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A STUDY OF TEACHER/STUDENT ROLE & ROLE RELATIONSHIPS IN THE IMPLEMENTATION OF THE LOWER SECONDARY SCIENCE PROGRAM IN SINGAPORE SCHOOLS

By

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ABSTRACT

A STUDY OF TEACHER/STUDENT ROLE AND ROLE RELATIONSHIPS
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The study examined ways in which a new, inquiry-based, guided-discovery science curriculum implied change in teacher/student role and role relationships and evidence of change during the first year the program was implemented. Concomitantly, the study identified parameters in the research setting and of the implementation process that constrained implementation of the program.

A long-term, case study approach was used involving extensive observations in classrooms of five cooperating teachers during the year prior to and the first year of implementation of the new program. An analysis of the curriculum materials package and an indepth study of the inservice program orienting teachers to the new program were included in the data sources. Focused and informal interviews with key informants (Ministry of Education officials, inservice trainers and curriculum writers) provided additional data. Patterns of teacher/student role and role relationships emerged phenomenologically within the broader conceptual framework of a cultural model.

The research findings indicated that although change in role and role relationships was axiomatic to the implementation of the new science curriculum, there was little evidence of such changes during the first

year the program was implemented. Lack of role change appeared to be linked with teacher perceived constraints through which they rationalized their teaching roles: the large class sizes, students' limited command of English, and the meritocratic nature of the education system as a whole. Potential for change was further constrained by the fact that the curriculum materials were not entirely consistent with the purported goals of the program. Moreover, inquiry teaching behaviors were neither adequately explained nor appropriately modelled in the teacher inservice experience.

The research findings further indicated that cultural norms prevailing in the broader sociocultural context of Singapore were essentially in conflict with the teacher/student roles axiomatic to inquiry-based, discovery learning. The assertion was made that since these established patterns of role relationships were indigenous to the research setting and were unaltered by the implementation of the new program, they served to maintain existing patterns of role and role relationships rendering the kinds of changes anticipated by the curriculum developers very difficult to achieve.

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ACRONYMS, ABBREVIATIONS & CODES

Acronmyms

CDIS	Curriculum Development of Singapore
LSS	Lower Secondary Science Project
MOE	Ministry of Education
STAS	Science Teachers Association of Singapore

Abbreviations used in connection with the data sources

AM	Anecdotal Memo
FN	Field Notes
FN TI	Field Notes, Teacher Inservice
ISTQ	Inservice Teacher Questionnaire
TG	Teachers Guide
TQ	Teacher Questionnaire

Codes used for the five schools involved in the study

du; es; nd; ss; & yq

CHAPTER I

THE RESEARCH PROBLEM

Introduction

Should we give up or try harder?(1) This is a question which must have haunted a legion of curriculum developers and policy makers as they have repeatedly witnessed even their most modest expectations of curriculum innovations amount to precious little. In fact, as the literature has accumulated over time, reports from virtually every country in which the products of curriculum innovations have been subjected to serious evaluation (Brown, 1983; Bruckheimer, 1978; Brugelmann, 1975; Connelly, 1972; Dalin, 1978; Fullan, 1972; Fullan & Pomfret, 1977; Harding, 1975; Massey, 1980; Shulman & Tamir, 1978; Swetz & Tamby, 1981; Waring, 1979) seem to reverberate a sense of frustration on the part of educators who are committed to seeing the products of centrally developed curriculum innovations transformed into classroom realities. Moreover, considering the input of money and manpower into the development of innovative science curricula over the past two decades, this sense of frustration might well have lapsed into a state of embarrassment on the part of science educators whose responsibilities lie in the development and implementation of these new science programs.

In light of these experiences and given that the science curriculum development movement has, like other sources of knowledge within the dependency paradigm (2), tended to flow from the center to the periphery (see Crossley, 1984; Maddock, 1981; Walters, 1981) science curriculum renewal efforts in countries at the periphery might well seem thwarted before even getting off the ground.

For, having to a certain extent satisfied the need to expand their education systems to provide basic education for all children, many countries at the periphery, especially in Asia, have recently begun to establish a firmer infrastructure to promote improved instructional methods through innovative curriculum development projects (3). And, for reasons that will be touched upon only briefly here, improvement in science instruction has been given particular attention in Third World countries in Asia, as witnessed by the recent UNESCO 'Science for All' movement (4).

It is understandable that science education, along with technical education, has been and will continue to be a nationally acknowledged priority in Third World countries that set their sights on economic progress through industrialization. In the minds of bureaucrats, science education is firmly linked with national development and long-term manpower planning strategies aimed at building up an indigenous scientific manpower reserve (Lim, 1983; Pang, 1975, 1979; Shekleton, 1975; Skolnik, 1976). In spite of a relatively fragile infrastructure, then, it is reported that science curriculum development has stood at the forefront of national curriculum reform efforts in several Asian nations for more than two decades (Alsmeyer & Atkins, 1979; Nielson, 1984).

In the early stages of this movement, science education in Third World countries was apt to take on a rigorous approach wherein the student was mainly preoccupied with the accumulation of facts through rote learning. This approach to science learning has been reinforced over time by the character of the national examination system which was inherited from the colonialists and has been retained as an integral part of the meritocratic post-independence education systems.

More recently, science curriculum innovations in several Asian countries have mirrored science curriculum reform efforts in the center, often adopting those associated with the countries of their colonial heritage (Blum, 1979). As a result, there has been a policy shift away from an expository approach to science teaching in favor of a 'discovery', 'inquiry-approach' in which the processes and methods of science are emphasized. Typically, the trend has been for curriculum developers to adopt programs developed in the center and adapt them to their local situation at the periphery (Lewin, 1981; Lillis, 1980; Sim, 1971; Watson, 1973).

So, while most often these new curricula were adapted and disseminated by change agents appointed by centralized education Ministries, their implementation has proved less smooth and less successful than anticipated. For one thing, the new programs have tended to follow a rather rapid cycle of implementation (Havelock & Huberman, 1978) and to be disseminated by means of a top-down approach. In addition, and this is particularly true of changes implicit in new science curricula, the kinds of changes prescribed by the new curricula have been ideologically in conflict with currently prevailing institutionalized teacher practice.

Furthermore, judging by global reports of science curriculum reform reported over time (Brown, 1979; Brown & McIntyre, 1982; Harris & Taylor, 1983; Shulman & Tamir, 1978; Welch, 1979; Welch et al., 1981) implementation of 'discovery'/'inquiry-based' science programs has more far-reaching implications for the teacher than simply using new teaching materials. The discovery/inquiry-based programs have required teachers to alter behaviors that are basic to their role enactments in the classroom, especially role behaviors that govern ways they commonly interact with students and that dictate their instructional strategies and classroom organization.

This mismatch between the way science teachers are used to behaving in their classes and the way they are expected to behave in implementing innovative discovery/inquiry based science curricula amounts to a dilemma wherein one group (curriculum developers along with centralized Ministries in the countries concerned) sets out to impose an ideology and notions about what is appropriate for a particular group of students on another group (teachers) who will eventually be responsible for putting the new curriculum into practice. The fact that there is a discrepancy between what curriculum developers advocate and what is established institutionalized teacher behavior is a phenomenon that lies at the core of any radical curriculum change which is intended to have impact in classrooms. As such, it is a dilemma which has repeatedly manifested itself over time as an inevitable and inherent part of curriculum reform, regardless of context or world location.

Added to this, a consensus has emerged from the literature on curriculum change (Brown & McIntyre 1982; DeRose, Lockard, & Paldy 1979; Ponder & Doyle, 1977; Dynan et al., 1978, 1981; Harding, 1975; Stake and Easley et al., 1978) that in effecting top-down change efforts, it is the individual <u>teacher</u> that determines whether or not the intended change ever takes place. Neither the quality of curriculum materials developed, nor the effectiveness of the particular implementation strategies that are utilized detract from the reality that it is the <u>teacher in the classroom</u> upon whose shoulders it falls to deliver the curriculum innovation into the arena of the learner; therefore it is the <u>teacher</u> who controls whether or not the intended change ever reaches the classroom level.

The present study, then, explores the problem of teacher change in the implementation of a selected science curriculum reform effort (known as the Lower Secondary Science [or LSS] project) at the junior high school level in the Singapore school system. The study attends to the conventional wisdom that change at a broader national level even in a small and highly centralized education system such as in Singapore, is differently felt and realised at the individual level. In so doing, the study investigates the impact of a science curriculum reform effort on the teaching and learning that takes place in the classes of a group of cooperating teachers. The study is also concerned with placing the curriculum reform effort into long-term historical and contemporary sociocultural contexts. For, only by attempting to understand the dynamics of the total system can insight be gained into the ways in which factors extraneous to the classroom influence the extent to which curriculum is implemented faithful to the intentions of the curriculum developers. For, as Dalin (1978) claims:

> The interplay between schools and their environments, and between the education system and society, is the crucial energy mobilizer in educational reform. Without this comprehensive understanding of the forces at work in these relationships, and the application of that understanding as the basis of educational changes, there is little chance that any real change can take place. (p. 1)

Planned Educational Change - The Problem in the Singapore Context

Being a minute city state with no natural resources and little to depend on for survival other than manpower, Singapore has been more fervent than her oil-rich Asean neighbors in pursuing educational policies which subscribe to the goal of national development through industrial and technological advancement(5). In fact, Singapore's commitment to upgrade science and mathematics education began more than twenty-five years ago when the fledgling leaders of Singapore's newly elected People's Action Party spelled out their education policy. The Annual Report of the Ministry of Education published in 1959 contained a pledge to what seemed imperative to the development of an economically viable industrial city state:

> The economy of the state can no longer be sustained by entrepot trade alone. In the reorientation of the economic policy of the State, industrialization is vital. Industrialization is the key to survival. To increase industrial productivity, potential skill must be trained. So a start in developing the latent skills must be made in the schools. The new education policy would ensure that students have increased facilities for training as craftsmen, technicians, scientists and engineers. (p. 1)

Even so, commitment to upgrade science and technology education with the long-term goal of national development in mind is an ideal that is more easily expressed as a national policy and subsequently incorporated into public rhetoric than it is realised as visible changes in the learning experiences of students in classrom settings. Certainly, in the sixties and early seventies, legislation and adequate funding brought impressive expansion and reform to Singapore's technical education under the directorship of the Economic Development Board. But, as has become increasingly apparent, significant changes in science teaching and learning in primary and secondary schools proceeded at a far slower pace.

So, in spite of Singapore's continued attempts at reform by the introduction of improved science curricula into primary and secondary schools (6), little change appears to have been made at the classroom level. Several reasons have been suggested for this. At the administrative level, the Report on the Ministry of Education, (1978) cited cumbersome bureaucratic procedures as problematic. Criticism was also levied at teachers for their poor response to change. "Entrenched beliefs, the stronghold of unrelieved and monotonous experience, bureaucratic resistance and fear" are but few of the criticisms made of teachers by one Ministry administrator (Wong, 1974, p. 35) when reviewing curriculum innovation in Singapore. "Insecurity", Wong contended, "keeps practitioners from taking the plunge". Apathy on the part of teachers was also implied by Wong who remarked that teachers declined to provide formative feedback on a new syllabus they were asked to try out.

But just what was involved in bringing about changes of the magnitude envisioned by policy makers as they implemented innovative science curricula over the years is portended in a much earlier report: <u>A Commission of Inquiry into Education</u> which was carried out in 1964:

> Some teachers insist on covering "so many pages" of the textbook per session and force pupils to do experiments of a "verifying" nature. The possibility of finding a solution (or a number of solutions) to a given problem is lost sight of. Beautiful diagrams and formulae are drawn on the blackboard and are studiously copied by the pupils into their notebooks. Occasionally, class demonstrations are arranged by the teacher but here again it is often to show "proof" of a statement, and not to discover the underlying principles through first hand observations by the pupils themselves. The result is that the pupils think of the laboratory session as a necessary chore, not of great value to be "dodged" or "palmed off" to one's partner whenever possible.... Often the more vigorous or keener pupils monopolise the practical work and the weaker pupils who need it most find themselves learning off "by heart" results from experiments for the purpose of passing examinations. The end of these efforts even when the pupil somehow gets through, is a permanent distaste for the subject and what is worse a permanent "idee fixe" that 'science' is just a catalogue of unrelated facts, just like dates in history. (p.61 - quoted from Tang, 1984.)

Likewise, Cheah's (1978) remarks referring to the reorientation of teachers towards the new inquiry-based Lower Secondary Science (LSS) program, which was at that time in its formative stages, indicate that science teaching practices at the lower secondary level had not changed even in the time span of fourteen years:

> ...very often the main objective of a teacher preparation course demands a reorientation of attitudes on the part of the participants. This is by no means an easy matter as in many cases it amounts to a 'mental revolution'. For instance, some teachers who have previously become 'text-book bound', teaching in very convergent situations (where there is a right answer somewhere!) have now to grapple with open ended situations, problems of design, problems of controversial human issues and the like. Usually the first few initial sessions of the LSS in-service are the most crucial - if the participants did not react favourably, they 'dropped out' there and then. (Cheah et al. 1978, p. 5)

And more recently, drawing on his personal experiences of observing classes in his role as a Specialist Inspector of Schools, Tang (1984) reported that the statement quoted earlier from the 1964 <u>Commission of Inquiry into Education</u> was enduring even to date:

> The (above) quotation may have been taken from a 1964 document, but most educators in Singapore would agree that it decribes very accurately what is still happening in a typical science lesson. (p. 8)

It seems apparent then, that in spite of continuing good intentions and some positive moves towards science curriculum reform over two and a half decades, attempts to implement innovative curricula in Singapore are just as problematic as in countries where the tradition of curriculum development has a firmer infrastructure. In fact, the prospect of change in science teaching resulting from the introduction of new science curricula seems to have been viewed by a number of informed observers with some scepticism.

Nevertheless, a renewed surge of hope in science curriculum reform occurred in the wake of the findings of a Report on the Ministry of Education prepared in 1978 (commonly referred to as the Goh Keng Swee Report) when a special institute - the Curriculum Development Institute of Singapore (CDIS) was set up to assume responsibility for curriculum materials development. For although the centralized Ministry of Education retained control over the curriculum content (or syllabus, as it is called) the CDIS was given the responsibility for developing all the necessary support materials such as student textbooks and workbooks, teachers guides and a range of audiovisual materials. The new Lower Secondary Science curriculum (the program that forms the focus of this study) then came under the auspices of the CDIS which took over from the combined Ministry of Education and the Science Teachers Association of Singapore committee (MESTAS) that had nurtured the program through its earlier stages of development and try-out in the trial schools.

The question that now emerges is whether the Lower Secondary Science curriculum, which has probably been through a more rigorous development and trial process than former science curricula, can realise the kind of success that is hoped for at the classroom level.

Role and Role Relationships as a Focus of the Study

There are several ways in which a focused research of the implementation of an innovative science program of the type undertaken in this study could be tackled. The study could be approached from the perspective of student outcomes, from indicators of teacher attitude change or from a detailed appraisal of teacher/student interaction, to name but a few. However, given the purported nature of the new LSS program and characteristics of the user system in which the new program will be implemented, the perspective of teacher/student role and role relationships was selected as a theoretical focus of the study for three important reasons. First of all, according to the limited information available on science teaching prior to implementation of the new LSS curriculum (Gremli, 1982; Morris & Thompson, 1979; Tang, 1984; Wong, 1974; Yeoh, 1980) institutionalized teacher/student role perceptions and concomitant role behaviors in science classes appeared to be a prevailing governing factor in the conduct of classroom events. Yet, significantly, role behaviors emerged as crucial to the types of changes implied in the introduction of the new Lower Secondary Science program which purportedly embodies a 'guided-discovery', 'inquiry-based' approach.

Secondly, on a global level, very few studies have focused specifically on the issue of role and role relationships and its significance for understanding teacher change in the implementation of a new curriculum - even though the problem of role change has been identified as an important factor the change process:

> The source of difficulty in bringing about changes at the classroom level does not appear to reside in actual development of materials... the main problem appears to be that curriculum change usually necessitates certain organizational changes, particularly changes in the roles and role relationships of those members most directly involved in putting the innovation into practice. (Fullan and Pomfret, 1977, p. 337)

Thirdly, a perusal of the change literature reveals that even fewer studies have been conducted on a long-term basis so that changes in role behaviors of any sort intended and/or accomplished as a result of the introduction of a new curriculum could be determined by comparisons of preimplementation and post implementation data.

Thus, by examining role phenomena implicit in the faithful implementation of a selected curriculum innovation relative to the institutionalized role behaviors identified within the research setting prior to implementation, the possibility arises for ascertaining the extent to which role behaviors of cooperating change participants (teachers and their students) are successfully changed in the direction intended by the curriculum developers.

The Research Questions

The intention of this study, therefore, is to investigate the extent to which evidence of change in teacher/student role and role relationships implied in the introduction of the new Lower Secondary Science curriculum is evident during the first year that the program is put into practice in classrooms in Singapore. The study addresses the problem by asking:

- What are teacher and student role and role relationships in science classrooms prior to implementation of the Lower Secondary Science program ?

- How do classroom events and classroom discourse prior to implementation compare with those advocated in the new curriculum and what changes do teachers and students need to make in their role behaviors in order to implement the program faithful to the intentions of the curriculum developers?

- What channels of communication (program information, in-service experiences etc.) inform teachers what is expected of them as they implement the new program?

- What evidence of change could be discerned during the first year of implementation?

- How does evidence of change or lack of evidence of change link with channels of communication and key events in the implementation process and/or with other parameters in the research setting?

As a means of examining these questions, the researcher investigated the role behaviors of five cooperating teachers and their students in five different schools in Singapore. Classroom observations extended over a period of two school years and monitored teacher/student role behaviors involved in teaching at least four topics in the lower secondary science syllabus. Observations of in-service training sessions designed to prepare teachers to teach the new program, interviews and informal communication with key informants (members of the curriculum writing team and Ministry of Education personnel) as well as a detailed examination of the LSS program materials provided an additional data base.

Summary

As evidenced by the foregoing discussion, science education, along with technical education, has been acknowledged as a national priority in Singapore and has therefore been heavily politicized as important to national development. The development of a new inquiry based, guided-discovery Lower Secondary Science program by the recently established Curriculum Development Institute of Singapore is one of many visible signs that this commitment to science education is more than just rhetoric.

On the other hand, the introduction of a new guided-discovery, inquiry-based science program has far-reaching implications for institutionalized teacher/student role relationships. According to earlier reports of the nature of classroom activity in science classes in Singapore schools, the types of teacher/student role behaviors implicit in the new Lower Secondary Science program most probably mean a significant departure from present practices. At the same time, experiences gained worldwide and in Singapore, strongly indicate that teacher behavior is predictably difficult to change.

The problem, then, is one that is set within a conflict of ideologies concerning established current practice and what is intended in a national curriculum reform effort in science teaching at the lower secondary level. By examining the meaning of role change for individuals most central to the faithful implementation of the curriculum under study (teachers and their students in the classroom setting) the research will both extend and refine models of change appropriate to Singapore, to other Third World countries and to countries in which researches on curriculum change have, to date, neglected consideration of change from the perspective of teacher/student role and role relationships.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

Human behavior in changing social systems is the broad conceptual framework within which literature relating to this study is discussed; teacher and student role/role relationships in the user system of the new Lower Secondary Science program is the specific aspect of human behavior in changing social systems that will be developed during the course of the discussion.

A review of selected literature pertaining to the research problem is presented in three parts. First, the scope of literature on educational change is surveyed in so far as it can more accurately shed light on the nature of the research problem. Next, germaine aspects of role theory are discussed in light of the ways in which role concepts interpret the impact of change implied by introduction of the new Lower Secondary Science program on the role behaviors of the target group of teachers. Finally, a cultural model is proposed as a conceptual framework within which change in student/teacher role and role relationships in the implementation of the new Lower Secondary Science curriculum in the Singapore schools can be usefully analyzed and understood.

Theorizing Educational Change

Although literature on educational change in some countries is voluminous (notably the UK, the USA, Canada and Israel) case study literature on the nature of planned educational change in Third World countries (7) has been reported as scarce (Huberman, 1975, Havelock & Huberman, 1978). With some notable exceptions (Hamilton, 1975; Shipman, 1974) the scope of change literature that exists worldwide has been overwhelmingly preoccupied with the formulation and testing of theoretical propositions aimed at seeking more successful ways of effecting change, principally through what has become known as a 'top-down' approach. The result of this line of research has been the theorization of the change process through the development and refinement of models of change focusing primarily on implementation processes (Zaltman, Florio, & Sikorski, 1977, chap. 3).

An important outcome of the emergence of these models of change, however, is that they can be applied both descriptively and prescriptively. Descriptively, such change models offer principles and generalizations about how change can be construed, which, when applied prescriptively, give indications as to how change efforts introduced into existing social systems can be optimally managed.

A perusal of exemplary models of educational change reveals that they comprise a common set of variables that are afforded different degrees of emphasis in different models. Each model takes into account: (a) the intrinsic qualities of the innovation (e.g. at the classroom level this may involve change in program materials or proposed changes in organizational and/or instructional procedures); (b) a series of key events to facilitate various channels of communication that comprise the intervention strategy; and (c) a set of outcomes often in the form of prescribed behaviors anticipated of change participants in their respective roles in the user system. The set of prescribed behaviors may be explicitly defined and/or implicitly communicated through the content of the program materials or through channels of communication incorporated into the implementation process (such as through the teacher inservice experience).

Collectively over time, models of change reported in the literature can be characterized as progressively precise attempts to theorize dimensions of human behavior within changing social systems. Endemic to these existing social systems about to confront change are, of course, both institutional and individual biases all of which have impact upon potential for change, irrespective of the model of change utilized by the change agents. More recent change models (Becher & Maclure, 1978; Fensham, 1978; Kogan, 1978) show an increasing tendency to extrapolate beyond the immediate user system taking into account institutional biases as well as the broader overriding sociological, economic or political factors that might interfere with the intervention strategies or to which intervention strategies might have to be accommodated.

Conversely, other change theorists have gravitated towards examining the perspective of the individual, looking at change in institutions as the cumulative effect of behavioral change of individuals. In line with this perspective, progressive levels of change in individuals have been identified (Hall et al., 1973, 1975, 1979; Louks & Hall, 1977; Louks & Pratt, 1979). In spite of these differing orientations, the idea that change in institutions involves common and cumulative behavioral changes of individuals within them now appears to be universally accepted. Gross, Giaquinta and Bernstein (1971) for example, contend that "the degree of implementation refers to the extent to which organizational members have changed their behavior so that it is congruent with the behavior patterns prescribed by the innovation".

