison between 3 groups of Teacher Responses: Teacher opinion PSP process skills oriented and Pupil use of process skills. (See Text 237) (Accept as significant if $p <= 0.05$)

Process Skill Categories	F ratio	F Probability
Discussing Observations	0.43	0.65
Making Observations	0.25	0.78
Discussing Interpretations	0.21	0.81
Discussing Hypotheses	0.57	0.57
Dialogue General Planning	0.70	0.50
Discussing Specific Plans and Procedures	0.23	0.80
Discussing Measurement	0.37	0.70
Using Measuring Equipment	0.25	0.78
Discussing Recording	1.07	0.36
Recording	0.03	0.97
Dialogue Raising Questions	0.70	0.50
Dialogue Recall	1.94	0.16
Dialogue Recap Work Done	1.11	0.35
Using Materials and other Equipment	0.01	0.99

Appendix 5

Table 1.c One-way ANOVA for comparison between 3 groups of Teacher Responses: Teacher opinion on PSLE process skills oriented and Pupil use of process skills. (See Text p. 237)
Group 1 Teachers: PSLE Process Skill Oriented
Group 2 Teachers: PSLE not Process Skill Oriented
Group 3 Teachers: PSLE a little Process Skill Oriented
(Accept as significant if p< = 0.05)

Process Skill Categories	F ratio	F Probability	Scheffe's Test for means Difference Significance
Discussing Observations	1.37	0.27	*
Making Observations	0.08	0.92	*
Discussing Interpretations	5.52	0.01	Pupils of Group 1 Teachers significantly higher than other 2 groups.
Discussing Hypotheses	4.01	0.03	*
Dialogue General Planning	1.42	0.26	*
Discussing Specific Plans and Procedures	1.13	0.34	*
Discussing Measurement	0.07	0.93	*
Using Measuring Equipment	0.06	0.94	*
Discussing Recording	0.24	0.79	*
Recording	0.35	0.71	*
Dialogue Raising Questions	2.21	0.13	*
Dialogue Recall	2.28	0.12	*
Dialogue Recap Work Done	2.53	0.10	*
Using Materials and other Equipment	0.94	0.40	*

* No significant difference between groups.

Appendix 5

Table 1.d Pearson correlation coefficient: correlation between pupil use of English as home language and pupil use of process skills (See Text p. 242)
(Accept as significant if p< = 0.05)

Process Skill Categories	Pearson correlation coefficient r	Probability
Discussing Observations	0.12	0.51
Making Observations	0.2	0.40
Discussing Interpretations	0.09	0.61
Discussing Hypotheses	0.10	0.57
Dialogue General Planning	0.34	0.06
Discussing Specific Plans/ Procedures	0.14	0.45
Discussing Measurement	-0.06	0.75
Using Measuring Equipment	-0.04	0.84
Discussing Recording	0.36	0.06
Recording	-0.09	0.64
Dialogue Raising Questions	0.10	0.61
Dialogue Recall	-0.23	0.23
Dialogue Recap Work Done	0.18	0.36
Using Materials and other Equipment	0.37	0.06

Appendix 5

Table 1.e Pearson correlation coefficient: correlation between % pupils with English as home language and percentage scoring A-star and A-grade at PSLE (1986) (See Text p. 244)

	A star	A grade
Pearson correlation coefficient r	0.86	0.86
Probability	0.0001	0.0001

Appendix 6

Table 1.a One way ANOVA for comparison between 3 levels (P4, P5, P6): Pupil Talk Variables (See Text p. 259) (Accept as significant if $p < = 0.05$)

Variable	F ratio	F Probability
Reporting	3.36	0.50
Reading Out/Discussing Instructions	0.85	0.55
Discussing Meaning of Words	0.82	0.55
Asking for help	0.19	0.18
Organising Task	0.37	0.30
Non Task	9.53	0.07

Appendix 6.

Table 1.b One-way ANOVA for comparison between 3 levels (P4, P5, P6): Non-Talk Pupil Activity Variables. (See Text 259)

Variable Categories	F ratio	F Probability	Scheffe's Test for means Difference Significance
Collecting/clearing Equipment	1.11	0.34	*
Reading book/worksheet	0.54	0.59	*
Copying from book/ worksheet board	1.62	0.22	*
Waiting for Teacher	2.30	0.12	*
Waiting for other Pupil(s)	9.43	0.0008	P6 sig. higher than P4 and P5.
Attentive to Teacher	1.96	0.16	*
Attentive to other Pupil(s)	4.32	0.02	*
Non-attentive to Task	0.19	0.83	*
Organising for group work	0.59	0.56	*
Moving to another location	3.74	0.04	*
Watching film/video	1.48	0.25	*

* No significant difference between groups.

Appendix 6

Table 1.c One way ANOVA for comparison between 3 levels (P4, P5, P6): Teacher Talk Variables (See Text p. 259)

Variable	F ratio	F Probability
Giving Information (Task)	0.09	0.92
Giving Instructions (Task)	0.26	0.77
Commenting on Pupils' Answer (Task)	0.05	0.95
Asking for Account of Progress	1.43	0.26
Questioning	0.23	0.80
Non-Task	2.95	0.07

Appendix 6

Table 1.d One way ANOVA for comparison between 3 levels (P4, P5, P6): Non-Talk Teacher Activity Variables

Variable	F ratio	F Probability
Collating Pupils' Ideas	0.64	0.54
Demonstrating Activity	0.99	0.38
Listening to Pupils	0.54	0.59
Writing on/correcting Pupils' work	2.25	0.12
Collecting Pupils' work	0.65	0.53

Appendix 6

Table 1.e One way ANOVA for comparison between 3 levels (P4, P5, P6): Audience/Interaction of Target Pupil

Target Pupils' Audience	F ratio	F Probability
Pupil - Pupil	2.56	0.10
Pupil - Pupil	0.60	0.56
Pupil - Group	1.77	0.19
Pupil - Whole Class	1.43	0.26
No Audience	0.83	0.45

Appendix 6

Table 1.f One way ANOVA for comparison between 3 levels (P4, P5, P6): Teacher Interaction

Teacher Interaction	F ratio	F Probability
Teacher Monitoring	0.12	0.89
Teacher Interacting	1.43	0.26
Teacher Not Present	1.08	0.35