Regardless of orientation, prescriptive application of the theorization of change processes has brought into focus some interesting ideas about relationships between educational change efforts and cultural, moral and ethical values prevalent in the society at large (Berman & Pauly, 1975; Berman & McLaughlin, 1976). Assertions have been made that change planners would optimally benefit from utilizing sources of influence in the polity at large (House, 1974, 1979; Levin, 1974) and that educational change efforts cannot occur in isolation from polity issues. Schwab (1970), for instance, says:

> Changes must be so planned and so articulated with what remains unchanged that the functioning of the whole remains coherent and unimpaired. (p. 183)

Viewed collectively and over time, approaches to studying educational change discussed so far appear to have progressively moved beyond a strictly 'systems approach' towards a perspective that is more sociocultural, humanistic and individualistic in nature. Although both of these perspectives can make their respective contributions to understanding change, it would appear that there is still a gap in the change literature, namely that little is known about what occurs at the interface of these two perspectives. To be more precise, it would seem that few attempts have been made to look at the influences and constraints that have bearing on role behaviors of individuals in the user system in light of the intrinsic qualities of the innovation about to be introduced with respect to immediate and broader sociocultural contexts, so that a more composite picture of change processes might be obtained.

Where current change literature is lacking, then, is in the confluence or integration of change theory with other human behavior theories so that a holistic level of insight into the success or failure of educational innovations at the individual level can be achieved. In the present study, the principles of role theory are applied to gain a better understanding of the influences and constraints of the individual teacher in the change effort under study, for, as asserted in the previous chapter, change in teacher/student role and role relationships in the conduct of science classes is critical to the implementation of the new Lower Secondary Science curriculum.

In the next section of the literature review, therefore, germane principles of role theory will be discussed to assist in understanding the behavior of individuals involved in the user system of the new LSS science curriculum. In particular, role theory will be applied to gain an understanding of how the individuals concerned experience and respond to the specific kinds of changes that are imminent in the implementation of the new Lower Secondary Science curriculum which is the focus of the present research.

Role Theory and Its Implications for this Study.

Having explored ways in which change theory can be informative to the study, as well as some of its shortcomings, we shall now attend to the conventional wisdom that change imposed at the system level may indeed be differently felt and experienced at the level of individuals in the user system. In the case of the particular change effort upon which this study will focus, the individual most affected in the user system will be the lower secondary science teacher whose responsibility it will be to implement the new curriculum.

Although role theorists such as Biddle and Thomas (1966) and later, Biddle (1979) have done much to operationalize role concepts and apply them to contemporary settings, early role theorists such as Ralph Linton and Talcott Parsons provided the essential seminal work upon which contemporary role theory is based. Ralph Linton (1945) describes role as follows:

> Role ... the sum total of the culture patterns associated with a particular status. It thus includes the attitudes, values and behavior ascribed by the society to any and all persons occupying this status... In so far as it manifests overt behavior: what a person has to do in order to validate his occupation of the status. (p. 77)

Parson's (1951) description of role was rather similar but he concerned himself with discerning levels of organization within social systems. He characterized social systems as being stable, patterned sets of role relationships in which the individual functions and which are largely governed by the normative expectations of its group members.

Parson's notion of role function captures the essence of individual behavior at micro as well as macro levels. For, within immediate and wider contemporary social contexts, individuals are involved in the enactment of mutually reinforcing behaviors which constitute the maintenance of institutionalized normative behavior. As Parsons explains:

> ...the essential aspect of social structure lies in a system of patterned expectations defining the proper behavior of persons playing certain roles, enforced both by the incumbents own positive motives or conformity and by the sanctions of others. Such systems of patterned expectations seen in the perspective of their place in a total social system and sufficiently thoroughly established in action to be taken as legitimate are conveniently called 'institutions'. (Parsons, 1949, p. 35)

By the same token, Parsons emphasized a link between the forces that maintain equilibrium within institutionalized patterns of role behaviors and the forces that create resistance to change. He used the term 'vested interests' to explain the integrated nature of need dispositions and concomitant value orientations of role incumbents. With regard to the necessity of understanding these forces, Parsons says:

> The phenomenon of vested interests then, may be treated as always lying in the background of the problem of social change. ... change in the social system is possible only by the operation of mechanisms which overcome the resistence of vested interests. It is, therefore, always essential explicitly to analyze the structure of the relevant vested interest complex before coming to

> any judgment of the probable outcome of the incidence of forces making for change. These considerations will often yield the answer to the questions of why processes of change either fail to occur altogether or fail to have the outcomes which would be predicted on a common-sense basis. (pp. 492-493)

Although the work of Linton and Parsons did much to sensitize the social scientist to the importance of role in understanding the social nature of human behavior, it was one of Parson's students, Robert Merton, who further clarified the interrelated nature of roles by introducing the notion of role set. Merton (1957) defined role set as that complement of role relations which persons acquire or assume by virtue of occupying a particular status in a social system.

Merton further subdivided individual roles within simple and complex role sets. He defined a simple role set as being a group of individuals that is few in number, remains fairly stable, and whose role incumbents do not differ significantly in status, as with teachers and their colleagues. In contrast, he described a complex role set as a set of individuals within which the role partners occupy a different status. For example, teachers and their students form one type of complex role set, teachers and their administrators another, and teachers and their inservice instructors yet another.

The value of identifying different types of role sets in a social system is in recognizing a major difference in the way that role incumbents in the two types of role sets interact. Merton acknowledged that individuals in a complex role set are more likely to experience differing expectations in their interrelationships than individuals in a simple role set. In turn, differing expectations can generate potential sources of conflict between role incumbents.

If this concept is applied to role and role relationships of teachers, then potential conflict within the variety of complex role sets in which a teacher is a role incumbent seems inevitable. Teachers are expected to behave in a way that meets student expectations and that complies with expectations set by administrators and the broader society. Aside from this, parents' expectations and expectations teachers have of themselves impinge upon the teacher to a lesser or greater extent and with differing degrees of intensity at any given time. Furthermore, in the context of the problem addressed in this study, teachers are charged with the responsibility of implementing a new science curriculum in which expectations (at least in the early stages) may be unfamiliar, unclear or contrary to the vested interests of teachers. Worse still, the role expectations imposed on teachers as they teach a new inquiry-based/guided-discovery curriculum may seem 'impractical' in the teacher's eyes (Ponder & Doyle, 1977).

But critical to reaching an understanding of the nature of teacher/student role relationships in the problem identified in this study is the potential conflict that arises if and when teachers attempt to implement the new program in accordance with the role prescriptions implicit in the new curriculum. Clearly, the likelihood is high that teachers could experience conflict as they place themselves at risk by opening up their classrooms to the ambiguity of a repertoire of behaviors and role relationships with which both they and their students are unfamiliar. For, what has previously existed as commonly accepted institutionalized reciprocal role expectations in the teacher/student role set, now becomes an arena that is rife with ambiguity and unforeseen consequences for the teacher.

Finally, in seeking to locate the behavior of individuals on an on-going basis in a matrix of conditions and events, role theorists underscore the contextual and interrelated nature of roles. And, when applying role theory to the functioning of established social systems, role theorists acknowledge the inseparability of position or status and role. As Linton (1945) puts it: "A role represents the dynamic aspect of status... There are no roles without statuses or statuses without roles" (pp. 113-114). Status, according to Linton's definition, is distinct from the individual who may occupy it. Linton reconciles the close association of role and status by linking them with rites and duties which are assumed and enacted.

The notion of individual role enactment as an expression of status is of particular relevance for this study since the social system which forms the cultural matrix of this study viz: the Singapore education system, is deeply rooted in the high profile of status within an established hierarchy. This hierarchy is repeatedly made explicit in the sources and expressions of authority in all facets of the system (See Perceptions and Practice: An STU Report, 1981; and Gopinathan & Gremli, 1984).

Schools and Classrooms as Social Systems

Viewing schools and classrooms as microcosmic social systems in which there exists a uniquely embedded culture which is continually subject to renewal is by no means a new orientation. Waller (1932) for example, vividly depicted the world of schools as follows:

> ... the world of the school is a social world. The human beings who live together in the school, though deeply severed in one sense, nevertheless spin a tangled web of interrelationships; that web and the people in it make up the social world of the school. It is not a wide world but for those who know it, it is a world compact with meaning. It is a unique world... (preface).

Berliner and Tikunoff (1977) Delamont (1976) Mehan, (1975, 1979) Stenhouse (1978, 1980) and Walker (1972) are among the league of educational sociologists and educational researchers on both sides of the Atlantic that has attempted to portray the richness and complexity of the social structure that makes up life in schools and classrooms. These researchers and others have made concerted efforts to understand some of the tacit qualities of school culture that emerged from studies which focused, for instance, on educational inequality and on the predicament of culturally disadvantaged students. Many of these early studies addressed socio-linguistic aspects of the classroom (Cazden, John & Hymes, 1972; Barnes et al., 1971; Barnes, 1976). Later, studies focusing on issues such as teacher effectiveness and school socialization further expanded this research base.

The growing popularity of ethnographic research methods has provided a suitable research paradigm through which such holistic portrayals of classroom culture can be investigated. Connected with this trend has been the emergence of models and paradigms which have been used as interpretive tools or as means by which the specific aspects of teacher and student behavior can be located in the broader question of effects in classrooms.

Bransford and Franks (1976) describe such models as "theories and tools that set the stage for clarifying and understanding situations". With this in mind, it was concluded that a cultural model would be most highly suited to obtaining a holistic insight into understanding the implications and outcomes of the introduction of an inquiry-based/guided discovery science program into the Singapore school system. Using a cultural orientation facilitates a course of research which takes into account the functional and the interactive nature of human relationships both in the classrooms themselves and in the society as a whole.

Applying a cultural model to understand change is a practice which, according to House (1975), has undergone recent revitalization due to the model's ability to explain diversity rather than uniformity of user systems. House cites Smith and Geoffrey, 1968; Sarason, 1971; Smith & Keith, 1977; Lortie, 1975; Wolcott, 1973; and Ruddock, 1977 as researchers who have used a cultural approach to investigate change in schools. These researchers and others like them tend to take the view that schools should be viewed as cultural entities in which a delicate balance of mutually reinforcing values, attitudes and behaviors exist. Once this has been recognised, it is easy to see that changes imposed by outside change agents might tend to disrupt or disorient the role incumbents concerned causing the intended change effort very difficult to bring into effect. On the other hand, understanding user systems according to a cultural orientation can, according to Romberg and Price (1983), consolidate the close-knit relationships between curriculum implementation, staff development and cultural change.

Before elaborating in detail on the ways in which a cultural model can be applied in the study and the potential the model has for interpreting the research problem addressed in the study, it will be pertinent to take into account the broader sociocultural context of Singapore and the genre of its education system so that the research problem can be addressed in context.

Singapore - A Pluralistic Society

The fact that Singapore is most commonly described as a pluralistic society and is indeed made up of a number of ethnic, racial, religious as well as socioeconomic subcultures makes any attempt to characterize a 'Singapore culture' infinitely problematic. Yet, during the twenty-five years since Singapore became an independent nation, there has been an undeniable and affirmative attempt on the part of the government to mold the nation's citizenry into patterns of behavior which bear distinct cultural overtones.

With few exceptions (8), the kinds of attitudes, values and behaviors that the government of Singapore has attempted to instill in the population via this 'social engineering' process are in harmony with accepted norms of Singapore's constituent Asian cultures (9). As such, they have been avidly communicated to the adult population through the mass media by means of national campaigns, community action and economic incentives (10).

In addition, cultural values have also been openly and unreservedly reinforced through the education system. Quoting Prime Minister Lee Kuan Yew in his open letter responding to the Report on the Ministry of Education (1978): 'No child should leave school after 9 years without the 'software' of his culture programmed into his subconscious' - a clear indication that the government holds the education system responsible for a good part of the enculturation of school-age Singaporeans.

Interestingly enough, Mr. Lee even suggests that a Singaporean identity can combine cultural values axiomatic to Singapore's constituent racial subcultures and those associated with the scientific and technological advancements that are part of Singapore's contemporary image. For instance, in the same letter, the Prime Minister argues:

> 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 sceptical Western methods of scientific inquiry, open discursive methods in the search for truth. (p. v.)

The Prime Minister goes on to describe the kind of citizen the Singapore education system should aspire to produce:

> What kind of man or woman does a child grow up to be after 10-12 years of schooling? Is he a worthy citizen, guided by decent precepts? Have his teachers and principal set him good examples? Imparting knowledge to pass examinations, these are important. However, the litmus test of a good education is whether it nurtures citizens who can live, work, contend and cooperate in a civilized way. Is he loyal and patriotic? Is he, when the need arises, a good soldier ready to defend his wife and children, and his fellow citizens? Is he filial, respectful to elders, law

> abiding, humane and responsible? Does he take care of his wife and children, and his parents? Is he a good neighbour and a trustworthy friend? Is he clean, neat, punctual and well mannered?
>
> We have a mix of immigrants from different parts of China, India and the Malay world. We have to give our young the basic common norms of social behavior, social values and moral precepts which can make up the rounded Singaporean of tomorrow. (p. iv-v)

So, no matter how tenuous and problematic references to a 'Singapore culture' may seem to be, it is both evident in the foregoing statement by the Prime Minister and vital to the thesis of this study to acknowledge that there are certain identifiable, distinctive cultural patterns already existing, or in the process of being integrated into the fabric of contemporary Singapore life. Moreover, there are certain attitudes, values and beliefs that are officially endorsed by the government through the national education system.

What is equally important to this study though, is that not only are such preferred patterns of behavior explicitly transmitted through the official school curriculum in the moral education and religious studies programs, but they are also predictably reinforced through the 'hidden curriculum' by the ways in which day to day events are conducted in schools and in classrooms. Manifestations of this hidden curriculum exist within the institutionalized patterns of social relationships permeating the education system; being both explicitly and implicitly defined in role expectations, role relationships and role enactments. Such institutionalized patterns of behavior are also likely to be brought more sharply into focus in circumstances that are being investigated in this study; namely: where one group in the system intends to impose certain changes on another group in the system.

Applying a Cultural Model

Applying a cultural model to understand change in a school setting is based on the assumption that schools are social systems characterized by sets of behavioral configurations which are held together by beliefs, values and rituals. In turn, these institutionalized norms are influenced by prevailing sources and expressions of authority. The cultural model is therefore concerned with looking at the basis for interconnectedness of cultural forms within the system under study in order to discover those which appear to be stable and those which appear to be dynamic.

The maintenance of social systems and schools as defined by the cultural model, then, is dependent upon people, their basis for mutual interaction and their spheres of influence and control. Understanding change within the context of a cultural model is adopting a perspective that would have to be assumed through channels that influence or control the dynamic aspects of the culture or by means of channels that mutually reinforce it. What renders this as an appropriate analytical model for the present study is that unlike other models which are grounded in structural dimensions, activities of individuals in this model are viewed in terms of their role within the structure.

In the cultural model, schools are viewed as subcultures of a wider culture. Administrators, teachers and students are role participants in the culture and their actions and transactions have mutually symbolic meanings. These meanings may be highly specific and different from meanings that an outsider may attach to the same events when viewing them in context. Also implicit in this model is that each situation has a high degree of uniqueness that needs to be investigated in detail before any kind of prescriptive move towards change can be made.

What further distinguishes the cultural model is its potential for understanding organizations <u>by way of</u> the activities of the participants, i.e.: viewing the structure of the organization through the activities of those who are role participants in it. This approach is consistent with a phenomenological perspective and, as such, is more concerned with the mutual interaction of participants than with individualistic attributes with regard to the broader organizational structure.

Summary

In this literature review, an attempt has been made to give an overview of trends in the literature on educational change and to indicate ways in which its orientation has progressed over time. It was argued that in further extending change theory, researches could benefit from drawing upon related paradigms within human behavior theory so that a more holistic understanding of implications for individuals in the user system could be achieved.

The major constructs of role theory were explored in so far as they furnish a conceptual framework within which to look at behavioral changes of individuals most intimately involved in the change process being studied viz: the cooperating teachers who would implement the new LSS program. The dynamics of the various role sets in which these teachers function was also discussed. It was asserted that role perceptions and role enactments within the teacher/student role set were axiomatic to the kinds of changes anticipated in the introduction of the Lower Secondary Science curriculum.

An additional thread in the literature that informed the present research is the body of research that has looked at schools as microcosms of the broader social milieu. In the study, each of the target classrooms, together with their respective schools, came to be regarded as cultural microcosms of the highly centralized education system. Likewise and in turn, the educational system, as an integral and dynamic consequence of Singapore's sociopolitical and economic circumstances, emerged as a microcosm of predominating sociocultural patterns that permeate contemporary Singapore life. It was within this frame of reference that this research attempted to understand change in teacher/student role and role relationships resulting from the implementation of the new Lower Secondary Science program.

CHAPTER III

THE RESEARCH METHODOLOGY

A Rationale

A phenomenological approach to the investigation of role and role relationships of teachers and students in the implementation of the new Lower Secondary Science curriculum was selected for this study. This approach is grounded in an ideology which takes into account that the world exists as it is but that different people construe it in different ways. Thus, the theoretical framework of the study is essentially ideographic in that it serves the purpose of extracting the sets of meanings through which individuals interpret their world and with which individual role enactments are inextricably linked. Within this frame of reference, researches become a search for meaningful relationships and the discovery of their causes and consequences. Research approaches that can achieve this end focus on a way of finding the means by which these varying views of reality can be portrayed for the purposes of analysis, understanding and appropriate action.

The research approach that has the greatest potential for yielding this kind of holistic view of varying constructions of reality and yet, by the same token, is most appropriate to the research problem addressed in this study, is an ethnographic research approach in which one or more case studies are investigated from an ideographic standpoint.

The Ethnographic Research Paradigm

Assumptions underlying the ethnographic research paradigm (11) that are particularly pertinent to this study have to do with understandings about human behavior in social settings. A key assumption for the ethnographer, for example, is that human behavior is contextual in nature, being irrevocably linked to the specific environment and the particular moment in time in which it occurs. Furthermore, the ethnographer recognises the interrelated nature of human behavior in terms of roles, role relationships, social groupings and cultural norms. These assumptions are, of course, consistent with the precepts of role theory and therein lies their potential for guiding interpretations of the sets of meanings that govern role and role relationships within the context of this study.

Another assumption underpinning the ethnographic research paradigm relates to the way in which ethnographers go about their work. It is assumed that a well trained ethnographer will become a sensitive instrument of research and, as such, will uncover meanings that participants within the setting attach to events and happenings. These meanings may or may not be explicitly expressed or even acknowledged by the role participants but they are discernible in a tacit sense from one or more of the many perspectives that the researcher is able to investigate during the course of the research.

The antecedents as well as the apparent intentions and motivattions linked with the role behavior of the participants may thus be inferred by the ethnographer as their meanings become more acute, more penetrating over time. The responsibilities of the ethnographer, therefore, evolve into seeking to become more and more immersed in the complexity of the research setting as the study progresses and in so doing becoming more and more conversant with the intricacies of the interactions of the respective role incumbents in their social groups.

In integrating the axioms of ethnographic research methods within the framework of a cultural model, it was assumed that the teacher's professional sphere of relationships comprises various simple and complex role sets within which they function as role incumbents. It was hypothesized that of all of the role sets in which the teacher acts as a role incumbent (teacher/students, teacher/colleagues, teacher/school administration, teacher/parents, teacher/centralized education system etc.) the role set in which the teacher has the most clearly defined vested interests and that would therefore have the most intense and enduring impact on the teacher is the complex role set comprised of teacher and students interacting in the classroom setting (12).

Patterns of teacher and student behaviors observed in target classrooms were therefore treated as stable, institutionalized systems of role enactments that were mutually reinforced in the context of the immediate classroom and school setting as well as in the broader society. It was further assumed that within the range of role sets in which each teacher is a role incumbent, a hierarchy of roles is well established and this hierarchy is an important controlling factor in the events that transpired during the two-year time span of the study.

It was further proposed that when introducing change through the implementation of the new Lower Secondary Science Curriculum, the conditions governing the majority of role sets in which the teacher is a role incumbent will remain constant, but that within the teacher/student role set, role definitions and role relationships are expected to change - and therein lies potential for role conflict. The nature of these potential role conflicts as well as their causes and their consequences formed an important line of inquiry in this study.

Data Sources

The Case Studies

Five science teachers and one of their respective lower secondary I science classes for each year of the study were regarded as case studies comprising the broader study. The research design included a total of four sets of observations undertaken in each case study (13), two during the year prior to and two during the year of implementation of the new program. Observations took place at prespecified intervals over a two year period so that a longitudinal perspective could be obtained:

Timeline

Phase	Research Strategy	Dates
I A	Schools were selected. Rapport was established with school personnel. A series of observations was undertaken on one topic of learning in the existing science program.	Jan-Mar 1982

I B	Contact with schools re-established. A second series of observations was undertaken on a second topic of learning in the existing program. Questionaires given to a shadow group of teachers.(14)	Aug-Oct 1982
IIA	A series of observations was undertaken involving one topic of learning in the new Lower Secondary Science program (this topic, where possible, corresponded to one of the topics observed in the baseline study). Every class meeting utilized for the topic was observed.	Jan-Apr 1983
II B	Contact was re-established with schools and cooperating teachers involved in the baseline study and in Phase I of 1983 study.	July 1983
	A second series of observations was undertaken of a topic of learning in the new LSS program.	Sept/Oct 1983

Comparisons were subsequently made between the two sets of observations within each case study. That is, for each teacher, data collected during the two sets of observations conducted <u>prior to</u> implementation of the new program was considered as baseline data and the two sets of observations conducted <u>during the first year of implementation</u> were compared with the baseline data by applying pre-determined analysis procedures.

<u>Selection of Schools</u>. Entry to the schools selected for this study was gained through application to the Research and Monitoring Branch of the Singapore's centralized education department - the Ministry of Education. Selection of schools was made on the basis of

consultation with personnel from the Research and Monitoring Branch and the Curriculum Branch of the Ministry. The schools were chosen from a group of schools listed by the Ministry of Education as having the same range of results in the school leaving examinations taken by fourth year secondary students (average of 1978 and 1979). Altogether, six different criteria were applied in the selection of the five target schools:

(1) All schools averaged 60-70 per cent General Certificate of Education 'O' level passes (average for 1978-79). (15)

(2) All were government schools (as opposed to government-aided, missionary schools).

(3) All were coeducational schools.

(4) All had approximately the same number of students enrolled.

(5) All have a similar intake of students in terms of socioeconomic status. (According to information available in school records, the majority of students live in nearby high-rise housing estates and their parents are employed in unskilled or semi-skilled occupations.) (Appendix A)

(6) All schools followed the same science program up to the end of the 1982 school year (i.e. none had piloted the new Lower Secondary Science program during its development phase).

A total of sixteen schools comprised the category of schools from which the five target schools were selected. It should be noted that this group of schools fell close to, but slightly above the national mean of 59% GCE 'O' level passes quoted in The Report on the Ministry of Education (1978). In order to obtain the best possibility of suitable representative teacher and student groups, schools were selected from different districts in Singapore.

Selection of Teachers. After receiving the necessary permission from the Research and Monitoring Branch of the MOE, the principals of the schools were contacted and appointments were made to meet the five principals concerned. The principals then introduced the researcher to teachers who were teaching at the grade level selected for the study. Subsequently, one teacher from each school agreed to become a cooperating teacher in the study. Of the five cooperating teachers, two were males and three were females; three were Chinese and two were Indian and their years of experience ranged from two years to 'twenty over' years (16).

Selection of Student Groups. In the selection of student groups, the researcher chose to observe groups of students that were, as far as possible, representative of the mid-range student population. To achieve this, it was necessary to take into consideration the national streaming policy in Singapore. Three streams exist in Singapore secondary schools: the Special stream for students with high ability (the top 10 percent), the Express stream for students with average and high-average ability and the Normal stream for students with average and below average ability which are assigned 50% and 40% respectively of students who reach secondary school. However, not all students attend secondary school. Some students (about 5% of the original cohort) are streamed into the lowest stream in the Primary school (the Monolingual stream) and from there they go on to vocational schools. Streaming of students occurs as early as the third year of primary school. Further categorization of students takes place after they have taken the nationally administered Primary School Leaving Examination (or PSLE) at the end of the sixth or eighth (17) year of primary school. But it should be mentioned that because of the emphasis placed on performance in the language component of the PSLE, some students are placed in a normal stream merely because they happen to score poorly in their second language.

Target classes were selected in consultation with the cooperating teacher. For obvious reasons, it was not possible to observe teachers working with carefully matched student groups. It soon became apparent that scheduling procedures in each individual school predetermined student groupings, making matching groups for the purpose of this study impossible. For instance, even though all of the cooperating schools were coeducational, some classes were comprised only of males or females and the cooperating teacher taught only classes separated according to gender. This meant that an all-girls class or an all-boys class was the only possibility for observation at the Secondary I level. In some schools, grouping depended on students' choice of elective subjects such as second language (Mandarin, Malay or Tamil) and in other schools grouping depended on options in vocational classes (technical studies versus home economics). The selection of classes for the 1982 (Phase I) and 1983 (Phase II) stages of the study are listed as follows:

Pre-implementation Phases IA & IB (1982)	Total 5 classes
	2 Express (mixed boys and girls)
	1 Normal (mixed boys and girls)
	1 Normal (all boys)
	1 Normal (all girls)

During implementation Phases IIA & IIB (1983)	Total 5 classes	
	1 Express	(mixed boys and girls)
	2 Normal	(mixed boys and girls)
	1 Normal	(all boys)
	1 Normal	(all girls)

It should be mentioned that the student groups observed were self-contained in the sense that they all had the same form or home-room teacher and that during each day, they all proceeded through their daily schedule as a unit, meeting with subject specialist teachers either in their own classrooms or in the subject classrooms of their teachers.

Classroom Observations. While engaged in observations in classes, the researcher remained as unobtrusive as possible observing the class proceedings from various locations in the laboratory, focusing attention either alternately or simultaneously on teacher and student behavior. On occasions when the teacher was making a presentation to the class or addressing the class as a total group, the researcher remained in one location but when students were doing laboratory work, the researcher circulated to mingle with student groups, sometimes attempting to discuss the experiment with the students and sometimes remaining as a detached listener. In each case study, notes were organized into lesson units and assembled in chronological sequence together with documentation of informal exchanges with teachers and their students. Details of the amount of time and the topics observed in the two phases of the study are outlined in Appendix B.

Physical features of the laboratories and classrooms in which classes were conducted and the ways in which these features appeared to influence classroom activity were assessed. The physical layout of the room and its furnishings, the proxemics of the classroom, and the ambient noise level and/or interference from adjacent areas of the school were all considered as important parameters of the research setting and therefore were carefully documented as part of the classroom observation data.

Supplementary Data

The Curriculum Materials. Another source of data arose from an investigation of the curriculum materials themselves. This included examination of the student workbooks and textbooks, the teachers guide and other related materials including audio-visual aids. Examination of the student materials was guided by a series of questions aimed at investigating the extrinsic and intrinsic qualities of the materials including their general presentation and coverage of certain topics. The way in which the materials communicated to the student about the nature of science and science learning and the way in which the curriculum writers explicitly or implicitly defined student and teacher roles also formed an important part of the curriculum materials analysis.

The Teacher Inservice Experience. As part of the implementation process, the Ministry of Education, in conjunction with the curriculum developers, conducted a thirty-hour inservice course to orientate lower secondary teachers to the new LSS program. The researcher took part in the first inservice course acting as a participant observer in all inservice sessions with the first batch of ninety teachers. The researcher collaborated with the course organizers in preparing a questionaire which solicited teachers' views on various aspects of the course.

Miscellaneous Data. To supplement the classroom observations, teacher inservice observations and analysis of curriculum materials, additional data were derived through informal conversations, questionaires and focused interviews with teachers and key informants from the Ministry of Education and the curriculum writing team. Data from secondary sources such as documentation of historical perspectives of science teaching in the Singapore school system, the history of the LSS program and its stages of implementation as well as documentation of the inservice course furnished an additional data base.

Data Reduction and Analysis

Erickson (1978) advised that in the data reduction and analysis process: "whatever rules of analysis the ethnographer chooses, he [sic] should make them, live by them, and make it clear to the audience what they were and how they affected the course of the researcher". The data accumulated during the two year time frame over which this study was undertaken were drawn from a variety of sources and each phase of the study addressed one or more of the research questions directly or indirectly. Figure 1 (page 44) illustrates the

	PHASE I		PHASE II		POST OBSERVATION ACTIVITY
RESEARCH QUESTIONS	JAN/MARCH 1982	JULY/OCT 1982	JAN/MARCH 1983	JULY/OCT 1983	NOV 1983/JULY 1984
1. What are teacher and student role and role relationships in science classrooms prior to implementation of the new Lower Secondary Science program?	Classroom observations Phase IA Phase IB Examination of reference material on science in Singapore prior to 1982				
2. How do classroom events and classroom discourse prior to implementation compare with those advocated in the new curriculum and what changes do teachers and students need to make in their role behavior in order to implement the program faithful to the intentions of the curriculum developers?	Examination of published local and regional reference sources on the new LSS program	Examination of trial materials	Analysis of LSS program materials		
3. What channels of communication (program information, inservice experiences etc) inform teachers of what is expected of them as they implement the new program?		Observation of In-service Experience of Teachers. Result of Teacher Evaluation Questionnaire.	Analysis of LSS program materials		
4. What evidence of change could be discerned during the year immediately following implementation?			Classroom observations Phase IIA Phase IIB		Comparison of data collected in Phases IIA and IIB with data collected in Phases IA & IB
5. How does evidence of change or lack of evidence of change link with channels of communication and key events in the implementation process and/or with other parameters in the research setting?	TRAINGULATION OF ALL DATA NOTED ABOVE TO INCLUDE FORMAL & INFORMAL COMMUNICATION WITH KEY INFORMANTS				

FIGURE 3: A CHART TO SHOW THE RELATIONSHIP BETWEEN THE RESEARCH QUESTIONS, THE DATA COLLECTED AND THE DATA ANALYSIS PROCESS.

relationship between the research questions, the research strategies and the type of data collected in each phase of the study.

A relevant assumption in this research is that: "What teachers do is affected by what they think." (Clark and Yinger 1979). But an even more compelling assumption is that teacher role behaviors in the classroom is equally likely to be inextricably linked with unconscious as with conscious 'thinking'. As Waller (1932) puts it:

> ... roles may be conscious or unconscious. Long established roles are moved from the center of consciousness by mechanisms of habit formation; such roles tend to be accepted as a matter of course while attention is transferred to the newly elaborated details or to newer roles in accordance with the long-established one. A difficulty in the introspective interpretation of behavior often arises from the following out of roles which have been so long established and have sunk so deeply into the foundations of the personality that it is no longer possible for consciousness to take account of them. (p. 324)

With this in mind, the classroom data were reduced and analysed according to <u>two distinct but interrelated dimensions</u> of the ways in which teachers acted out their roles within the classroom culture viz: (a) the <u>routines and rituals</u> of the class, and (b) the <u>controlling processes</u> that enabled the functioning of the social systems in the classrooms observed. These two interrelated dimensions provided a means of structuring the data from the perspective of the role incumbents in the research setting.

Within the observable <u>routines and rituals</u> dimension of the classroom culture, three constituent components or perspectives were selected for analysis. These three perspectives, which were derived from predominating themes in the data collected in Phase I of the study, can be operationalized as follows :

1. A profile of organizational and instructional strategies for class periods observed was obtained:

   a) Organizational strategies referred to the amount of time spent on each type of activity within class periods, the way in which these activities were sequenced and methods of grouping for instruction.

   b) Instructional strategies referred to the mode of instruction eg. teacher led discussion, A/V presentation, demonstration by teacher or student, experiments carried out by students, procedures for student record keeping.

2. Teachers' procedures for mediating classroom events were ascertained. This involved scrutiny of teachers' classroom management behaviors including the way they motivated students towards the class activites, the way the teacher maintained pupil attention, structured teaching episodes, made transitions from one activity to the next and achieved momentum throughout the class. Idiosyncrasies of the teacher interactional style were also incorporated into this aspect of the data analysis.

3. The nature of classroom discourse was analysed in terms of who spoke and what kinds of statements/sanctions were made, by whom and to whom and who initiated the discourse. Under this category, teachers' questioning techniques and their verbal and

non-verbal reactions to students' responses were taken into consideration. The ways in which teacher/student and student/ student interactions (verbally and non-verbally) communicated their expectations were noted.

The first perspective (and to a certain extent, the second perspective) indicated above provided a vehicle through which the researcher could infer antecedents of classroom events (eg. teacher planning) while the second and third dimensions revealed aspects of the teachers' intuitive responses to classroom events arising from implementation of these plans ie. by the messages or statements communicated to the class and the resultant classroom activity and discourse.

Complementary to the three perspectives of classroom activity falling within the first dimension of classroom culture, the three derived from the second dimension dealt with those qualities of classroom activities which were tacit as opposed to explicit expressions of the classroom culture. These perspectives were derived from manifestations or expressions of beliefs, values, and codes of behavior that more often than not conveyed hidden meanings. These meanings were often communicated through statements that were initially intended to communicate something other than the meaning extracted by the researcher.

These controlling processes were identified within situational frames (Hall, 1977) or analytical units of classroom proceedings (18). Inevitably though, these meanings often interfaced across one or more of the perspectives they could be ascribed to and they formed an interface across perspectives within the first dimension (routines and rituals of the classroom). In the context of this study then, situational frames reflecting controlling processes that were active in the classroom and which were extracted for analysis pertained to:

1. Indications of teachers beliefs about the purposes of science learning and the way in which these beliefs were communicated to students; including ways in which teachers appeared to view their roles with regard to the curriculum and the broader field of science. The ways in which teachers linked current with past learning or with the out-of-school environment.
2. Evidences of the reward systems operating in classrooms were examined to discover when and how teachers gave positive reinforcement to their students, how they evaluated students' work, conduct, and/or class participation. The types of rewards were examined such as teacher praise, peer recognition special priviledges, grades on report cards, or recognition at the school level such as promotion to a higher class.
3. Evidence of sources and expressions of authority in the classroom and the school were examined at two levels: (a) with reference to teacher perceptions of science as a discipline and the nature of science knowledge; and (b) with reference to the status and concomitant spheres of influence and control accorded the range of role incumbents (as individuals and as groups) included in the study.

By examining patterns of teacher/student interactions within the dimensions of the classroom culture descibed above, the basis for teacher role perception and role enactment in the various role sets in which they were involved could be ascertained. The value of structuring the data around these two dimensions in the data analysis process lies in their respective contributions to understanding teacher/student role behaviors together with their contextual meanings in the classroom culture. Clearly, whilst the value of the first dimension is that it draws on pedagogical and linguistic frameworks from an etic standpoint, the second perspective is directed at psychosocial and sociocultural dimensions of the classroom culture which fall within an emic frame of reference (19).

Relationships between events and behaviors thus evolved as the 'corpus' of the data was explored at different levels during the data reduction and analysis process. The researcher subsequently sought patterns and associations in the data in order to derive naturalistic generalizations about the meanings behind what was occuring in the setting. Linkages were constructed between people, behaviors and events and through these linkages, hypotheses were formulated, re-formulated and tested by means of examining and re-examining data present in the 'corpus' of the data. (Erickson, 1978; Florio, 1976)

Summary

In summarizing this chapter it is important to reiterate that the concern of the researcher in this study was the discovery and presentation of multiple views of reality. This concern is quite different from that of a researcher engaged in a quantitative research study whose research effort is directed towards uncovering a single reality in the form of a causal relationship.

Since the intention of this study was to make a phenomenological inquiry into science curriculum change in Singapore schools, it was not concerned with examining predetermined change indicators quantifiable in terms of a discrete measurable scale. Neither did the study seek to establish single causal relationships between independent and dependent variables inherent in the change process. Rather, the study was concerned with presenting a holistic, existential picture of teacher/student role and role relationships that emerged as the events in the change process unfolded to the researcher through the progressive stages of development of the five different case studies.

Furthermore, the purposes of the study did not incorporate evaluation of the quality of the LSS science program - nor the quality of the teacher inservice experience provided to prepare teachers for teaching the new program. Neither was its purpose to evaluate the cooperating teachers' performance or effectiveness. Rather, the thrust of the study was directed towards discovering what types of changes were intended by introducing a new program at this level, how these purposes were communicated, how the participants in the change process perceived and acted upon these changes and whether, from the researcher's perspective, change of any type occurred. Moreover, the intention of the research was directed towards uncovering parameters that appeared to influence observed changes or lack thereof.

CHAPTER IV

THE RESEARCH FINDINGS

SECTION I : Research Question I

Introduction

The first research question was intended to furnish baseline data for the study by investigating the nature of the teacher/student roles and role relationships in science classes prior to implementation of the new Lower Secondary Science curriculum. Two sets of classroom observations constituting Phase I (Parts A and B) of the study provided the necessary preimplementation data to address the research question.

Before proceeding with a presentation of the research findings, some important assumptions which emerged, evolved, and eventually became central to the conceptual framework of the study should be reiterated and elaborated upon in light of the phenomenological perspective from which the research problem was addressed.

In the study, each of the target classrooms served as units of analysis, and the classrooms, together with their respective schools, came to be regarded as cultural microcosms of the highly centralized national education system. Likewise and in turn, the educational system, as an integral and dynamic consequence of Singapore's historical sociopolitical and economic circumstances, emerged as a microcosm of predominating sociocultural patterns that permeate contemporary Singapore life.

Whilst the primary thrust of the present research was to discover what was occurring in the target classrooms, the long-term nature of the study and the kind of the data that were collected as the study progressed, made it necessary to interpolate within and extrapolate beyond the data obtained in classrooms. Hence the data analysis process took into consideration successive layers of subculture influence so that the research findings could be tested from a multivariate, phenomenological perspective.

A description of the research findings will begin with a perusal of the physical features of the learning environment in which the science classes took place. Some inferences will be made about the impact that this environment appears to have on the learning environment of the classes observed in the study.

The Learning Environment

The majority of science classes observed in Phase I of the study were conducted in spacious science laboratories. Each laboratory contained ten large fixed student laboratory benches arranged in paired, parallel fashion. A teacher demonstration bench was located immediately in front of the blackboard and raised above the level of the student benches. Most laboratories had one bulletin board that extended the length of the back wall of the laboratory. One of the six laboratories used by the classes observed in Phase I of the study displayed four small-sized poster photographs illustrating cell structure; otherwise, the boards in the other laboratories were empty. No student work was displayed on any of the laboratory bulletin boards observed during Phase I of the study.

When science classes were in session, the doors and windows of the laboratories were left open and therefore the learning environment was susceptible to noise from outside. This high ambient noise factor was greater in schools where the walls of the laboratories did not completely separate one lab from another. Noise from road traffic, from conversation and activity in areas adjacent to the laboratories, (including bottle stacking from the nearby cafeteria) and from intermittent heavy rainstorms resulted in an environment that was not conducive to class discussion. Under these circumstances, it was difficult, on occasions, for students sitting at the rear benches to hear teachers' instructions.

Although most of the double-period class sessions took place in laboratories, single class periods were conducted in regular classrooms. Likewise, when the mock and actual GCE 'O' level practical examinations were taking place (in June and October each year) all students, except examinees, were barred from using certain laboratories Hence, unless another laboratory was available, lower secondary science classes were held in regular classrooms for the duration of the examinations.

Classroom Routines

Data collected during Phase I of the study indicated a high degree of uniformity both across settings and over time regarding the ways in which the five cooperating teachers and their students appeared to perceive and act out their roles in science classes.

In general, student role behaviors reflected courtesy, uniformity and conformity. Around the schools, students conducted themselves in a courteous and orderly fashion, walking in lines from class to class. Students began their classes by lining up in pairs outside the laboratory. Usually there was a class member who had been assigned responsibility as class 'chairman' or class 'monitor' who saw that this was accomplished in a satisfactory manner. Some classes lined up with the shortest students at the front of the line and the tallest ones at the rear. Upon entering the class, students would most often prepare their books and other materials and remain standing.

A formal exchange of greetings would then occur:

T : Good afternoon, Class!

S's: Good afternoon, Sir!

[After this greeting the class would greet the researcher and the class would proceed.] [FN es 9/2/82.]

As more and more classes were observed during Phase I of the study, it became evident that the five cooperating teachers demonstrated similar organizational and instructional strategies, similar mediating (managerial) behaviors and they maintained similar patterns of classroom discourse.

Organizational and Instructional Strategies. Whilst some 'theory' classes were organized in such a way that the teacher spent the entire time giving information verbally or in the form of notes from the blackboard or overhead projector, other 'practical' lessons in which the students performed experiments were planned and carried out according to a preplanned four-part format which could be described as (a) teacher instruction, (b) teacher demonstration, followed by (c) student experimentation, and (d) guided student record keeping.

Typically, the teacher referred to above and the other four cooperating teachers began their class periods with the following type of scenario:

T: Sit down and take out your practical book.
Did you finish the exercise from yesterday?

S's:YES [Students respond in chorus.]

T: Before the end of the class, I want you to pass
up your book to the center of the bench.
[Teacher pauses slightly before continuing.]
Take out today's experiment sheets.
Any questions from yesterday?
Yesterday we learned that if you take an ice cube
and heat it, you get a liquid - this type of change
is a ....change? [Teacher gives a verbal blank.]

S's:PHYSICAL CHANGE! [Students respond in chorus.]

T: Yes - it's a <u>reversible</u> change.
Look at today's experiment.
Have you pasted it in your book?
[Students mutter to each other as they look over
at each others notebook.]
T: There are three experiments, we are going to do
them in order! [FN nd 2/9/82]

Four students were seated at each laboratory bench and students worked on experiments in groups of four or, less frequently, in groups of two. Students were expected to cooperate with their assigned group to set up, carry out, and clean up after an experiment and to wait quietly whilst slower groups completed their work. One of the four students assigned to each lab bench was designated as group leader and this student was responsible for distribution and management of equipment for their lab bench at appropriate times. Students were usually grouped in homogenous sex groupings and, in one class, the teacher alternated rows of boys and girls.

As the class proceeded, teachers spent the majority of the allocated class time engaged in whole-group or class instruction. But in classes where their students engaged in experimental work, teachers would circulate among the student groups, talking to them, acting as trouble shooters and intervening in any situation students were unsure of. Although this teacher/small group interaction had the greatest potential for teachers to converse with students in ways that would stimulate student thinking, it was observed that teacher time in such instances was most often taken up with verifying instructions given previously regarding the set-up of equipment and/or procedures for carrying out experiments.

Electric bells signalled the ending of each class period but usually teachers prepared students to leave a few minutes before the end of the lesson period, especially if time was needed for clean-up of equipment. To mark the end of the lesson, there was a formal exchange of greetings between students and their teachers. In some schools, students politely recited "Thankyou, Sir" or "Thankyou, Miss _______ after they had said goodbye to the teacher.

Teacher as Mediator. The role enactments of the five cooperating teachers appeared, therefore, to be realised in terms of imparting information to their students, describing and demonstrating specific tasks to be accomplished during lessons, and pacing and monitoring students through the sequence of activities scheduled for completion within allocated time periods.

With the exception of one teacher who, on the first occasion she was observed, introduced her lesson with a discrepant event, the data revealed that teachers did not normally incorporate motivating activities into their lessons, thereby indicating that they did not assume ownership for motivating students toward the topic of study or the activities planned for the class.

During class, student territory was closely defined and student behavior closely regulated. Students were expected to listen attentively to all information and direction given by the teacher. Statements and sanctions by teachers cued students as to when to copy from the blackboard, textbook or overhead projector, when to proceed with experiment work and within what time constraints. When students were not carrying out experimental work, instructional settings were usually whole group. The teacher controlled when students would speak, such as in response to questions posed by the teacher (written and/or verbal) and when students would answer questions from the textbook, workbook or from the blackboard.

Students stood up whenever the teacher addressed them, whenever they asked the teacher a question (which was the exception rather than the rule) and whenever they raised their hands and were called upon by the teacher to answer questions in class. The outcomes of all student activities (such as the results of experimentation) were anticipated by the teacher before the lesson, were uniform for all students, and were characteristically confirmatory in nature.

Teacher Interactional Style.

In spite of the overwhelming similarities across the classes observed, there were some differences in teacher interactional style that affected the ways in which individual teachers mediated classroom events. Although all teachers accepted total responsibility for directing classroom activities, there were some differences in degree of directiveness. One teacher was particularly directive, prefacing many of her statements with "I want you to" or "I told you to" or other "I" statements. During the 70 minutes that comprised one double period observation with this teacher, the following "I" statements were recorded:

> "Now I want to give you a reminder.
>
> "I want you to do the problems on your own.
>
> "I want you to do them in your exercise book.
>
> "Now I told you to see me before twelve o'clock if you could not hand in your book.
>
> "Now, I'll go over these answers as soon as the books are in.
>
> "I'm going to give you one of these so that you can try.
>
> "I want the leader to come and get two beakers and a pipette.

"I told you to look at the mark first.

"I told you there's a mark <u>there!</u>

"I said <u>release</u> the water.

"I want you to look at the beaker.

"I want you to put the spring in so that it comes as close as possible to the end of the tube.

"I want everyone...

"I want to explain to you.

"I'm still waiting for silence.

"I want you to use this and measure accurately 50ml of liquid.

"I will come around and look.

"I want everyone to do this because in the next few lessons you'll be using the measuring cylinder."

"I want the leaders to go over there and get a big measuring cylinder." [FN da 22/2/82]

Fewer "I" statements were made by the other four teachers but "don't" statements were used frequently by another teacher:

"Don't touch the apparatus in front of you.

"Do not pour on the label side.

"Don't move!

"Don't put it on the table; put it on the stand.

"Don't carry it like that!

"I don't want to see a drop of water when you have finished!

"Don't use the word 'pour' - this is a solid, you use 'put'.

"Now - don't forget how to pronounce these words!" [FN yq 4/2/82]

The same two teachers tended to use statements that were reproachful and undermined the ability and dignity of class members:

> " How many times do I have to tell you the same thing!" [FN du 22/2/82]
>
> " After six years in school, I would have thought that you could spell brilliant." [FN yq 11/2/82]
>
> " Alright, make sure you don't make this mistake again." [FN du 17/2/82]
>
> " Now, I'm sure there are some of you who are weak in math - am I right? No - not some of you, <u>most</u> of you! [FN du 17/2/82]

In the same two classes sarcasm was sometimes used:

> "I can't hear you - move your jaws and your lips." [FN yq 4/2/82]
>
> "I think some of you don't know how to count." [FN du 15/2/82]

Paradoxically, alongside what, at times, appeared to be a pejorative disposition, one of the same teachers quoted above was often humorous and the students appreciated his sense of humor. For instance, when some students accidently got sprayed with water during a demonstration on water pressure, he joked:

> T: Don't be afraid of water...
> I never heard of water melting you!
> You're getting wet are you? [FN yq 26/8/82]

<u>Student Autonomy</u>. The reciprocal effect of such close control by the teacher over their students' classroom activity was the reduction of student autonomy in the classroom setting. As might be anticipated, a variety of student role behaviors reflected this. With some

notable exceptions students were passive listeners, dependent upon the teacher for instruction and direction. The majority of students showed a reluctance to participate in classroom discussions. Hence, classroom discourse was dominated by teacher talk and answers to questions asked by teachers solicited primarily one-word or short-answer responses from students.

Patterns of Classroom Discourse. Although some variance in teacher interactional style among the cooperating teachers has been acknowledged, it should be mentioned that these variations did not manifest themselves to the extent that they substantially altered behaviors intrinsic in teachers' role perceptions and role enactments as operationalized in chapter two of this research report. Such differences did, however, appear to affect certain aspects of the learning climate that prevailed in the respective classes and the extent of verbal participation by students.

Questions and Answers. Only one of the five student groups observed (a class of 32 normal stream girls) in Phase I of the study was responsive or eager to answer questions in class. Most commonly, out of the thirty-seven or so students in class, only three or four students would raise their hands in response to teachers' questions. In spite of this, it seemed that students often did know answers because they frequently verbalized responses to each other within earshot of the researcher. In this regard, it seemed more important for students to demonstrate to their immediate peer group (rather than to their teacher or the class) that they knew the answers to questions.

When students failed to volunteer an answer, teachers would most often answer their own questions, allowing very little wait time:

T: Leaders come and take one burette.
[Teacher waits until all leaders are back at their benches.]
T: Can you see the zero there?
Between the zero and the one mark - how many divisions?
[No response by students.]
Do all of you say ten?
Ten little divisions?
One milliliter each? [FN da 22/2/82]

Chorus responses. Chorus responses were used to a lesser or greater extent by the five teachers observed in the study and they were used for various purposes. In one classroom, immediate recitative chorus responses of the following type constituted a fair proportion of the classroom discourse, especially in the early part of the year.

T: The water I gave you is lime water... is what water?

S's: LIME WATER!

T: Another name is Calcium hydroxide.
Its other name is CALCIUM...?

S's: HYDROXIDE! [FN yq 4/2/82]

In other classes, chorus responses were expected when teachers surveyed the class for a consensus:

T: If you want to measure 500 ml (of a liquid) would you use this one?

[The teacher surveyed the class for a response.]

S's: NO! [Students respond in chorus.]

T: That's right, you would use a bigger one. [FN ss 16/2/82]

Other instances of teachers soliciting a chorus response occurred when they wanted to ensure that students had the necessary entry behaviors for a concept to be presented:

T: Do you know what is a cube?
S: YES! [The students answered in chorus] [FN ss 19/1/82]

<u>Peer Interaction</u>. Interaction among students was observed at various levels. On occasions, students conversed surreptitiously among themselves at times when they were supposed to be listening to the teacher or writing in their notebooks. At these times, and also when they were conversing 'legally' about an experiment, a number of languages were spoken. Although class rules strictly forbade communication in their dialect language and teachers reproached their students when they heard them doing so, much verbal interaction was in Hokkien or Cantonese dialect. Some Mandarin was spoken among Chinese students and Malay among the Malays, and, not surprisingly, English was the language spoken most often in classes where there was a mixture of ethnic groups.

Further data on peer interaction in class reveal that it was not unusual for students who finished early to pass their notebook to someone else to share answers. It also became apparent that some of the students' textbooks were hand-downs from previous generations of Secondary I students and, in these cases, the answers were often already written in the blanks of the questions at the end of each chapter. Therefore it appeared to the researcher that it was entirely feasible that some students might copy down answers without ever understanding the question.

A pattern emerged regarding the ways in which the peer group reacted to teacher/student interaction and this had an effect on the learning climate in all of the classes observed in Phase I of the study. If students gave incorrect answers or if they mispronounced words they elicited laughter from their peers. Embarrassed laughter or restrained amusement was predictably exhibited when a student was asked to write an answer or draw a diagram on the blackboard. (One teacher used this strategy). The same reaction was elicited when a teacher reproached a student for misconduct, except when the reproach was in such a strong tone that the entire class was shaken by it.

Apart from the exceptional class mentioned earlier which, as it happened, was taught by the least experienced of the five cooperating teachers, both normal and express stream students seemed equally reticent to obtain visibility through answering questions in class. A set of competing and/or associative explanations for this finding was inferred by the researcher and tested against remarks and explanations offered by key informants:

a) Students were self conscious about their inadequate command of the English language; both in terms of pronunciation and in terms of adequate vocabulary.

b) Students were afraid of receiving negative feedback, or worse still, being ridiculed by the teacher and 'losing face' in front of the teacher if they happened to give the wrong answer.

c) Students are afraid of being accused by their peers as 'show-offs' if they were over-eager to give answers.

d) Students jealously guarded their knowledge and did not want other students to realise how 'smart' they are (perhaps other students may want to depend on their help?).

Whilst the first two explanations were most often referred to by key informants in connection with the normal stream, the second were most often associated with the express stream. But, in any event, the effect was the same. In the majority of class sessions observed, students manifested a reluctance to participate in classroom discourse thereby rendering the teachers' task of maintaining a balance between teacher talk and student talk exceedingly difficult. And, though it may appear to the casual observer that teachers dominate classroom discourse as a matter of preference or habit, the normative role enactments of students tended to be such that teachers seem to have little choice but to reciprocate students' role expectations and fall back on didactive instruction.

Controlling Processes

As explained in the previous chapter, three predominating themes in the data which reflected recurring controlling processes were selected for analysis. These controlling processes were effectively institutionalized mechanisms which directed or governed classroom events through expressions of values, beliefs and attitudes of role incumbents. These were identified in the form of contextual situational frames (Hall, 1977) and could be collectively described as (a) those in which teachers made direct or indirect references to the purposes of science learning, (b) those in which teachers communicated explicitly or implicitly to the students or to the researcher about reward systems that were operant in their classes or in the school system as a whole, and (c) those which revealed sources and expressions of authority within the research setting.

Purposes of Science Learning. Attitudes and beliefs communicated by teachers to their students and to the researcher regarding the purposes of science learning could best be discussed within the framework of long-term as opposed to short-term purposes.

Long-term purposes: Preparing students for more advanced studies in science was the most pervasively emphasised long-term purpose of science teaching and learning communicated explicitly and implicitly by teachers. This was made evident in statements made by teachers when they provided a rationale as to why a particular topic should be covered or a skill learned.

Very rarely, though, did teachers extend their allusions to long-term perspectives to incorporate discussion of possible career prospects or the importance of scientific literacy on the part of their students. Rather, their long-term perspective was confined to school-based learning and was largely associated with expectations purported to be held by future teachers as expressed in this episode:

T: Now later on when you go to your chemistry classes...

[Teacher pauses to gain the full attention of the class.]

T: You will be using a lot of catalysts... and you will be expected to remember what they are and what they do!
[FN du 2/2/82]

Short term purposes: As has become evident in the vignettes presented in connection with routines and rituals of the classroom, immediate short-term purposes were expressed by teachers in terms of verifying known facts or confirming already established principles that are present in the textbook:

T: All of you look at the transparency.
Can you see it? I'm sure it is quite clear!
[Teacher pauses for the attention of the class.]

T: Actually, it is taken from the textbook so afterwards when you draw this you can refer to your textbook. [FN du 26/8/82]

Student Record Keeping. The fact that teachers devoted so much time and energy to ensuring that students accrued neat, identical records of the 'theory' covered in the class communicated to students that it was an important purpose of science learning. This assumption became even more apparent to extremes in situations where teachers required students to copy notes and diagrams directly from the textbook or from an overhead projector.

The record keeping procedures expected of students were, as might be expected, highly demanding. Students in most classes were expected to keep regular exercise books in which they wrote neat copies of their notes and another in which they wrote rough notes during class sessions. Three of the teachers required their students to keep yet another exercise book in which they wrote 'exercises' viz: their answers to fill-the-blank or multiple choice or other exercises from the textbook or blackboard. This meant that, apart from their textbooks, some students were responsible for upkeep of three different types of exercise or notebooks all of which had to be organized and maintained according to guidelines given by the teacher. The following scenario was typical of the record keeping portion of the lesson:

T: Take out your lab notebook and copy the experiments.

[Students began to look in their school bags and take out their books.]
[The teacher reproached them.]

T: Some of you have not started at all!
[Some students are flipping through their notebook, some appear to be preparing to draw diagrams, taking out their rulers and pencil etc.]

T: Look, there are two diagrams, I want you to draw one of them on the upper page... divide the page in two halves and draw the other diagram at the bottom.
Don't forget that when you write a title, it should be underlined with a double line! [FN du 24/2/82]

To a lesser or greater extent, teachers related students classroom experiences with events in their everyday lives and to the world around them but, in the overwhelming majority of cases, it was the teacher who made the connection rather than the teacher leading the way for students to do so. The following is an example of this pattern of behavior when the class was about to begin their work on measurement:

T: We are going to be talking about measurement. Measurement is very important - for instance when we go to the market - we ask for a certain amount of something, fish, meat, vegetables. We are going to start by looking at our rulers. All of you have got rulers, now take them out... we'll be using the METRIC system... Now! I want you to measure your exercise book... [FN da 22/2/82].

As teachers related present activity to past learning they often did so from the standpoint of reproaching students for not having remembered certain things from previous years, saying they had "better go back to primary school". In looking to the future, teachers did so sometimes with foreboding:

T: When are you going to start studying? If you cannot study one chapter, what will happen when you have to study ten chapters - or ten subjects for that matter?! [FN da 28/8/82]

<u>Reward Systems</u>. As teachers managed classroom discourse and engaged in interaction with individual students, they would nod, point or look in the student's direction saying "yes" to the individual to solicit responses to their questions. Students who raised their hands and/or were called upon by the teacher often appeared embarrassed or uncomfortable even if their answers were correct. An incorrect answer was typically responded to by the teacher with "no" or "wrong". Two teachers tended also to respond to wrong answers with comments such as: "Are you sure?" or "Does anyone else have a different answer?!"

In all of the classes observed, only one of the cooperating teachers offered positive feedback to students as they responded appropriately to teacher questions:

> T: Yes, did everyone hear that? Explain again, Siew May!
> [FN ss 16/12/82]

> T: Very good! She got it! Say again, Elizabeth!
> [FN ss 16/2/82]

But most of the time teachers would abruptly brush aside answers, especially if they were incorrect. This meant that more often than not students received negative feedback ranging from mild to extreme. Students were not, as a general rule, asked to qualify their answers with supportive evidence, neither were they encouraged to modify answers that were close to, but not exactly what the teacher was expecting. Only once was a teacher observed asking a student to explain an answer:

> T : Kee Leong told us earlier that liquids could be compressed. Can you explain that?

[Kee Leong responds from the back row but the teacher cannot hear him.]

T: Repeat your answer louder so that the entire class can hear.

[In this instance, since the student was unsuccessful in speaking loud enough so that the class could hear, the teacher gave her own explanation.]

One teacher seemed aware that students' reluctance to answer questions was linked with the fact that they were afraid of being scolded:

T: Have you drawn up your conclusions from yesterday's experiment?

S's NO! [Chorus response accompanied by laughter.]

T Well you were supposed to!
We'll discuss it now!
You say... in this experiment...
What is a catalyst?
What do catalysts do?
What does a catalyst do?!
Come on ... put up your hand!
It doesn't matter if you are wrong!
I'm not going to punish you... I'm not going to scold you
if your answer is wrong... just try! [FN du 25/8/82]

Student/Teacher Interaction. Two of the five cooperating teachers addressed students by name, making use of a seating chart. The remaining teachers did not use students names when addressing individuals in front of the group. Although some teachers seemed to know the names of the few students who took on extra responsibilities in the class, one teacher even addressed the class chairman not by his personal name but simply as 'Chairman'.

This does not, of course, rule out the possibility that teachers used student's personal names when addressing them individually, out of earshot of the researcher. Nevertheless, the researcher gained the impression that at least three of the five cooperating teachers did not, as a regular practice, use students' names. One teacher was observed handing back student test papers by calling out 'index' numbers which students were required to write on their test paper.

Given this set of circumstances, it was inferred by the researcher that a close, personalized teacher/student relationship was not part of the role perception of the teachers involved in the study.

Sources and Expressions of Authority. The teacher and the textbook were the most frequently cited sources of authority as far as verification and acquisition of science knowledge is concerned. Hence, the textbook was often quoted verbatim even in oral recitation exercises. In some instances where teachers allowed students to look in their books to obtain responses to questions, students would read answers (very often definitions) verbatim from the textbook. In such cases, it often transpired that the student concerned could not pronounce the words they were trying to read:

T: Suppose I ask you to measure the external diameter of a measuring cylinder - what will you use?
[No response from students.]

T: Come on, what will you use?
[Teacher signals to one student.]

S A tape...

T: What else besides?

[Teacher calls on a student who tries to read her answer from the book. The student becomes embarrassed and gives up trying to pronounce the word. The teacher reacts:]

T: Not vernier sleeding caliper... vernier sliding caliper!

The fact that students anticipated that they would obtain identical results in their laboratory work and that each activity would result in a 'right' answer is highlighted in the following episode which took place shortly after students began an experiment in which they were required to take readings for the weight of pendulum bobs:

T: Don't be alarmed if you get different answers.
All your pendulum bobs are not the same.

[Shortly afterwards, as students continued to weigh additional pendulum bobs, the teacher surveyed the class.]

T: What is the weight of your pendulum bob?
Who gets 70?
Who gets 72?
Who gets 80? [FN es 26/2/82]

Then, after a similar procedure with a different pendulum bob, the teacher said:

T: How many of you got the right answer?
See if you got the right answer!

Then, instead of allowing students to reason for themselves why some readings were vastly different, the teacher offered a suggestion:

T: Did you minus the weight of your pan?! [FN es 26/2/82]

Incidentally, in this class, the students were expected to repeat the experiment if they did not obtain the 'right answer' (meaning an accurate reading for an experiment).

The textbook was often used as an approved authority for the source of answers to the teachers' questions:

T: Can you tell me: What is mass?
[No response from students.]
[Teacher observes one boy looking in his textbook.]

T: Don't look it up in your book!
Can you tell me what is weight?
You tell me!

[Teacher points to one boy who stands up. The boy is visibly embarrassed as he is unable to answer the question. The teacher rescinds his previous statement.]

T: Alright! Look in your book if you do not know!
[FN es 26/2/82]

Both teachers and students seemed to be more comfortable with questions that were lower order, recall questions. On one occasion when a teacher asked students to explain why results of a displacement experiment were discrepant, she got no response from the students so she answered her own question:

T: Why do you think your answers are different?
[No response from students.]

T: Chee Fong?
Edwina?
[Still no response from students.]

T: Is it some of you have bubbles? [FN ss 23/2/82]

It is significant that in the instance cited above, other possible sources of discrepancy such as: (a) parallax error, or (b) incorrect reading on the curve of the meniscus, were not considered. Yet, both of these concepts were introduced by the teacher prior to the experiment being performed. The fact that a cork (which had to be held underwater using a piece of wire) is not manufactured to the degree of precision needed to differentiate between volume readings of within one milliliter tolerance (using a measuring cylinder) was not alluded to either.

Summary

Most of what could be discerned by the researcher about teacher and student role and role relationships prior to implementation of the new LSS curriculum is implicit in the descriptions given of events in science classrooms in the preceding pages of this chapter. Research findings in the preimplementation phase (Phase I) of the study indicate that a similar pattern of organizational and instructional strategies was discerned across teachers prior to implementation of the new LSS curriculum. These strategies were oriented toward didactic instruction, recitative discourse and neat, accurate record keeping by students. Instructional strategies also appeared to address short-term goals linked with providing answers to specific, factual recall questions typical of questions that may be set in tests or examinations.

From the ten sets of observations (two for each of the cooperating teachers) conducted during Phase I of the study (20), it was therefore inferred that recurrent teacher behaviors indicated that teachers viewed their role as exclusive planners, mediators and controllers of classroom events. All decisions concerning organization, instruction and course of events in classroom proceedings rested with the teacher. Classroom events were highly structured in the sense that little or no ambiguity existed in the outcomes of such events and their resulting classroom discourse. For example, in none of the classes observed did the teacher allow students leadership roles beyond those of acquiring and distributing equipment on behalf of their group. No class activity was structured so that students would have an opportunity to discuss their work, to lead or participate in a group or a class project of which the outcome was not predetermined. Neither did students participate in a decision-making process about content and conduct of future classes.

Long-term goals such as developing student competence in the methods of science or in scientific literacy were not in evidence as teachers interacted with their students. Neither was there any emphasis placed on learning opportunities involving problem-solving activities which could be pursued through individual student initiative or collaborative planning and hypothesis testing. Student roles in class were characterized as being consistent with orderliness, group cooperation, and diligent record keeping in accordance with directions given by the teacher. Students were also described as polite, deferent to teacher authority, and reticent to speak out in front of their peers.

There further appeared to be an implicit belief operating in the classrooms concerned that all classroom activities should result in a 'right' answer. Instances in which results of experiments, some of which involved measurements, were discussed in terms of 'right' or 'wrong' 'answers' exemplified this tendency.

In all of the instructional sequences observed, both teachers and students appeared to be more comfortable in situations where learning experiences were presented and realised as discrete, finite entities resulting in some kind of closure. Without exception, it fell within the teachers role definition to provide such closure. Teacher and student role and role relationships prior to implementation of the new Lower Secondary Science program therefore can be broadly characterized as clearly defined, inflexible and mutually exclusive. Moreover, the data revealed that the rules that governed student/teacher role and role relationships were mutually reinforcing and reciprocal in nature.

SECTION II: Research Question 2

In the previous section of this chapter, an attempt was made to characterize student/teacher role relationships in the user system of the Lower Secondary Science program prior to its implementation in schools. Inferences drawn from extensive observations in the classes of the five cooperating teachers provided the necessary data to formulate such a characterization. By addressing the first research question in this manner, it was possible to compare existing role behaviors with those intended by the curriculum writers. With this data in hand, it then became possible to ascertain changes that teachers would have to undergo if they were to implement the program according to the intentions of the curriculum developers. This, in essence, is the substance of the second research question.

LSS: Some Background Information

An essential strand of this line of inquiry was to locate the origin of the new LSS curriculum in the chronology of worldwide movements in science curriculum development and to examine the history and development of the program. For, even though the Lower Secondary Science program was first implemented on a national scale in January 1983, its history and development spans more than a decade. The actual beginning of LSS can be traced back to 1970 when interested members of the Science Teachers Association of Singapore (STAS) presented a curriculum proposal entitled: Science Program Development Project to the Ministry of Education. As a result of this proposal, a combined committee of interested STAS members and Ministry of

Education personnel (called MESTAS) was established to develop science curricula at the primary and at the lower secondary levels.

The new program developed for the first two years of secondary school (known in the Singapore system as lower secondary I and II) was appropriately called the Lower Secondary Science or LSS project. The LSS project began as an adaptation of the Scottish Integrated Science program - the program also selected for adaptation at the same level in Malaysia (see Watson, 1973 and Lewin, 1981). After a series of revisions that rendered it more suited to the Singapore situation, the program was approved by the Ministry of Education for piloting in nineteen different trial schools, beginning in 1976. As a result of teacher feedback on the second version of the program, further revisions took place and a school-based evaluation was undertaken (Cheah et al. 1978). Following the school-wide reforms precipitated by the New Education System introduced in 1980, the principles of the LSS project were officially incorporated into the revised lower secondary science syllabus issued by the Ministry of Education and thereafter brought under the auspices of the Curriculum Development Institute of Singapore for its subsequent and most recent phase of development.

Intentions of Curriculum Developers

In order to define as precisely as possible the intentions of the curriculum developers with regard to teacher/student roles and role relationships, all available sources of documentation on the LSS program were examined. Aside from the program materials themselves, local sources of documentation of the LSS program included those of local agencies, viz: the Ministry of Education and the Curriculum Development Institute of Singapore, and the local English media newspaper. Documentation at the regional level such as contributions to regional publications and journals was also examined.

Interestingly enough, the most recent description of the LSS program is recorded in a regional publication: The Twenty-fifth Bulletin of the UNESCO Regional Office for Education in Asia and the Pacific, published in June 1984. In this publication, the goals of the Lower Secondary Science program are recorded as intending to:

a) Provide pupils with the essential scientific knowledge and skills that will meet their educational and vocational needs;

b) Develop science concepts and an understanding of our physical and biological environment;

c) Develop students ability to use the methods of science;

d) Provide a science course which is both relevant and meaningful in the technological environment of today;

e) Enable students to appreciate the humanistic aspects of science. (p. 297)

The text of the bulletin then goes on to explain the ideology of the program:

> The emphasis is on an inquiring mind by which pupils are guided to discover things for themselves, analyse data collected and draw inferences which they may apply to new situations logically and creatively. (p. 298)

While all of these statements convey implicit messages about teacher/student role expectations in the LSS program, the statement about pupils being 'guided to discover things for themselves' portends the greatest implications for change in the modus operandi of science teaching in the user system. As mentioned earlier, the new Lower Secondary Science program is purportedly an 'inquiry-based', 'discovery' program. Both of these terms have been used repeatedly to describe curricula emphasizing the 'methods of science' developed in the United Kingdom, the United States and elsewhere during the sixties and seventies. But, like much of the well worn rhetoric associated with this curriculum development era, the terms 'inquiry-based' and 'discovery' have been variously used and misused and are therefore fraught with ambiguity (See Atkinson and Delamont, 1977; Brown, 1981; Brown & McIntyre, 1982).

But to discover exactly what the terms 'inquiry-based', and 'discovery' mean in the context of the new LSS program, it is important to examine the meaning that LSS curriculum writers ascribe to these terms. In the opening statement of the LSS Teachers Guide for level I of the LSS program, the Project Director refers to the terms as follows:

> Although many curriculum developers including those in the LSS team have advocated 'discovery or enquiry based' teaching, one has to proceed with care and caution. Enquiry based discovery science does not imply that students can learn everything by themselves, not the vast majority anyway. Teacher guidance is still of utmost importance. In fact, in a discovery/enquiry-based science teaching situation the teacher has to play the rather onerous and tricky role of a manager in the classroom. He/she has to provide the environment (physical/material support and resources) and psychological support or encouragement so that pupils can 'find things out for themselves'. (p. v.)

It is interesting that in this communication from the Project Director, the notion of 'discovery or enquiry-based' approach is introduced in a somewhat tentative fashion. It appears, in fact, as if the tone of the statement is sensitive to the fact that teachers need assurance that they do, indeed, have a role to play in the teaching of the new LSS program - hence the statement: 'Teacher guidance is of utmost importance'. In fact, in other descriptions of the program, this idea of teacher guidance is reinforced by the term most often used to describe the approach used in LSS: 'guided discovery'.

In the introductory section of the LSS student textbook entitled Exploring Science, there are further indications of the curriculum writers' intentions of teacher/student roles. In his reference to the differences between the new LSS program and the former general science syllabus, the Project Director writes:

> The most significant change from the general science syllabus is the new approach: a move from purely fact-centered to an inquiry based science teaching. This means 'discovery teaching-learning situations' with pupil participation and appropriate teacher guidance. A guiding principal of this course therefore is the leading of the pupil towards finding out things and thereby gathering knowledge.' (p. v.)

Examination of specific aspects of the student textbook reveals further insights into the intentions of the curriculum writers with regard to student roles. The way in which the language of the text addresses the student clearly signifies the intention of the program to incorporate a student-centered approach. For example, the opening statement of the introduction to the student workbook reads: 'You are now studying a subject called science'(p. v). In the introductory chapter of the textbook, the authors join forces with the student, using the second person plural for much of the communication: 'when we study science... we are going to discover many things... we will also try to apply what we discover to our daily life...' (p. 2). The communication continues in such a way that the text places the student as the subject of the sentence (and by implication the focus of the teaching/learning experience). It should be stressed that this way of addressing students as active participants of their own learning contrasts sharply with the impersonal and indirect way in which the language of previous lower secondary science textbooks addresses students (Gremli, 1983a).

An indication of the intention of the authors of the LSS program that student users of the text should have some control over their learning is revealed in the statements following the introduction to the student workbook: 'remember that there is more than one way to conduct an experiment or investigate a problem. If you think you have new and better ways of doing things, do not hesitate to tell your teacher about it' (p. v).

The authors also refer to arousing both long-term and short-term interest of the student beyond the classroom, inspiring students to 'appreciate our world' and helping them to develop 'lifelong hobbies and careers'(p. v). The authors also refer to the fact that they hope the study of science will be 'enjoyable' and 'relevant' along with the overall goal of intending to 'inculcate' in students the 'basic concepts and techniques involved in laboratory and field work'(p. v).

Explicit and implicit messages communicated by the authors of the LSS program therefore reflect a philosophy in which teacher role prescriptions are less directive, less controlling and less didactic than those that were observed in classes during Phase I of the study. There also appears to be an intention on the part of the curriculum writers to encourage a collaboration between teachers and students through which a link between the learners world and the activity of science is achieved.

As far as student roles are concerned, the curriculum writers infer that greater independence of action, a higher level of inquiring behavior, and more active participation in class is prescribed. This is a critical factor to attend to in this study because prior to implementation of the new LSS curriculum, student participation which involved students asking questions, exploring competing explanations, or posing alternative ways of solving problems was notably absent from the classrooms observed.

Teacher Roles

Considering the assertions outlined above, the teacher/student role and role relationships implied in the faithful implementation of the new LSS program were contrasted with those that emerged as prevalent in the user sytem prior to implementation of the LSS curriculum i.e.: those ascertained in Phase I of the study. Based on this comparison, it was asserted that the kinds of changes to be expected if the five lower secondary science teachers observed in Phase I of the study were to teach the program according to the axioms of 'guided-discovery' or 'inquiry' learning within the definitions ascribed by LSS curriculum developers, would be as follows:

1. From acting as a major source of information in the classroom to acting in a way that arouses inquiring behavior on the part of students.

2. From highly structured organizational and instructional strategies in which most decisions rest with the teacher to more flexible teaching strategies in which the pupils also participate in the decision making process.

3. From offering confirmatory laboratory experiences to offering exploratory laboratory experiences.

4. From tolerating minimum ambiguity in the classroom to accepting greater ambiguity in the classroom.

5. From being primarily concerned with deductive thinking to also being concerned with developing inductive thinking in pupils.

6. From presenting a definitive view of science knowledge to presenting a broader view of knowledge related to science.

7. From assuming total leadership in classroom events to allowing students a degree of participative leadership in classroom events.

Student Change

Along with changes in the role behaviors of teachers, corresponding changes would also be required of students. Based on the weight of evidence in the baseline data, the following list of changes in student roles were generated:

1. From being a passive receiver of information to actively seeking knowledge through a variety of experiences.

2. From minimal or no verbal participation in lessons to greater verbal participation in lessons, in spite of self consciousness about pronunciation of unfamiliar words.

2. From dependence on the teacher for information and direction to more self-reliant behavior.

4. From an unwillingness to risk offering a wrong answer in class to a willingness to test incorrect ideas or alternative perceptions as a means of arriving at a satisfactory solution to a problem.

5. From the type of peer behavior that elicits laughter at students' wrong answers or requests for clarification on tasks to one which is more supportive of peers who are willing to speak out in class.

6. From the acceptance of information on face value to scepticism about information that is not based on fact. (See Teachers Guide for Exploring Science, page 4).

7. From viewing science learning as a purely school-based experience to viewing science learning as being related to humanistic issues and everyday events.

Clearly, from the data presented so far, the most problematic area for student change would be greater verbal participation in class. For, any attempts to arrive at a level of classroom discourse more consistent with an inquiry learning situation would inevitably be hampered by two major constraining factors in the user system which emerged as central issues to the findings in Phase I of the study: students' difficulties in pronouncing words and an acute reluctance on the part of students to draw attention to themselves and speak out in front of their peers. Such reluctance appeared to be associated with a variety of possible reasons ranging from fear of being thought of as a 'show off' to the high risk state assumed when students gave a 'wrong answer' and became the focus of laughter by their peers.

Evaluation of Students

Also of importance to impending change upon introduction of the new Lower Secondary Science curriculum is the means of assessing student progress. In Phase I of the study, student progress and achievement in science classes was ascertained by performance in written class and homework assignments and in class-based and school-wide 'common tests'. Such assessment practices are inconsistent with an inquiry philosophy in the sense that the exams were based primarily on factual recall questions (See Appendix D). Responses to this type of test question are obtainable by extracting literal information from the textbook.

Furthermore, the research evidence suggests that there may be some need for teachers to reorientate themselves to the purposes of testing students. Prior to implementation of the new program students' test scores were looked upon by teachers as indicators of student ability and assiduousness rather than indicators of appropriateness and effectiveness of instruction. Teachers associated poor test performance with the fact that students did not study or with their limited command of the English language. This was the conclusion of the teacher of one student who obtained a score of only 5% in his first term test.

Associated with this issue of student assessment is the general nature of reward systems operating in classrooms. The preimplementation data indicated that student progress and achievement in science was based solely on student performance in class-based or school-based tests to the exclusion of student participation. This factor, along with the observation that at least three teachers habitually neglected to use students' personal names in class suggests little or no incentive for students to change their participatory role behaviors.

Summary

As indicated in Section I of this chapter, organizational and instructional strategies and patterns of classroom discourse observed in classes conducted by the five cooperating teachers prior to implementation of the new LSS program were strongly consistent with a didactic approach to instruction and a recitative approach to learning.

It was therefore inferred that if the five cooperating teachers in this study were to faithfully implement the new Lower Secondary Science program (purported by its developers to be a student-centered, discovery approach to science teaching and learning) they would have to undergo a number of changes with regard to their role enactments as science teachers. In this section of the chapter, an attempt was made to define very precisely the types of changes the five cooperating teachers would have to undergo if they were to implement the program faithful to the intentions of the curriculum developers. At the same time, it was understood that as role incumbents in the same role set, students would be expected to undergo corresponding and complementary role changes.

Two sets of propositions were therefore formulated to specify the types of changes desirable of teacher/student role and role relationships as they interact in the classroom setting in implementing the new LSS program. The sets of propositions were arrived at by examining all available literature on LSS from national and regional sources, and by carefully examining the classroom culture as characterized in the pre-implementation data, including data from secondary as well as from primary sources.

By examining the apparent intentions of the curriculum developers and the teacher/student roles they prescribed both explicitly and implicitly in their portrayal of the program, it was found that role changes pertaining to the role incumbent in the research setting clustered to a lesser or greater extent around certain interrelated components of the classroom culture: namely the routine activities that constituted the day to day events for the classes concerned, the ways in which the teacher mediated these events, and the richness of discourse associated with these events. Secondly, and perhaps more importantly, change is implied in the underlying conrolling mechanisms or processes governing these routine events.

As far as organizational and instructional strategies and teacher mediating behaviors were concerned, the new program stipulates a far greater degree of flexibility in classroom activity and a far greater ambiguity of outcomes of these activities. Further, a greater degree of autonomy (students of their teachers and teachers of the broader educational system) is strongly implied. And, with regard to classroom discourse, teacher/student interactions would have to improve both in their quantity and their quality.

With regard to the underlying controlling processes of classroom events, it is apparent that teachers would have to change their orientation with regard to the purposes of science learning, that these purposes need to become more balanced between long-term and short-term outcomes. Furthermore, teacher feedback and student peer relationships should become more supportive to allow greater risk taking in verbal responses. Finally, it would seem that if the LSS program is to be implemented faithful to the intentions of the curriculum writers, sources and expressions of authority in classrooms would have to be more closely associated with empirical and experimental evidence in preference to confirmation of principles expounded in the textbook. This would mean that knowledge acquisition on the part of students would take on an exploratory rather than a confirmatory orientation.

Hence, in light of these propositions, the impending role changes to be incurred by teachers and their students such that their behaviors would become consistent with an inquiry teaching/learning situation are fairly extensive. Similarly, the role conflicts that are likely to emerge as a result of attempting to make such changes are indeed both extreme and complex. These role conflicts and their implications for the successful implementation of the new LSS curriculum will be elaborated upon in more detail in the succeeding sections of this chapter.

SECTION III: Research Question 3

In the preceding section of this chapter it was asserted that if the new guided-discovery/inquiry based Lower Secondary Science program were to be implemented faithful to the intentions of the curriculum developers, considerable changes in role behaviors of teachers and their students would have to occur. Further, it was predicted that role changes of such proportions could result in role conflicts that would have far reaching effects on the role incumbents (teachers and their students) as they continue to interact in the classroom setting.

In the research, it was considered important to look specifically at the ways in which teachers were informed about the new kinds of role behaviors implicit in an inquiry approach to teaching. The third research question therefore investigated channels of communication that enabled lower secondary science teachers to learn about the roles that were expected of them as they implemented the new LSS program. Both formal and informal channels of communication were investigated. The formal channels of communication consisted of: (a) the preparatory teacher inservice course in which the researcher took part as a participant observer, and (b) all available documentation relating to LSS available to the teacher, including the program materials themselves. Informal channels of communication pertinent to this research question included incidental reports on LSS in the national press and informal self-report by teachers about how they first learned about the program.

Origins of the LSS Program

Before the key events and channels of communication in the dissemination process are discussed in more detail, it will be relevant to once again examine pertinent information on the origins and development of the LSS program in light of how events in its course of development over time may have had prior effect on the decisions of the change agents and on the response of the cooperating teachers and their students. As it happens, the Project Director of LSS was not only one of the early writers and enthusiasts of the LSS program, but he was also Head of Science in the Institute of Education (the sole teacher training institution in Singapore). Consequently, over time, the Project Director had both the opportunity and the cause to actively promote 'inquiry, guided-discovery' approaches to science teaching in the preservice and inservice courses conducted at the Institute.

Aside from this, an informal network of support for an inquiry approach to science teaching was realized through the activities of the Science Teachers Association of Singapore (STAS) which, through its regular seminars and workshops, promoted innovative approaches to science teaching and learning. Considering that these two channels worked both informally and formally to transmit the philosophy of the LSS program it is not surprising that two of the cooperating teachers in the study reported that they had first heard about the project even before it was officially brought under the auspices of the Curriculum Development Institute of Singapore.

Dissemination and Implementation of LSS

Disregarding any incidental knowledge that teachers may have had about the LSS program prior to the study, the first official stage of dissemination and implementation of the LSS project beyond the trial schools occurred in mid-1982 with a meeting of Senior Science Teachers and officials of the Curriculum Branch of the Ministry of Education. The post of Senior Science Teacher is usually assigned to teachers of the 'upper' two levels of secondary schools (Secondary III & IV) who, apart from their teaching duties, have additional responsibilities including overseeing the implementation of the Ministry of Education syllabii.

It may be useful to clarify the role of the Ministry of Education and the Curriculum Development Institute of Singapore with regard to the preparation of syllabii and curriculum materials for the Singapore school system. Since the implementation of the New Education System in 1979, the Ministry of Education has retained its former responsibility for preparation and revision of existing syllabii but has done so in collaboration with key personnel in the Curriculum Development Institute where the necessary materials packages that correspond to the syllabii are developed.

The revised lower secondary science syllabus that was introduced for the first time by the MOE at the above mentioned meeting was officially documented in the form of a booklet which included a statement of goals and objectives and a list of science content to be covered. Since the revised version of the lower secondary syllabus presented at the meeting involved a substantial change of content, all but one of the textbooks available at that time for use in schools became obsolete. This meant, of course, that the new LSS Exploring Science materials fit the lower secondary science syllabus (newly prepared by the Ministry) closer than any other approved textbook.

Sample materials used in the trial schools, brochures and hand-outs describing LSS project materials were distributed at the meeting and it was expected that the Senior Science Teachers would share this information with their colleagues who would event- ually teach the new LSS program. There appeared to be no doubt among teachers at that time that the majority schools would use LSS project materials to fulfill the requirements of the new lower secondary science syllabus - in spite of the fact that the Deputy Director of CDIS had stated his preference that schools be allowed to choose whether or not they use LSS, or indeed, any of the other CDIS packages (21).

Later the same year, further publicity was given to the CDIS sponsored LSS program package through a nationally organized book fair in which copies of the new program materials were put on display. The LSS package was also highlighted in the two English medium national newspapers, the Straits Times, and the New Nation where both the materials themselves and details of the teacher inservice courses designed to orientate teachers to the new program were featured (22).

The Teacher Inservice Course.

The first teacher inservice course for LSS entitled 'A Refresher Course for Lower Secondary Science Teachers', organized jointly by the

CDIS and the MOE, took place in mid 1982. Based on teacher feedback from this first course, a second course was planned for later the same year. Approximately 180 teachers had attended these two courses prior to the implementation of the first level of LSS in January 1983.

Scheduling and Organization. The LSS inservice courses were scheduled outside regular school time for a total of 35 hours on ten consecutive Saturday mornings. The course comprised two 'mass lectures' and two 'workshops' which took place at a centrally located junior college, and six 'practical' sessions for which participants were divided into three groups rotating to three different laboratory locations. The six laboratory sessions were organized according to the three traditional science disciplines. The physical science component consisted of physics and chemistry sections and was conducted in two different laboratories in the Institute of Education campus. The biological science component, focusing on ecology, was conducted in the laboratories and outdoor ecology facility at the Singapore Science Center. Altogether, the ten sessions comprising the course were spread over three different locations in Singapore.

Objectives and Projected Outcomes. The objective of the course,as stated in literature sent to schools, was twofold: (a) to familiarize teachers with the Lower Secondary Science (LSS) syllabus, and (b) to familiarize teachers with science content and methodology in Lower Secondary Science teaching. The first part of the second objective was considered necessary by the inservice planners because most lower secondary science teachers have been trained as generalists rather than specialists i.e.: they do not have a specialized degree in science. The course organizers therefore deemed it necessary to teach the newly introduced content areas (such as energy and ecology) with which teachers may not be familiar.

Seven expected participant outcomes for the course were listed in the course description; viz: that the participants would:

" (a) Identify the differences between existing and the new LSS syllabus.

(b) Compare and comment on these syllabuses.

(c) Organize and conduct new approaches in Biology, Chemistry and Physics practicals.

(d) List ways of managing science practicals effectively.

(e) Write specific instructional objectives for lesson/topic.

(f) Identify strategies for teaching slow learners.

(g) List enrichment assignments for the teaching and learning of science."

The objectives of the course were described in the course literature as 'action oriented' involving the participants in:

"(a) studying the new syllabus, comparing the new syllabus with the existing Sec 1-2 General Science syllabus.

(b) thinking about the Philosophy of LSS and Enquiry-Based Approaches to Science Teaching.

(c) carrying out actual experimental/practical work involved in Lower Secondary Science learning.

(d) reading and discussing on the methods of effective management of science practicals.

(e) reading about and learning how to write specific instructional objectives."

(f) reading and discussing on strategies to teach slower learners in science.

(g) reading and discussing about enrichment assignments for fast learners as well as slow ones."

Of the course objectives listed above, the area that received by far the most attention was objective 'c' for, as described earlier, six sessions were allocated for this activity (but, as will be described later, some of this time was taken up by pre and post tests). One of the workshop sessions was devoted to objective 'e' and the remainder of the objectives were addressed in the remaining three course sessions with objectives 'a','b' and 'j' receiving higher priority (or more time) than objectives 'd' and 'f'.

Objective 'f' received only scant attention, and the issue of slow learners seemed to be confused with that of students having difficulty with learning science due to limited competency in English.

<u>Course Requirements</u>. Apart from meeting a 90% attendance requirement, each course participant was expected to complete and submit a number of written assignments to the Specialist Inspectors of the MOE who were the principal organizers of the course. The assignments were listed as 'course requirements' and they were specified in the course literature as follows:

"1. To make a comparison of LSS syllabus and existing syllabus.

2. To conduct an enquiry-based experiment in one of the sections (Biology/Chemistry/Physics) and to indicate problems faced and to propose possible solutions to the problems.

3. To write out specific instructional objectives for one lesson.

4. Write out enrichment assignments for five topics in science."

As far as the reseacher is aware, none of the teacher products of the four assignments listed above were shared by the participating teachers with others in the wider group of participants. Discussion that took place on assignment #1, for example, merely involved one of the teacher instructors making the comparison of differences in the physical sciences (even before the assignment was due) and one of the Specialist Inspectors commenting at a later date on the assignments that had been turned in. As far as the researcher is aware, none of the products of assignment #2 were shared among the group, whilst assignment #3 was completed during class time. One of the workshop sessions in which student project work was discussed by a Specialist Inspector was all that was shared publicly on assignment #4.

Course Instructors. It is significant to mention at this point that although a report in The New Nation [June 2nd 1982] attributed the organization of the teacher inservice course to a joint effort by the Science Teachers Association of Singapore (STAS) and the Singapore Science Center, it transpired that the Science Department of the Curriculum Branch of the Ministry of Education was, in fact, the primary organizer of the course. One member of the Curriculum Branch of the Ministry confided in the researcher that it was preferable for teachers to think that the course was organized by bodies other than the Ministry because then teachers would be more willing to attend. Whereas, in fact, many of the office holders of STAS are Specialist Inspectors at the Ministry.

The course instructors listed on the course description were drawn from several institutions in Singapore and worked on a no-pay, volunteer basis. Three of the LSS project team i.e.: the Project Director and two of the specialist writers were listed as course instructors. Three Specialist Inspectors from the MOE Curriculum Branch took responsibility for running the workshops and one of the laboratory sessions. Two lecturers from the IE and two officers from the Science Center were also listed as instructors. The remaining practical sessions were conducted by teacher members of the Science Teachers Association of Singapore. With the exception of one individual, most of these teacher/instructors appeared to be upper secondary school level (Secondary III & IV or Junior College) teachers who would not actually be teaching the LSS program in schools.

Management of the Course. Also important to this strand of the research was how the course was actually conducted or managed. This varied not just according to the nature of each session: workshop, lecture or laboratory session, but also according to the inclinations of the individuals responsible for that particular portion of the course. The mass lectures took place in a tiered lecture theater with all 90 or so participants present as listeners. In the first mass lecture the Project Director gave an introductory lecture explaining the history of LSS and its philosophy. This lecture stood apart from the rest of the course in terms of the Project Director's approach. For instance, at the outset of the lecture, he remarked: "This is not my lecture - it's yours... you should hear what you want to hear!".

He then distributed pieces of paper to all participants so that they could write down questions and concerns about the program that came to mind as he proceeded with his presentation. The papers were collected later in the lecture and most questions were duly responded to.

The Project Director was the only lecturer to solicit participant input in this fashion and he was the only course instructor to make reference to teacher role. He mentioned teacher role when comparing teacher behavior in the former general science program with that expected of teachers in the LSS program. Curiously enough, the adverbs used by the Project Director in connection with the new discovery approach may have had negative connotations for his listeners. Posing the rhetorical question: "How can I tell them about hydrochloric acid without actually telling them about hydrochloric acid?" he suggested: "We have to think much harder... and sometimes we have to be indirect, insidious, cunning, crafty".

On the other hand, (depending on the inclination of the listener) the Project Director acknowledged positive attributes of the course by asserting that the approach used in LSS presents a "greater challenge to the teacher".

In the same lecture, the Project Director also conceded that the way teachers would eventually teach the course would depend on their values and beliefs about teaching. He said, for instance, that teachers would have to face up to the question: "Do we tell them everything or do we let them find out for themselves?". "Either you believe in it," he told his audience, "or you do not!"

Inspite of the Project Director's attempts to raise teachers awareness of the implications of the ideology of the program for their role behaviors, questions and concerns that were forwarded on the pieces of paper handed out at the beginning of the session mainly revolved around practical aspects of running a class. Questions such as how to cope with large class sizes, difficulties with language experienced by normal stream students, availability of equipment, and scheduling of practical sessions seemed to be foremost in teachers' minds. But one very poignant question which may well have been on the minds of several of the participants as the Project Director stressed over and over that students should be guided towards finding things out for themselves: "What happens if students carry out the experiment again and again but they are unable to arrive at the expected correct answer?" proved difficult even for the Project Director to answer.

In contrast to the introductory mass lecture described above, the other mass lectures and the two workshops involved a one-way communication offered by the course lecturer to their listeners. Interestingly enough, the mass lectures happened to be the particular aspect of the course most heavily criticised by the teachers in their evaluation of the first course (see section on evaluation).

Laboratory Sessions. The 'practicals' or laboratory components of the course seemed to be conducted according to the preferences of the instructor involved. The physics section, which focused on energy, was organized differently from the other two sessions. The laboratory was set up with a number of demonstrations that illustrated energy conversions (23). Alongside some of the demonstrations were questions relating to the investigation. Teachers were given a prototype worksheet which was a copy of the one that would eventually be included in the student workbook. The participants were then invited to go around the lab and to try out the experiments and to make observations and notes on the experiments they were interested in. They were encouraged to interact with each other and discuss what they observed. Towards the end of the session, the two instructors invited teachers to talk about the demonstrations and to critique the prototype worksheet.

The way in which the biology and chemistry sections were conducted differed from the physics section in two major ways. Whilst the physics section had a rather open classroom arrangement as described above, the chemistry and physics sections followed a similar four-part format: (a) direct instruction, (b) instructor demonstration (c) participants repeating the demonstration experiment for themselves and, (d) further discussion on the experiment or related topics, if time permitted.

Another distinguishing factor in the approach used by the instructors in the physics sessions was that they gave no tests of any kind to participants. Both the biology and chemistry instructors administered both pretests and post-tests which were collected, marked and handed back to the teachers at the beginning of the next session (in the case of the pretests) or returned later by mail (in the case of the post-tests).

Also worthy of mention is that these pre and post-tests were administered in much the same way that tests would be administered to students in schools. For instance, on the cover page of the test were typed such instructions as "DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO" (in capital letters) and "Attempt all questions. You are advised not to spend more than 1/2 minute on each question." Some instructors even went so far as to circulate among the participants, whilst they were taking the test, looking over their shoulders as they completed the test paper.

One of the instructors concerned did, however, offer the participants a rationale for giving a post-test of this nature. Her claim was that she chose to administer a post-test to check on the effectiveness of her instruction. But, the fact that teachers were required to put their names on the paper, that the tests were handed in to be corrected and subsequently mailed to the teacher at their school address, suggested to the participants that the motives for administering such tests were not solely associated with assessment of instructional effectiveness.

Course Evaluation. The researcher collaborated with the course organizers to prepare a questionaire which was handed out to course participants at the last session of the first inservice course. The purpose of the questionnaire was to obtain feedback so that the second course could be planned to more accurately meet teacher expectations. The questionnaire was handed out by the Specialist Inspectors from the MOE and a total of 63 questionnaires were returned.

The questionnaire asked general questions about the strengths and weaknesses of the course and asked for teachers' suggestions for conducting future courses of this nature. In general, the responses from teachers indicated that the course was well received. The most significant recurring comment in teachers' responses was that more time should have been devoted to practical sessions and less time to lectures.

Only four teacher-respondents commented on the inconvenience of using three different venues for the course, three commented on the fact that they would have benefited from smaller groupings with more discussion, and three commented on the required written assignments. One of these three stressed the inappropriateness of being given assignments:

> "Don't call them assignments - ask instead for professional contributions to the course!!" [ISTQ 01]

A number of other respondents felt that, as experienced teachers, their potential contribution to the course remained untapped:

> "Lecturers always get to relate their experiences first before participants can do so. In workshop sessions, I think it should be the other way around. The response from participants would be better then." [ISTQ 26]

Eight teachers felt strongly enough about the pretests and post tests to comment on them:

> "There were too many pre-tests and post-tests administered weekly. They should be eliminated. If necessary, only one pretest/post test to be given at the beginning and end of the entire course". [ISTQ 11]

The teacher inservice course described above was organized strictly for teachers of science at the lower secondary level, but a series of school-based inservice courses organized by the MOE Curriculum Branch were offered to reinforce the goals of LSS. School based inservice courses on writing instructional objectives, on strategies for teaching normal stream students, and on use of audiovisual aids were aimed at reinforcing efforts to implement LSS and other newly introduced CDIS programs.

However, given that by no means all teachers attended the two LSS inservice courses, the remaining formal channel of communication available for them to find out specifically about the program (aside from obtaining information second-hand from their colleagues who did attend the course) would be the program materials themselves. These materials were made available to schools during the last month of the school year (November 1982).

The Program Materials

Sample LSS materials were distributed to schools prior to the end of the 1982 school year. Together with student textbooks and laboratory workbooks, the materials package for LSS included, for the first time in the history of science textbook publication in Singapore, a Teachers Guide. The introductory section of the Teachers Guide contained a one-page letter addressed to teachers which gave a very brief overview of the ideology of the program, details of which have already been given in Section II of this chapter. Most of the remainder of the guide corresponded sequentially to chapters in the student text, providing information on how to conduct classes and details on materials needed for experiments etc. Both the introductory letter and the sequential lesson guides conveyed role expectations of teachers as they implemented the program.

The complete LSS materials package also included other audio-visual aids: a set of wall charts, a comprehensive set of overhead transparencies and a series of television programs which were also available as video cassettes. Thus, teachers could glean from the availability of this eclectic assortment of support materials that they were expected to manage the program through a multimedia approach. A statement on the back cover of the Teachers Guide and students textbook which referred to the program as a 'scheme of integrated science' communicated some elements of teacher role with regard to integrating traditional science disciplines.

<u>The Teachers Guide</u>. Contrary to expectations of an inquiry/discovery program, some parts of the LSS Teachers Guide reinforced traditional teacher-as-director/student-as-follower roles reminiscent of classes prior to implementation of the new LSS program. Role stipulation of this kind is illustrated by the way in which the manual provides guidance to teachers in the conduct of their lessons. For example, in the section on measurement (Lesson 4) under a heading which deals with instruction on how to use a ruler and a measuring

tape, part one of the procedure focuses on measurement of length and parallax error. Instructions to the teacher read:

"1. Ask pupils to place their pencils or ball point pens along the edge of their rulers. Help students to take a correct reading of length.

2. Ask pupils to draw the pens or pencils on their worksheets and indicate by an arrow the point where the reading should be taken. Instruct pupils to place the eye vertically above the point to be read in order to measure a length accurately."
[TG p. 17]

In this and other examples, there is little evidence that students are intended to engage in a 'discovery' experience. In fact, accuracy in measurement and the phenomenon of parallax are concepts that have strong possibilites for discovery/inquiry teaching, if the lesson were designed appropriately.

In other parts of the text where there are instances of questions or problems couched in a way that would have potential for students to devise their own experiments, the curriculum writers supply modes of inquiry. For example, under the general heading: <u>To find out differences between inhaled and exhaled air</u>, ways of finding possible differences are supplied under four headings:

To compare the amount of oxygen in inhaled and exhaled air.
To compare the amount of carbon dioxide in inhaled and exhaled air.
To compare the amount of water vapor in exhaled and inhaled air.
To find out whether inhaled air is warmer than exhaled air.

<u>Student Materials</u>. Closer examination of the student materials reveal that they, too, communicate subtle messages about teacher roles. One very obvious example is the stereotype characterization of

teachers portrayed in the student textbook's owl cartoon series. This set of cartoons runs through the entire text and its intention is to reinforce key concepts in a humorous and appealing manner. But, due to the kinds of verbal transactions between the cartoon figures, they clearly, if unintentionally, reinforce traditional teacher and student roles.

A perusal of the sequence of cartoons reveals that the teacher owl (complete with British-style mortar board) is portrayed as a provider of answers and as a disciplinarian. Out of thirty examples of teacher owl/student owl interactions identified in the text, only three involved the teacher asking students a question. Of the three instances, one required a recitative answer, the second seemed to be merely rhetorical because the answer could not be derived from the cartoon; and in the third instance (which happened to be a good model for teacher questioning technique) the cartoon provided an example of how teachers could generate inductive reasoning from a student's question (See Appendix E). Most of the other interactions in the cartoons involved the teacher owl providing answers to student owl questions or acting as a disciplinarian checking on mischievous behavior of student owls.

Informal Channels of Communication

It was mentioned earlier that teachers who did not attend the inservice courses were likely to hear about the course and what was expected of them as they implemented the new LSS program from their colleagues who attended the course and/or from the Senior Science

Teachers in their schools. This strategy for informing teachers on educational innovations was commonly used in Singapore in previous years and is known as 'the multiplier effect'. Since the researcher was not privy to these exchanges there was no way of finding out the effectiveness of this channel of communication in informing teachers about their roles in implementing the new LSS program. Possibilities also existed for teachers to find out about the new LSS program prior to seeing the materials through the various communiques sent out to schools by the LSS team through the CDIS.

Other informal means of communication (meaning that it was not distributed formally through schools) were the reports written in Singapore's two English medium newspapers The Straits Times and the New Nation (since renamed The Monitor). Two short reports on the LSS inservice course (June 2nd 1982 and June 4th 1982) were published prior to the first inservice program. Three separate reports on the LSS program were published in The Sunday Times (the Sunday version of The Straits Times) on December 26th 1982, about one week before the program was to be introduced into schools. All of the cooperating teachers in this study read the above mentioned report in The Sunday Times on the day in question.

One of the news cuttings on the teacher inservice course implicitly stipulates teacher role by describing the LSS program as follows:

> The activity oriented syllabus emphasizes the practical aspect of science teaching. Students are shown how experiments are carried out and left to discover the results for themselves. [New Nation 2/6/82]

And a report on the LSS program itself inversely specifies teacher role by decribing new roles expected of students as they progress through the program:

> The LSS program sells students a new image of themselves. They are scientists making new discoveries. They are detectives looking for evidence. [Sunday Times 26/12/82]

But every indication of the hesitance with which the curriculum writers introduce this image of 'student-discoverer' in the Singapore context is revealed in the way the term 'discovery' is later modified in the report:

> But while enquiry is very much the hallmark of the LSS syllabus, the project team is careful not to go overboard and not make the same mistake their predecessors made... the LSS materials that will make their way into classrooms next year are more realistic and suitable to Singapore. They call for a discovery approach but with a difference.
>
> In the words of the LSS team, the approach is 'discovery with teacher guidance'. Students will not be left to flounder on their own. Neither will they be spoon fed. Instead, teachers will guide them into making their own discoveries. [Sunday Times 26/12/82]

Thus, regardless of teacher/student role and role relationships prior to implementation of the new LSS curriculum, it has become clear through the preceding discussion that a variety of means existed to expose teachers to the nature of teacher/student role expectations implicit in the new program. Whether the teachers concerned heeded those sources of information and whether, in fact, the sources and channels of communication were explicit enough to provoke in teachers a realization that role changes were imminent are issues that will be addressed in the remaining two sections of this chapter.

Summary

In this section of the present chapter, formal and informal channels of communication which were intended to define teacher/student role and role relationships in implementing the new program were investigated. It was found that the teacher inservice program designed to prepare teachers to teach the new LSS program concentrated on cognitive and manipulative aspects of the program rather than on strategies of inquiry teaching. Furthermore, by virtue of the example set in the organization of the inservice course, the course emphasized a separation rather than an integration of traditional science disciplines. In spite of this, the teacher inservice course generally appeared to meet the expectations of the teachers.

It was also noted that the curriculum materials themselves were not completely consistent with the stated program goals. The Teachers Guide, written expressly to assist teachers in implementing the program as planned, both presented and modelled a didactic tone when informing teachers on how to prepare for and conduct their classes. The student materials (particularly some sections of the workbooks) contained activities which were inconsistent with an inquiry approach in the sense that avenues of inquiry into stated problems were provided by confirmatory experiences from which the student could infer outcomes without performing the experiment.

Both formal and informal channels of communication repeatedly emphasized the student-centered nature of the program and the inquiry approach to science learning. The 'discovery approach' descriptor was somewhat modified to incorporate a guidance role on the part of the teacher - hence the term 'guided-discovery'.

None of the channels of communication examined in this part of the study seemed to adequately address teachers' concerns about the conditions in which they were intended to implement the new LSS program - at least in so far as these were identified by the researcher in Phase I of this study. Neither did the channels of communication acknowledge other constraints in the user system such as a learning environment in which there was a high ambient noise factor and that was so spacious that eye contact between the teacher and 70% of the students in the class was not possible.

The research data therefore suggested that, taken as a whole, channels of communication or ways of teachers finding out what was expected of them in terms of role and role relationships as they taught the new program were ambiguous and may have appeared to the teacher to be far removed from the realities of the classroom.

SECTION IV: Research Question 4

Research question 4 was posed in order to find out what types of change in teacher/student role relationships were evident in classes taught by the five cooperating teachers during the first year of implementation of the new LSS curriculum. Evidence of change was sought by comparing predetermined units of analysis in two sets of observations undertaken in the preimplementation phase with two comparable (24) sets of observations carried out in the post implementation phase of the study.

Evidence of Change

As in the previous year, classes were mostly conducted in the same kind of laboratory setting ie: in laboratories which were shared with several other classes at different times of the day. The laboratories continued to be susceptible to noise from surrounding activity and unsuited to classroom discussion.

Some changes were, however, noted on the bulletin board displays. Two laboratories displayed energy and ecology posters published by the Singapore Science Center. Student-made posters were displayed in another laboratory but a close perusal of the content and condition of these posters revealed, however, that they were projects completed by secondary three students and that they had apparently been retrieved from storage from previous years. Therefore, the observation that no current student work completed by the target classes was displayed in the laboratories they used for their science classes was consistent with Phase I of the study.

For the most part, students continued to conduct themselves both around the school and in the science classes observed in a courteous and orderly manner. In all of the classes observed, no students challenged the teachers' authority in an obvious or overt way, no students questioned teacher instructions or directions and, given the objectives of the LSS program, no student suggested to the teacher an alternative way of carrying out an experiment (refer to page 82).

The most significant change from Phase I to Phase II of the study, however, was noted in teachers' use of A/V materials. Whilst only one out of five teachers had used an overhead projector in the first year of the study, four out of five did so in the second year of the study. This change apparently had to do not only with the comprehensive set of A/V materials produced by the LSS media team, but also with a concomitant inservice effort by the MOE to improve A/V utilization in schools. However, as we shall see shortly, the ways in which teachers used the overhead projector facility, were not necessarily conducive to learning. The research data also revealed that while none of the teachers used video or TV in Phase I of the study, two did so during Phase II of the study.

As far as student roles were concerned, they remained highly consistent with those described in Phase I of the study. The most significant change was the mode of record keeping introduced with the new program. Formerly, students recorded their experiments in their own laboratory notebooks, whereas in the new program they recorded their work in workbooks that were part of the curriculum package. These workbooks usually contained the title, apparatus, and procedure of the experiment along with a blank chart or some blank lines in which students could write their evaluations. Blank lines were also provided for students to write conclusions following each experiment.

The student workbook eliminated some of the kinds of copying that were noted in Phase I of the study, ie: copying parts of the laboratory reports. However, one teacher insisted that students keep a laboratory notebook in addition to the workbook, because: "they don't remember it if they don't write it down". Apart from workbooks (and in one class laboratory notebooks as well) students were expected to keep the same number of supplementary exercise books (at least two and up to four) noted in Phase I of the study.

Apart from maintaining these books, one of the five classes in Phase II of the study was required to complete a group project on a well-known scientist. Students were assigned rather than being allowed to chose the scientist they were required to work on and they were expected to work on their projects in out-of-class time. Some guidelines were given on what the finished product was expected to contain but no guidance was given to students on how to go about dividing the work and conducting the necessary library research. It is not surprising that student response to this assignment was poor. When the date came along to hand in the work, five groups handed in nothing at all, four groups handed in covers with nothing inside, and only one group handed in a set of papers that resembled a project.

Classroom Routines

Teachers continued similar strategies for organization and instruction of classes as well as remaining the sole mediators of classroom activities and the exclusive decision makers within the teacher/student role set. Classrooms continued to be dominated by teacher talk and students were equally reticent in participating in classroom discourse.

Organizational and Instructional Strategies. The five cooperating teachers showed similar regimens for use of class time and sequencing of class events to those they had in Phase I of the study. Identical grouping procedures were used and teachers continued to devote a good proportion of their time to whole group instruction.

Classroom data collected after implementation of the new LSS program also indicated that teachers did not change the basic four-part routine for conducting practical lessons. After a formal exchange of greetings, classes tended to proceed in much the same way as they had before the introduction of the new LSS program:

T: Right, we are on page 49 of your textbook. Take a look!
I see there's only one absentee today. Good!
Turn to page 38.
[The teacher is flipping over pages in the Teachers Guide.]
About one minute later, he said:
T: I notice that your books are not open yet. The topic is air.
We've talked a little about air already, haven't we?
You know about air, don't you?
Alright - we're going to read ...
[The teacher paused.]
T: I think we've covered up to ...
[One student then prompted the teacher on the page number the class worked on last.] [FN yq 23/8/83]

Teachers still tended to separate both verbally and by example 'practical' and 'theory' aspects of their classes. Practical sessions typically involved the teacher demonstrating experiments for the class, the students doing the experiment for themselves, followed by a recitative discussion of the results and guided record keeping.

It should be mentioned that the teacher who participated in the inservice course was aware that this was discrepant with the aims of the program, for, after following the first two parts of this format and allowing students to proceed with the experiment, the teacher came to me and said: "Actually, I should have let them do that first, then get them around the front - this is supposed to be the discovery method!" [FN yq 6/2/83]. In spite of this remark (which he made during my second observation in Phase II of the study) he persisted with the usual four-part format during all of the subsequent observations that year.

In 'theory' classes, students often spent their time reviewing concepts through verbal recitation, or they copied notes from the textbook, from the blackboard, or from the overhead projector. In one class that was studying energy relationships, students copied notes from the overhead projector for four double periods of 90 minutes each period. By the second session of this routine, the students not only anticipated the teachers expectations; they did so eagerly. As the teacher moved from one part of the presentation to the next, she revealed subsequent portions of the overhead transparency. As she did this, the students responded:

S's: Copy?

T: No... don't copy yet. Listen first, then copy!

S's: Copy? Yes! We want to copy! [FN nd 28/9/83]

Teacher as Mediator. The data collected for Phase II of the study indicated that teachers still did not incorporate motivating activities into their instructional strategies and that they continued to be sole mediators of classroom events stipulating student conduct, student territory and student movement around the laboratory in very exact terms. Students were assigned permanently to seats at the laboratory benches and one teacher insisted that her students remain standing for experiment work (even though four students were assigned to one set of equipment) but she did not allow them to move around or discuss their work with adjacent groups [FN ss 25/1/83]. Another teacher, who regularly brought his students to the demonstration bench, even specified where each student should stand as they watched his demonstrations:

T: All right... come over and let's look at the next part. Move into your positions 1,2,3,4,5,6,7,
[The teacher indicated student positions around the demonstration bench.]

T: If you are not in your positions from now on you are for it! I put some of you chaps at the front so that you could see. Some of you are dwarfs, some of you are giants!
[FN yq 8/2/83]

Teacher Interactional Style. Some adjustments were noted in the interactional style of four of the teachers during Phase II of the study. This appeared to be linked with what could be described as the 'collective temperament' (25) of the classes as compared to classes assigned to their teachers in the previous year of the study. In this regard, it was noted that although teachers did not markedly change role enactments that are central to the thesis of this study (ie: didactive/recitative behaviors versus inquiry/guided discovery teaching behaviors) some adjustments in interactional style were noted.

For example, the teacher who, during the previous year, had the richest interaction with her class of 32 girls was assigned a class that was much more recitent in volunteering answers. On one occasion she became so frustrated at their lack of response that she asked them: "Are your hands so heavy that you cannot put up your hand?". On the other hand, the two teachers who were cited as being punitive in Phase I of the study were observed teaching classes that were more attentive, less talkative and less inclined to be engaged in off-task behavior than the class observed in Phase I of the study. Hence, these teachers adjusted their interactional style accordingly. Conversely, a teacher who had a more restless class during Phase II of the study appeared correspondingly more punitive in her interactions with the class.

Student Autonomy. Teachers continued to take sole responsibility for cueing students when to make transitions from one part of the lesson to the next, regardless of how quickly they worked as individuals or lab teams. Teachers continued to cue students when, as well as precisely how, to record their work:

> T: Page 18 of your workbook.
> Right! Now! ...date on the top right hand corner, and fill up the contents page.
> Now, I'll read the procedure for you...
> I want you to draw the pencil... then write: 'This average error is due to parallax'.
> The length is... I want you to give your answer in centimeters... You'll divide by what?
>
> S: Ten [One student responds at the teacher's request.]
>
> [The teacher acknowledged the answer and moved on.]
>
> T: You must draw the eye. Don't draw the eye on two sides like in the textbook, or otherwise some of you will be very untidy.
> Do you understand now what you have to do? [FN du 26/1/83]

In some classes, teachers predetermined exact responses to workbook questions to such a degree that after the experiment was conducted and a follow-up discussion attempted, they would reveal a portion of the blackboard or put a transparency on the overhead projector which already had prepared answers that had been written even <u>before</u> the experiment was carried out. By this act, not only did the teachers demonstrate to students that the teacher prepared answers were preferable or superior to any that students may or may not have contributed during the discussion, but they also communicated to students that there was an <u>expected outcome</u> of the experiment independent of the outcome obtained by the students. Students therefore had no ownership over their workbook records, neither as individuals nor as contributors to a collaborative group effort.

Similarly, instances were noted where <u>students</u> seemed to have prepared answers prior to the lesson. In one class, a few students had parts of their textbooks highlighted and questions answered, even before the teacher introduced the topics. It should be mentioned here that it is fairly common in Singapore, even for parents with modest means, to engage tutors to assist their children with school work. One explanation for the highlighted paragraphs and completed answers is that students had gone over the topic and were prepared for the lesson by their tutors. The impact of this is significant. For these students class time meant repeating things they had already studied on a one-to-one basis with their tutors. Certainly not the kind of 'discovery' mode of learning anticipated by the curriculum developers.

Even in Phase II of the study students continued the practice of copying each others' work even when the work assigned allowed for individualization. This was noted even in an express stream class that were assigned a short essay on Galileo. Just before the class, several students were observed kneeling on the ground outside the laboratory copying work from each other as they waited for the teacher.

<u>Patterns of Classroom Discourse</u>

Patterns of classroom discourse after introduction of the new curriculum also remained much as they were during Phase I of the study.

<u>Questions and Answers</u>. In general, discourse tended to be halting with the teacher initiating and dominating verbal discourse. When teachers <u>did</u> attempt to involve students in some kind of discussion, students' responses seldom amounted to more than one word answers. As in Phase I of the research, it became clear that students lacked the

vocabulary to participate in classroom discussions, even if they understood the concepts:

T: Do you remember what happened when we heated the mercuric oxide last time?
[No response from students.]
T: Do you remember?
[Still no response...]
T: How did we test it?
We used a wooden splinter... how did we test it?
We used a wooden splinter... what did we do with it?

S's: Burn it! [Two students spoke up at the same time.]

T: First we burned it. Then what did we do with it?

S's: Blow it!

T: Then, what next?

S: Splinter! [One student calls out.]

T: What do you call the little thing on the end of the splinter?

S: Lighted... [The same boy speaks up.]

T: Lighted but not burning... what do we call that?
[No response from students.]
Glowing... isn't it?
Glowing... [Teacher pauses.]

S's GLOWING... [Students repeat in chorus.] [FN yq 2/8/83]

Because of the difficulties students experienced in expressing themselves in English, teachers often provided answers to their own questions. Teachers also found themselves explaining words that were not necessarily specialized scientific words but words that the curriculum writers had assumed that students would understand. In other instances students used words they associated with the terms they were being asked to explain or define and the teacher would elaborate accordingly:

T: What precautions must you take when you are doing this kind of measuring?
[No response from students.]
Precaution... you know what the word precaution means?
Have you heard it before?
Perhaps you have heard the word CAUTION ?

[Teacher writes the word 'caution' on the blackboard.]

S: Road.

T: You might have seen it on the road... when there is some roadworks or something else going on.
No? But what does precaution mean?
Yes? [The teacher points to one boy.]

S: Danger.

T: No... it does not mean danger.

[The teacher points to another boy. Students are muttering to each other.]

S: Careful.

T: Yes it means to be careful... then what does the 'pre' mean? It means earlier... it means to follow steps carefully. [FN yq 9/2/83]

Chorus responses: As illustrated in the vignettes cited above, all teachers solicited chorus responses to a lesser or greater extent and for various purposes and students seemed to be perfectly tuned to when these responses were expected:

T: By now on your desk you should have an overflow can, a measuring cylinder... now be careful with the measuring cylinder... be very, very careful - don't break it!
T: Be very, very...

S's: CAREFUL [FN es 1/3/83]

Peer interaction. As in the previous year, students' reluctance to answer questions appeared to be most strongly linked with their fear of 'losing face' due to their difficulties in expressing themselves or for fear of giving the wrong answer. Students also seemed extremely embarrassed when they were called upon to answer a question which was likely to include a long and complicated word they may be unable to pronounce:

T: We mixed iron and sulfur and what happened then?
[No response from students.]
T: Come on! Let's have a show of hands... Who knows?... Yes?
Next step, we added some ...

S: meth... meth... Sir! Cannot pronounce...
[The class bursts out into laughter.]

T: Say it ... methylated spirits...
[Students mutter among themselves.]
T: I've told you many times ... you must keep on saying these words over and over so that you will pronounce them correctly! It's methylated spirits ... say it!

S's: (in chorus) METHYLATED SPIRITS...

T: Also called alcohol... [FN yq 22/8/83]

Controlling Processes

Purposes of Science Learning. As in Phase I of the study, attitudes and beliefs communicated by teachers to their students and to the researcher regarding the purposes of science learning can best be discussed within the framework of long-term and short-term purposes.

Long-term purposes: In Phase II of the study, teachers appeared to persist in their beliefs that the most important purpose of science

learning at the lower secondary level was to prepare students for classes yet to come in their secondary schooling. This was invariably expressed as a rationale for learning a particular topic, concept or skill. For example, when demonstrating a simple electrical cell, a teacher explained:

> T: The core is surrounded by bubbles.
> The liquid can't get to it so the reaction slows down.
> The reaction slows down because of the bubbles.
> This is called polarization but you will be learning more about polarization in secondary three.
> [Teacher writes the word 'polarization' on the blackboard.]
> [FN du 26/8/83]

Another teacher used this rationale to encourage students to put more effort into their work. When reproaching her students for not 'trying' and then explaining the consequences that this may have for them three years hence, the teacher said:

> T: Some of you are not trying!
> You <u>have</u> to try!
> When you go to secondary four you will be expected to know how to read a vernier sliding caliper and your teacher will not show you again!... You <u>have to try!</u>
> [FN ss 25/2/83]

As far as students acquiring and developing skills in the processes of science is concerned, one teacher stressed becoming a good observer as a desirable long-term goal of science learning:

> T: You must observe the experiment very, very carefully.
> You must know what is going on... that's why you must observe. You must become a good observer!
> It's the most important part of chemistry... to observe the changes that take place.
> Right? O.K.!
> What do we see here? [FN yq 2/8/83]

Short term purposes: Much more teacher attention was given, however, to the short-term purposes of science learning. One teacher alluded to carrying out an activity as if its purpose was to fill blanks in the workbook:

> T: Turn to page 21... 5 questions to be answered.
> 5 blanks to be filled up.
> Fill the first few blanks of the worksheet... you can describe what sulfur looks like... can't you? [FN yq 1/8/83]

As in the first year of the study, students who lacked confidence in giving responses to teachers often read out their responses verbatim, either from the textbook or from their own workbook or notebook; or, in the case of one student, from his test paper. In this instance, the teacher was going over a test that had been given a few days earlier:

> T: You see, you must be alert!
> You must know what the question asks...
> This one was not answered very well... [Teacher referred to one of the questions.] but then, question four...
>
> [The teacher paused...]
>
> T: What is a strike back?
> Who got that right?
> What is a strike back?
> You! [Teacher points to boy near the back of the room.]
>
> [The student reads his answer verbatim from the test paper and the teacher acknowledges it as correct.] [FN yq 25/2/83]

One teacher linked purposes of science learning with language acquisition as he had in the previous year of the study:

> T: For instance, you learn many new words in science - when you come across a new word, you must first know how to <u>say</u> the word, you must <u>know the meaning</u>, and third, you must know the spelling and how to use the word correctly Four things, only then is your learning complete!

The same teacher was also very concerned about students speaking loudly and clearly:

T Make sure you use your mouth when you speak... use your chin, your jaws... Don't shout though!
How do you pronounce properly?
If I speak now... look at my mouth.
Did you understand me?

S's: (in chorus) YES SIR!!

T: If you move your mouth, nothing will happen... your jaw will not drop off! [FN yq/83]

Teachers also linked the purposes of science learning with preparing for examinations, as in the following example where the lesson was nearing an end, students were becoming inattentive, and the teacher suddenly announced that there would be a test on Friday of the following week:

S's: When? When? [Some students called out, acting confused.]

T: Look on the board if you want to know!
[The teacher began to write on the blackboard and at the same time commented to the class.]

T: I'll write down the topics on the blackboard.

[The teacher began to write: What is energy ?
Potential energy
Kinetic energy]

S: Copy? Copy? [The students called out.]

T: No, these are points that you have to learn. Go home and revise these points and go through the questions at the end of each chapter... revise them too!
[FN nd 28/9/83]

On more than one occasion, teachers were observed to announce upcoming tests in a more threatening tone:

T: You have plenty to do to revise for your test!
You'll have a lot of questions.

> So make sure you know your lessons and your facts very well. You'll have a lot of questions... If you come back from your break late (due to bad behavior) I will not give you extra time and you will lose marks that way.
> So, go through your calculations, learn your formulae... like how to find the area of a triangle and a trapezoid.
> Your first questions will be multiple choice, then conversion, then you label diagrams.
> You have to describe an experiment and read a micrometer reading I have drawn. You will have to say what the reading is... and I am warning you...
> I will not give you marks for nothing!! Either your answer will be right or it will be wrong. And it will be no use coming to me and saying your answer is 'quite' right. Well your answer must be <u>exactly</u> right, not <u>quite</u> right! As I see it, if you do not study you will fail the test. You'll have a lot of questions to answer in one hour and ten minutes!
> [FN du 25/2/83]

And with regard to neatness and accuracy in record keeping as one of the purposes of science teaching the teacher said:

> T: These pens have been given to you so that you can write neatly.
> I said make sure you write down the notes neatly!!
> Alright those of you who talk will copy out twice!
> Page 28... the summary there, copy it out.
> I can still hear plenty of noise, If I hear noise I will give you extra work to do during the (Lunar) New Year holiday!

[At this, the students soon settled down to work.] [FN du 31/1/83]

<u>Reward Systems</u>. As in Phase I of the study, high scores in examinations, memorization of facts and neatness and accuracy in record keeping appeared to be the three most highly valued student behaviors and therefore the behaviors most rewarded in classes conducted by the cooperating teachers. A fourth aspect of behavior - cooperative student conduct was also valued but since such conduct seemed to be <u>expected</u>, teachers were not seen to reward students for

this kind of appropriate behavior. However, it appeared that for many classes, appropriate student behavior was more likely to be that solicited by or imposed upon the student by the teacher than self-discipline on the part of students.

It was found that on the few occasions, when two of the teachers brought half of the class to the demonstration bench to observe a demonstration, the alternate group were not able to work on their own. Even though an appropriate assignment had been given, students tended to cluster into groups and engage in off-task behavior. [FN du 8/8/83]

As far as examinations are concerned, students in the normal streams did not perform well. The average score for one normal stream class was 54% for the first test they took folowing adoption of the new LSS program. As in the year prior to use of the new program, student failure in tests was attributed by teachers to poor study habits and poor command of the English language rather than inappropriateness of instruction or testing instruments.

Students in normal classes were reminded that by obtaining good results in examinations they could be promoted to a higher class:

T: But we must be very clear about these three things:
elements, compounds and mixtures.
Can you remember some of the compounds we had last week?
We started burning them ...
By now you should have revised (reviewed) all of this.
It is very important that you keep on doing that: revise all the time.

If you do well and you get three merit points, you can go
to a higher class.
Learn it up as it comes.
Otherwise it is too much to learn when the exams come.
And the exams are coming very close and they'll be here
before you know it! [FN yq 3/8/83]

Another teacher expressed the belief that 'retaining' material presented in class was important to science learning:

T: If the lines on the main scale and on the vernier scale make
a straight line... what does that mean?
[No response from the class.]
T: Now I wonder why you don't know this!?
I TOLD you last lesson to observe that and you told me that
there was no zero error.
So now... why don't you know this?
Why can't you remember?
Please retain what has been learned in class!
Is that clear? [FN du 9/2/85]

Sources and Expressions of Authority. Much teacher attention was directed in class to the pursuit of the 'right answer' that had already been predetermined by the teacher. In some instances, even though students' responses came close to the response the teacher expected, they did not probe further or even give credit to the student for an answer that was close to their expected response. Instead, they persisted in their own idea of what the 'right answer' should be:

T: The sulfur... how does it feel to you?
S's: Dust!
T: Like soil, like powder.
That's the answer, right there, like powder!
Who can spell powdery? [FN yq 23/8/83]

As in classes observed in Phase I of the study, some instances were noted in which results of experiments were discussed in terms of 'right' and 'wrong' answers as in this review of an experiment that had been carried out the previous day:

T: Yesterday we were calculating...

[The teacher walks to the right hand side of the blackboard. There is a chart listing a set of results. The same chart can be found in the student workbook.]

T: For instance, your answers...
Are they the same or different?
Your answers were the same.

[Student non-verbal behavior indicated agreement.]

T: One or two were different, but most were the same...
that is... equal to the clockwise moment.
So the question asks you: "What do you conclude?"

[The teacher reads the question from the workbook.]
[The teacher moves to the blackboard and begins to write on the left hand side. He writes the following sentence:]

T: "Since the clockwise moments are the same..."

[The teacher then turned to the class and adds an aside.]

T: ...or if your group did not get the right answer put more or less the same...

[The teacher continued to write on the blackboard and at the same time said:]

T: "...that is the Work Principal..."
Is that clear now ?

And in similar instance a different teacher gave the conclusion of a group of experiments as 'proof' of a scientific law:

T: Now - all of these experiments conform to a scientific law.
Do you know what is meant by conform?

[Teacher waits for an answer.]

T: They follow the law. We learned about energy changes heat - electricity - kinetic energy... The fact that these changes take place illustrates a law. What is the law?

[The students respond appropriately.]

Sources of Authority Outside the Class. As far as authorities outside the classroom dictating what will occur inside the class, the following vignette derived from a lesson that took place during the early part of the year following implementation illustrates the way in which one teacher communicated to her students how a source of authority external to the classroom influenced what was to be learned:

> T: Today... we'll do the exercise with the vernier sliding caliper. I don't know if you have mastered the skill or not, so I'll give you a brief revision.
>
> [The teacher stands next to the overhead projector and displays a transparency of a vernier sliding caliper.]
>
> T: If these two lines are not level, you get an error...
> - what kind of error?
>
> [Some students raise their hands and the teacher calls upon one of them.]
>
> S: A zero error.
>
> T: That's right, a zero error!
> I haven't marked your exercise books yet. I don't know whether you got the exercise correct or not.
> But it's not required for you to know how to calculate zero error... so we won't be doing that.
> For the time being, in our experiments, we'll assume that there is no zero error. [FN ss 26/1/85]

Disconfirming Evidence

In spite of the overwhelming evidence supporting the assertion that teachers did not change their role behaviors as a result of the introduction of the new LSS program, there were two instances in which one of the cooperating teachers engaged in a problem solving dialogue with students. Both situational frames were extracted from the data of the same teacher and both indicated that if the teacher could stimulate students sufficiently to the extent that they lost their inhibitions about speaking out in class, such discourse was, in fact, possible. Interestingly enough, neither of these episodes was deliberately planned by the teacher - meaning that it was not the teachers intention to structure the lesson around a problem-solving activity. Rather, the incidents occurred by chance. One arose as an outcome of a student's question and the other as a result of inadequate distribution of equipment:

T: Stop working for a minute... Here is a good question... This boy asked me what he should do if the top number... in other words... the mass, is smaller than the volume. What do you think he should do?
[No response from students.]
T: Any answers?

S: Put the volume over the weight.

[Some students are calling out "Yes" and others are calling out "No!"]

T: I do not want any calling out of the answers.
Raise your hands!
Yes? [The teacher looks at the class chairman.]

S: Put the volume over the weight.

T: I see! Any other answers?
Now, listen and think about it!
If the mass is smaller than the volume, how can you find the density? He says put the volume on top. What do the others say?
[The teacher points to another boy who had his hand up.]

S: Get a decimal.

T: Get a decimal? You mean ... use the small mass over the volume and divide so that you get a decimal answer? Anybody else?

[Some students begin writing - presumably because they seemed to think that the teacher had elaborated on the students response because it was correct and/or they discerned from the tone of the teacher's voice that a correct answer had been given.]

T: Don't start working yet!
Do you agree with our friend over here - or do you think he is right?

[The teacher gestured to the two boys who had given two competing answers].

Come on... don't be scared... put your hand up!
[Some students raise their hands.]
And who agrees with his point of view?
What about those who have not put up their hands yet?

[The class laughs.]

T: You have to think about what <u>is</u> density actually.

S: Mass over weight!

T: But how do you explain density?
What we are trying to find out is how much mass is in one cubic centimeter of the body.
We <u>have</u> to divide mass by volume!
It does not matter how much mass we have if we have to find how much mass in 1 cubic centimeter.
It is <u>how much</u> mass...
He is right... you'll get decimals for your answer!
[FN yq 22/2/83]

Then, on a separate occasion, the following scenario was recorded:

T: Ah! here! ...here is another problem...
You notice that this spout is shorter than the height of the measuring cylinder.
How are you going to solve that?
S: Tripod?

T: Listen, look up... it is most important when you do this that you do not let drops flow out of the spout.

[The teacher then asks one pair of lab partners how they plan to position the displacement can and then moves on to others asking them what they would do. The students are visibly excited by the discussion.]

T: You have three methods:
This one involves clamping the displacement can onto a stand.
Are you sure your can is level?

S's: YES!

T: Don't just say yes; look and see!
This one...

[The teacher points to one that is held in place by a clamp.]

T: If it's not level you may loose a drop of water. You've forgotten...
You need any extra water?
Get off the stool!!

[The teacher reproaches a boy who is standing on stool staves in order to reach the experiment.

T: Right, how are you doing? Clean up!

[Boy goes forward to get a cleaning rag.]

T: I want to ask you a few questions.
There are three different ways you can find the volume.
Straight up... the bottom of the can, was it level?
Don't just say yes... take a good look!!
Another method was at the sink
When the dripping stopped, some water was displaced

A third way was you could put it on the table... the table won't move will it?
Alright... what about you?
Did you loose any extra drops of water? [FN yq 22/2/83]

In spite of the fact that the teacher concerned did not demonstrate these teaching strategies during Phase I of the study and that the two incidences occurred incidentally rather than by design, they showed that this particular teacher (who happened to be the teacher who attended the inservice course) used instructional strategies that are critical to inquiry teaching. Firstly he demonstated that he knew how to engage students in problem solving situations, that he was willing to allow students to make decisions concerning the set-up of equipment, and that he could tolerate an ambiguous situation which might result from students using different experimental set-ups. Finally the teacher recognised the importance of having students evaluate which method was likely to produce the most accurate results. The question of why the teacher did not plan these types of activities into his science lessons for the remainder of the year is an important one to be addressed. Some propositions will be made about this in the remaining section of this chapter.

Summary

As cumulative discussion in the preceding sections of this chapter has suggested, an analysis of classroom data gathered over the two-year period of the study revealed that, with very few exceptions, the manner in which the five cooperating teachers acted out their roles as science teachers did not change appreciably from the pre-implementation to the post-implementation phase of the study. In other words, during the first year of implementation of the new Lower Secondary Science curriculum, recurring patterns of teacher behavior persisted. Teachers continued to view themselves as disseminators of information, as sole initiators of student learning in the classoom setting, and as directors and controllers of all classroom activity. Recurring teacher behaviors consistent with 'discovery' or 'enquiry-based' teaching roles (advocated by the LSS curriculum developers) did not feature significantly during the nine sets of observations that constituted the post-implementation phase (Phase II) of the study.

Classroom discourse tended to be dominated by teacher talk and student responses to teachers' recall questions were almost all short and recitative. Both teacher and student roles continued to be exclusively defined, mutually reinforcing and non-interchangeable.

At the same time, it was recognised that at least one of the co-operating teachers was aware of how to go about structuring a teaching episode to incorporate a discussion of competing ideas and alternative ways of setting up apparatus. The same teacher also recognised an anomaly in using the usual four-part format of introducing and demonstrating an experiment before the students were allowed to carry out the practical work. But clearly, the teacher concerned did not place sufficient priority on these strategies to incorporate them into his teaching on a planned and regular basis. Apparently, the forces which governed the way in which this teacher normally enacted his role as a science teacher were heavily grounded in other factors in the setting in which he taught. Some inferences pertaining to the reasons for this are discussed in more detail in the next section of this chapter.

SECTION V: Research Question 5

Research question 5 asked: How does evidence of teacher change or lack thereof link with key events and channels of communication in the dissemination and implementation process and/or with other parameters in the research setting? The research question was addressed by triangulating data from the numerous and varied research sources drawn upon as the study progressed.

The Dissemination and Implementation Process

Two aspects of the dissemination and implementation process were intended to orient teachers to the new program: (a) the teacher inservice course and (b) the LSS Exploring Science Teachers Guide. Closer examination of the dissemination and implementation process operating within the context of the research setting has revealed some underlying reasons as to why they were less effective than they might have been.

The Teacher Inservice Course.

Since only one of the cooperating teachers took part in the in-service course prior to implementation of the new curriculum, no claim will be made here that any change or lack of change on the part of individual teachers could be attributed to their participation or lack of participation in the course. Neither will any attempt be made to compare the degree and kinds of change on the part of the one teacher who did participate with changes in the four cooperating teachers who did not. Rather, the teacher inservice course will be discussed from the researcher's perspective as a participant observer in the course. As it transpired, the content and conduct of the course provides two important insights into parameters of the broader research setting. Firstly, it furnished an avenue for examining <u>congruence between theory and practice</u> with regard to the change agents' presentation of the LSS program. Secondly, it provides a basis for inferring and/or observing in action the <u>sources and expressions of authority</u> with regard to the broader context of the educational system in Singapore and the impact this may have had on teachers' attitudes and their subsequent level of implementation of the LSS program.

<u>Congruence Between Theory and Practice</u>. It was mentioned earlier that the introductory lecture given by the LSS Project Director was the only occasion in the teacher inservice course on which indication of teacher role change in the implementation of an inquiry/guided-discovery program was referred to. Other than this, the expectation that teachers would change their role perceptions and associated role behaviors did not feature as a priority among the planners and instructors in the inservice course. Rather, the inservice course focused on two other aspects of the new curriculum: (a) dissemination of information concerning <u>content change</u> of the syllabus issued by the Education Ministry and (b) demonstration of the <u>laboratory techniques</u> which had been newly introduced into the

practical component of the program and therefore may have been unfamiliar to teachers.

Interestingly enough, data obtained from the teacher evaluation of their inservice experience indicated that the latter emphasis (demonstration of laboratory techniques) met the needs of the majority of the teachers who favored 'practicals' as a way of learning about the new program. The mass lecture in which ideologies of the program were discussed was dismissed by some teachers as being 'boring' and 'a waste of time' [ISTQ 04/60] - perhaps due to the fact that lectures may have seemed to teachers to be covering 'old ground'. (personal communication, Tang, March 1985)

The research data reveal that none of the inservice instructors modelled appropriate inquiry teaching behaviors as they conducted their laboratory sessions. The nearest semblance to a 'discovery/ enquiry approach' were the practical sessions conducted on energy. But even in these sessions, the participating teachers were left on their own to carry out the investigations. When the time came around for discussing the investigations the teachers were reluctant to do so. It was then left to the instructor who ended up giving final explanations and providing closure to the session.

Whilst the activity-centered nature of the inservice course reinforced the activity-centered approach of the LSS program, no sessions were observed in which an instructor used a strategy such as discrepant event or a dramatic episode (26) as a means of arousing teacher interest and motivation. Neither did any of the inservice instructors model exemplary inquiry teaching through their questioning techniques. On no occasion in the inservice course, as experienced by the researcher, was an instructor observed drawing a group of participating teachers through an inductive reasoning process. Thus, teachers had neither the opportunity to observe vicariously nor the opportunity to practice the kinds of roles intrinsic to inquiry/guided discovery teaching.

A similar and perhaps equally significant anomaly which had impact by omission was failure to integrate the traditional science disciplines and organize the course around the integrated themes that form the basis of the LSS textbook and workbook materials. As it happened, the inservice course was compartmentalized and organized around the traditional disciplines of physics, chemistry and biology. The fact that the LSS program purports to be an 'integrated approach' to science learning seems to have been ignored and, by its very omission, the value of this approach for teaching science at this age-level was depreciated.

Expressions of Authority in the Inservice Course. Several events in the inservice course for teachers manifested very clear expressions of authority within the complex role set comprised of the teachers and their inservice instructors (which included Ministry of Education personel, curriculum writers and subject specialists).

First, there was the fact that with the exception of one teacher-instructor (27) all teacher-instructors involved in the course were teachers of 'higher' levels of the school system, meaning that they were either teachers of third and fourth year secondary students or they taught at the Junior College level. Other course instructors were lecturers at the Institute of Education, CDIS curriculum writers or Ministry of Education personel.

Choosing instructors from these sources could have had various effects on the participants. The most damaging effect to the intent of the course, however, was that the teacher-participants may have felt that these subject specialists are competent in carrying out the experimental work included in the new program, but they (the participants), as generalists, are not. Using teachers who had successfully piloted LSS in the trial schools at the secondary 1 and 2 levels may have been a more effective strategy. Teachers could then perhaps have identified more closely with the instructors, feeling some commonality in dealing with anticipated problems as they faced the prospect of implementing the new program in their classes.

Secondly, the fact that so much of the allotted time in the biology and chemistry components of the course (at least 15%) was taken up by test-taking communicated tacitly to teachers that testing was a priority in the inservice course and it is conceivable that teachers may project this priority onto their own teaching of the LSS program. Furthermore, the fact that the tests were potentially an intimidating experience for the course participants, and that some ambivalence was noted with regard to their purpose, served to reinforce lines of authority in the broader educational system. Were the tests being used for teacher evaluation or as a check on instructor effectiveness? The fact that the tests were not corrected by the teachers themselves and that the test scores might well have been made public knowledge (since the corrected tests were mailed to schools) raised this question in the minds of the participants.

Thirdly, on the same theme of accountability was the fact that teachers were required to submit written assignments to the course organizers who happened to be Ministry of Education Specialist Inspectors. It is significant to mention that during the workshop on specific instructional objectives, the entire group of teacher participants was reproached (albeit moderately) for the number of assignments that were overdue. And, commenting on the quality of the assignments that had been handed in, one inspector said: "I have read through the assignments. Now, <u>some</u> of you really went through the syllabus thoroughly..." (implying that some assignments were less than adequate).

Fourthly, and this has become obvious from the anecdotes cited above, was the tone in which some of the inservice instructors communicated with the course participants. For example, when one teacher complained of experiencing difficulty in obtaining laboratory equipment because it was being reserved for the secondary III and IV classes, the response from one Specialist Inspector was: "I hope you will go back and cooperate. <u>You must exercise care when you go back</u>. When you prove that you can take care (of the equipment) then the Senior Science teachers will let you use the equipment you need".

Similarly, during one of the laboratory sessions, when the instructor saw that some teachers were taking more chemical than was necessary, she said: "Hey! Don't use so much!! - you must listen to all advice." On another occasion during the workshop on instructional objectives, teachers were asked to work on their own in a programmed learning booklet. Noticing that some teachers finished early, the instructor said: "Go through it again and really cover up the answers this time". And later, when the same instructor was reading over some instructional objectives handed in by teachers, the instructor remarked: "One person actually got the idea of how to write instructional objectives - FULL MARKS!"

Hence it became increasingly obvious to the researcher that sources and expressions of authority exemplified in the statements quoted above clearly manifested themselves in the role set comprised of the teachers and their inservice instructors. This was apparent even among those instructors who were teachers themselves and who had been temporarily recruited as inservice instructors for a few sessions during the course. Even these individuals adopted an authoritative stance in their interactions with the course participants.

One notable exception to this was the teacher-instructor who was himself a lower secondary science teacher. This teacher was also the only teacher-instructor observed by the researcher who made the effort to introduce himself to the class, saying who he was and where he taught. Later in the session, the same instructor was also quick to acknowledge the expertise of the participants by suggesting that they may already have their own (better) ways of teaching certain concepts.

The impact that these explicit expressions of status may have had on teachers both personally and professionally is a debatable issue. But what seems self-evident is that such experiences were neither good for teacher morale nor conducive to favorable teacher predisposition towards the new LSS program. Furthermore, it could be argued that such treatment would be unlikely to encourage teachers to voluntarily attend further inservice sessions of this nature.

<u>The LSS Teacher's Guide</u>

As discussed in detail in Section 3 of this chapter, it would be expected that the LSS program materials themselves would be consistent with the ideologies expressed by the program developers. In fact, the research indicated that this proved not to be the case. This was especially true of the way in which the Teachers Guide instructed teachers on how to conduct their classes and it may now be pertinent to raise the question of whether the curriculum writers were aware that by using a directive tone in communicating with teachers, they were modelling authoritative roles. Moreover, the tone of the lesson guidelines encouraged teachers to act authoritatively in their roles in classrooms. This was particularly true of some problem-solving and decision-making situations that had potential for autonomous management by teachers and their students.

On the other hand, it could be argued that the curriculum writers themselves, who are both products of and current role participants in various subcultures of the education system (and the broader milieu of Singapore life) are perhaps unable to divest themselves of the traditionally ascribed roles of teachers and students. Furthermore, it should be asked to what extent the final product or LSS materials produced for use in schools were true to the ideologies of the curriculum writers and to what extent they compromised their ideologies to satisfy the expectations of role incumbents in the user system. One indication of this possibility is inherent in the initial intention by the curriculum developers not to provide answers to workbook questions and thereby by-pass the tendency of teachers to focus on 'the right answer' (Cheah, personal communication, March 1982). But whilst the materials were being piloted in the trial schools, the curriculum writers yielded to the pressures of the teachers who firmly requested that answers be included in the Teachers Guide. Hence the 'right' answers provided in the Teachers Guide are now conceivably the authority to which the teachers adhere in arriving at outcomes of their instruction.

Connected with this was an indication by one teacher that part of her role perception was a need to 'outguess' the system. She remarked for example that: "They seem to put more weightage on the energy section so I shall spend more time teaching that" [AM 19/1/83]. Adherence to the syllabus as an authority for what should be taught was communicated in a direct sense by one teacher to her students after explaining about how to identify a zero error on a vernier sliding caliper: "But I'm not going to teach you how to calculate the zero error because that is not required." [FN ss 26/1/83].

Another source of authority that makes its presence felt at the lower secondary level is Singapore's National examination system administered by the Cambridge Examination Board in Britain. Even though secondary school students do not normally sit for their General Certificate of Education until the end of their fourth or fifth year of secondary school, teachers at the lower secondary level are so attuned to the fact that they are expected to prepare students for the next level of schooling that part of their role perception is to 'train' students to take examinations. Further, teachers are conscious of the fact that if students have not mastered certain concepts and do not appear to be fully prepared for the next level (in the opinion of their next teacher) there may be repercussions which will have impact on their self esteem - hence, the emphasis of science learning as preparation for succeeding years.

Teachers Concerns.

Aside from the linkages examined so far which have tended to extrapolate beyond the classroom situation, the evidence that there seemed to be an abiding relationship between the unchanging nature of teacher/student role relationships over the two years of the study and teachers' concerns about the conditions prevailing in the teacher student role set is at least, if not more, significant. As explained earlier, the three concernes cited most often as teachers rationalized ways in which they organized and instructed their classes were: (a) the large number of students enrolled in classes, (b) the limited written and spoken competency of their students in the English their students in the English language and c) the importance attached by the teachers themselves, their colleagues and others in the system (school administrators, Ministry of Education personel and parents) to satisfactory student performance in class-based and school-wide tests.

Large Class Sizes: All except one of the cooperating teachers made reference to the large class sizes. Teachers expressed concern about supervising such a large number of students in laboratory work especially Lower Secondary 1 students who had no prior experience in working in the laboratory. Also, the first question that was raised to the Project Director in the introductory lecture of the inservice course was:

> I teach 42 students, this is too large a class for practical classes. Did you take into account class sizes when planning LSS? [FN IS 01]

Other teachers' concerns about large class sizes focussed on how time consuming it was to correct the work of such a large number of students. In spite of this, according to the experience of the researcher the teachers inservice course did not adequately acknowledge teachers concerns about how to conduct laboratory work with large classes neither did it present strategies to deal with the problem of coping with inexperienced students in the laboratory.

Language Competency of Students. Of the three main teacher expressed concerns cited earlier in the chapter, concern about the language competency of the students featured most strongly. This was particularly true of teachers of the 'normal' streams and it was expressed consistantly throughout the two years both in informal communications with teachers and in comments written in teacher questionaires given to a shadow group of teachers (28):

> My students are taught in English but discussion among themselves are conducted in Mandarin or dialects. (Scientific terms have to be translated and this is not always possible.) They have problems in understanding descriptions in the textbook. [TQ 6]

Another teacher identified student limitations in their command of the English language as a barrier to class discussions and as a problem in students understanding and carrying out instructions:

> Students must be proficient in the language before discussions of any nature can take place'. [TQ 1].

> Very often pupils are not able to follow the instructions given by teachers if these instructions are not painstakingly repeated over several times.[TQ 1].

Teachers' concerns about students' language competency was legitimized repeatedly by the researchers' observations throughout the study. Students had difficulty not only in comprehending but also with pronouncing common English words, not to mention specialized scientific words that were introduced to them for the first time. Student embarrassment about their own and their amused embarrassment of others' difficulties in pronouncing words was a frequent occurrence in classes in which the teacher attempted to draw students into the classroom discussion.

On this theme, another question raised at the teacher inservice course concerned student's language difficulties. One course participant asked: "The problem of normal stream students writing up experiments - Can you suggest a solution?". Various solutions were offered by the instructors but none of the suggestions removed the reality of the plight of these students and their teachers as witnessed first-hand by the researcher. One attempt was, however, made to address the problem of teaching students whose first language is not English in the form of a journal article which was photocopied from an American professional journal (29) and distributed to teachers. However, no discussion ensued from teachers' reactions to the article, neither were specific concerns of teachers on the language competency of their students pursued by the group. (This does not, of course, preclude the possibility that teachers may have taken up the matter on an individual basis with one or more of the inservice instructors.)

Tests and Examinations. The theme of examinations came up in many of the researchers informal conversations with teachers. Some teachers expressed concern about 'common tests' that were set periodically in all schools for students at the same grade level. It was drawn to the researcher's attention that student results in tests are taken into account in their own professional evaluations. Teachers of low-streamed students felt that they would be at a disadvantage if results were compared from class to class. It was therefore within the teachers' best interests to apply themselves as vigorously as possible to prepare students for such tests. One teacher described the situation in her school in this way:

> 'My principal seems to assess teachers by the number and quality of passes' (TQ2)

Another respondent drew attention to the fact that teachers may adjust instructional strategies to maximize students' performance in examinations at the expense of carrying out laboratory work - thereby undermining one of the major stated goals of the science program at the lower secondary level even before the introduction of the new LSS program:

> The haste to complete the syllabus, the cry to produce instant results - good results in examinations - have all added to the anxiety of teachers and believe it, contagiously transmitted to pupils. Many teachers therefore prefer to forgo experiments for theory. (TQ 1)

Teachers cited upcoming tests and examinations both to the students and to the researcher as a means of justifying the way they conducted their classes. They also used them as a means of provoking students into paying attention in class, doing assigned homework and developing appropriate study habits. As a general rule, this amounted to memorization of the facts presented in class and in the textbook.

The teacher-expressed concerns cited earlier were not addressed in the inservice course and their omission may have been perceived by the teacher participants in a variety of ways. The most damaging perception to the intent of the course, however, is that it may have appeared to teachers that the inservice planners and instructors were unaware of their problems. Regardless of how unfounded these problems may seem to others in the change process (curriculum writers, MOE personel etc.) the fact that the concerns were ignored signalled to teachers that the course instructors were unrealistic in their expectations of the LSS program.

The other side of the coin is, of course, that the inservice planners and instructors were highly aware of teachers' concerns but did not address them for their own reasons. For instance, it was expressed by one key informant that addressing teachers' concerns would have legitimized their reluctance to change their way of teaching. Alternatively, inservice planners held the opinion that it was more productive to design a course that would give teachers confidence in knowledge of new content areas and proficiency in laboratory investigations. The inservice planners considered these two areas as the first crucial steps to successful implementation of the program.

Summary

This section of the chapter sought to discover whether degree and kinds of changes in teacher/student role and role relationships exhibited by the cooperating teachers with regard to teacher/student role and role relationships could be linked with particular parameters of the research setting. The research findings revealed that although role change was intrinsic to faithful implementation of the new program, evidence of consistent, appreciable change in the five cooperating teachers in this study was non-existent. It was suggested that lack of role change could be linked with a number and variety of parameters in the research setting.

Teacher self-report and observations of ways in which teachers communicated with students suggested that their role enactments were linked with understandings of sources and expressions of authority both in their classrooms and the educational system as a whole. In the classroom, the authority resided in what was predetermined as a set of verifiable facts documented in the textbook. The pursuit of this authority lay in the reiteration of 'right answers'. At the school level, the tests for which teachers prepared their students became an authority to which teachers subjected themselves and their students for the sake of their peer (teacher) approval and professional esteem brought about when their students scored well in tests and appeared adequately prepared for the next level of schooling. Beginning at the Ministry level and permeating the system, the syllabus looms large as an authority, not just for the existing year but for successive years when students would be preparing more directly for the Cambridge examinations. In the society at large, prescribed societal norms relating to teacher/student role relationships may also be a part of the complex web of authority structures which influence what was occurring in classrooms of the cooperating teachers .

As far as preparing teachers to teach the new LSS program, it was asserted that the teacher inservice course did little to address teachers' concerns about their work and yet it was through these concerns that the five cooperating teachers rationalized their role enactments. It was also noted that role change was not emphasized in the teacher inservice program and that the program materials themselves were not completely consistent with an inquiry approach - thus providing the teacher with mixed messages about the intent of the program.

Finally it was recognised that faithful implementation of the new LSS program implied a far more expansive notion of change; change that necessitated extrapolation beyond the classrooms and schools of the cooperating teachers. It was asserted, for instance, that teacher role change of the type implied in the faithful implementation of the new LSS program, challenged acceptable norms of teacher/student relationships that prevail in the broader cultural milieu of Singapore life.

CHAPTER V

REVIEW, INTERPRETATIONS AND IMPLICATIONS OF THE RESEARCH FINDINGS

Introduction

The intention of the study was to discover whether the introduction of a purportedly inquiry/discovery based science curriculum into the Singapore school system resulted in changes in teacher/student roles and role relationships during the year immediately following implementation of the program. Furthermore, the study investigated parameters of the research setting and of the impleentation process that appeared to be linked with the kinds and extent of changes that were observed.

The research problem was addressed from a phenomenological, ideographic perspective. Role behaviors of five cooperating teachers were documented over a two year period - two sets of observations were carried out during the year prior to implementation and two sets during the year following implementation of the new program. A holistic portrayal of the role and role relationships of the five cooperating teachers was attempted by comparing data collected prior to and following implementation of the new program. A detailed analysis of the program materials, an in-depth study of the teacher inservice program and interviews with key informants (Ministry of Education officals, inservice trainers and members of the curriculum writing team) provided additional data sources.

At the outset of the study, it was proposed that a curriculum change of the type intrinsic to the introduction of the new inquiry-based, guided discovery Lower Secondary Science program would be differently felt and realized at the individual, school and education system levels. In this regard, it was asserted that the role set that would have the most intense and enduring effect on the role behaviors of the teachers concerned would be that in which the teacher has the greatest vested interest: namely the teacher/student role set. It was also asserted that the introduction a science curriculum in which teachers were expected to assume more open and discursive role behaviors would result in role conflicts for the teachers concerned and that unless these role conflicts were resolved, teachers would be unable to implement the curriculum in accordance with the intentions of the curriculum developers.

The Research Findings - A Synopsis

The research findings presented in the various sections of chapter four have strongly suggested that the role enactments of the cooperating teachers in this study did not change appreciably from the preimplementation to the post-implementation phase of the study. Teachers persisted in exhibiting behaviors suggesting that they viewed themselves as disseminators of information and controllers of all student activity in the classroom - in contrast to acting as the kind of 'facilitators' of student learning advocated by the curriculum writers of the Lower Secondary Science program (Cheah et al., 1982).

Similarly, students continued to reciprocate teacher roles by being passive listeners, reticent to participate in classroom discussion and dependent on the teacher for information and direction.

With regard to science knowledge, the textbook and the teacher continued to be the recognised sources of authority in the classroom. All class activity, including experimental work, was directed towards obtaining 'right answers' which concurred with principles presented in the textbook. Teachers introduced experimental work as if the outcomes were predetermined and they both explicitly and implicitly communicated to students that the purpose of laboratory work was to engage in confirmatory experiences, even when the 'answers' to workbook questions were contrary to empirical evidence obtained from students' experimental work.

Within this frame of reference, teacher role enactments became those of transcribing the curriculum for their students, breaking it down into discrete, managable sets of statements which encapsulated the major principles or factual content outlined in the syllabus. Teacher role enactment, then, necessitated ensuring that students made neat, accurate records of these sets of statements which amounted, in effect, to annotated transcriptions of the curriculum. The experimental work carried out by students served the purpose of providing illustrations or examples of the major principles expounded in the textbook.

Given this proposition, student role prescriptions became those in which they were obliged to keep records which conformed to teacher expectations and were identical to those of their peers. In effect, the records became annotated reference sources for use in preparing for tests and examinations. As will be explained later, both teachers and students had a vested interest in making sure that these records were neat, accurate and well organized.

Sources and Expressions of Authority

Teacher self report and observations of ways in which teachers interacted with students suggested a linkage between the unchanging nature of classroom activity and teachers' understanding about sources and expressions of authority within and outside their classes. These sources of authority influenced the ways in which the cooperating teachers conceived of science as a discipline as well as the ways in which they enacted their roles as science teachers.

As mentioned earlier, factual information presented in the textbook and the teachers' self-professed knowledge were the established authorities under which knowledge transactions took place in the classroom. By the same token, acquisition of knowledge occurred within the confines of a knowledge base dictated by a higher authority: namely the syllabus issued by the Ministry of Education. Science learning, as viewed by the cooperating teachers, appeared to be an obligation on the part of students to memorize the body of knowledge prescribed in the syllabus. Teachers appeared to view their role as gatekeepers of this knowledge and as a vehicle for imparting it to students. Examinations and tests were justified as a natural and necessary consequence of the knowledge transactions at the classroom level. Intermittent examinations became an authority source used by the teacher to justify their mode of interaction with students. To this end, students were prevailed upon to pay attention in class, keep up with assignments and 'learn' their work.

Within their own peer group or role set, and for the sake of their professional performance evaluation, teachers felt pressure to demonstrate that their students were able to memorize and reiterate science concepts by performing well in class-based and school-wide examinations. Teachers' attention to record keeping was a reflection of their role in facilitating the 'learnability' of the syllabus with the objective of optimizing favorable test scores on the part of their students.

Teachers' Concerns

Much of the teachers' concerns about difficulties encountered in their work revolved around students' inability to express themselves and to write coherent English. This constraint reinforced teachers' authoritative behaviors due to their belief that they could not entrust students with responsibility for their own record keeping. Moreover, students' difficulties in understanding verbal directions given in class compounded teachers' tendencies to exhibit highly directive behaviors. Teachers' concerns about the effect of large class sizes on their instructional practice, justifiably or not, rationalized their hesitancy in undertaking complicated management procedures and in tolerating increased ambiguity involved in inquiry-based/guided-discovery teaching.

Channels of Communication

The research findings also suggest that lack of evidence of teacher change during the second year of the study may, to a certain extent, have been linked with unclear channels of communication which existed within change agent/teacher role set during the implementation process. Channels of communication, which comprised both the inservice experience designed to prepare teachers to teach the program and the curriculum materials themselves, communicated ambiguously to teachers about the goals and ideology of the program. It therefore seemed evident that teachers did not internalize the implications of the program to the extent that they were aware of the necessity to change their roles. Hence, far from being 'defenders of curriculum traditions' (Romberg and Price, 1983) it appeared that the teachers in this study had neither the opportunity to observe and reflect upon, nor the opportunity to assume and practice the kinds of roles implied in the introduction of an inquiry-based, guided-discovery science program.

Social Values Pertaining to Teacher/Student Role Relationships.

The research findings discussed so far suggest linkages between the lack of evidence of teacher change, teachers concerns about their work and the prevailing sources of authority that seemed to govern instructional practices of the teachers concerned. These factors and others referred to extensively in chapter four (reward systems, teacher interactional style, peer interaction etc.) have portrayed a classroom culture in which teacher/student roles and role relationships are clearly defined, mutually exclusive and mutually reinforcing.

These factors alone suggest that without considerable forethought and effort, change of the nature anticipated in the introduction of an inquiry science program would have very little chance of taking root. But, even so, there exists an underlying question concerning the broader cultural context of the study viz: the appropriateness of an inquiry-based, guided-discovery program both in Singapore's meritocratic education system and in its sociocultural milieu. For, as Sarason (1978) has suggested, in every culture, or indeed every subculture, there are certain norms of teacher/student role relationships that are enduring regardless of educational policy.

In line with this premise, a case was made earlier in this paper for attempting to define a 'Singapore culture' and mention was made of the part to be played by the educational system in this endeavor. Statements made by Prime Minister Lee Kuan Yew in February 1979 concerning the role of the education system in providing the young Singaporean with the 'software of his culture' were brought forward as evidence of the extent to which the Singapore government holds the education system accountable for the enculturation of school-age Singaporeans.

Six years later, after the implementation of the New Education System and its ensuing curriculum innovations (of which the new Lower Secondary Science program is just one) it would appear that Mr. Lee may have rethought some of his assertions about the desirability and feasibility of attempting to combine 'sceptical Western methods of scientific inquiry' with the 'traditional values' which jointly constitute the sociocultural fabric of Singapore life. In a pre-election press conference granted to five foreign correspondents in October 1984, Mr. Lee was asked :

> "Singapore's great ecomomic achievements have won great acclaim abroad. One of the criticisms I have heard most often made of Singapore of the education system, and perhaps more widely, the media or the cultural environment is that in some sense it does not put enough emphasis on independent critical thought, that the government errs, if you like, in favor of control.
>
> Looking ahead to the future as you've been doing, is that your intention for the future as well, and do you feel that it creates the best climate in which future leaders, your successors, can cope with the unexpected?" (Straits Times 18/10/84)

To which the Prime Minister responded:

> "First let me divide your statement because I think they are two different things, one that our education sytem does not allow more independent thinking, more creativity and therefore, more scientists more discoverers of the great undiscovered frontiers of knowledge and science.
>
> I do not think that is just a question of the system of education. I think it has to do with culture or with norms, standard behavior of students and teachers .
>
> The Japanese face the same criticism and they want more creative innovators. They are saddled with the same criticism that they lack this questioning this debate, this ruthless pursuit of truth even at the expense of dignity of one's teachers.
>
> I think that we are all products of our own culture. And Oriental cultures require pupils to be polite not obstreperous. I mean if you know so much you should not be in the class, you should be running your own class.
>
> At the same, time because we have had so many foreign teachers in our schools, definitely in our universities and many of our teachers themselves having been educated abroad, there is more give and take than say a typically Chinese language school in the 1950's or 1960's.
>
> But I am reconciled to accepting a more polite classroom situation. I think that is part of the Oriental culture and we can't change that." (The Straits Times 18/10/84)

Clearly, Mr. Lee's most recent perceptions of teacher/student relationships reflected in the statement above differ considerably from the ideals he expounded in January 1979. From his most recent statement it would appear that he now seems to be resigned to the fact that the Singaporean identity cannot, within the next several generations at least, incorporate values that are entirely alien to its constituent Oriental cultures - neither does he seem to think that such changes would be desirable.

But even more pertinent is that, in his statement, Prime Minister Lee has revealed attitudes that uncover a core of beliefs about teacher/student relationships in the Singapore context: that questioning and challenging behaviors by students are undesirable attributes of a classroom environment. Lee associates them, for instance, with obstreperousness, with ruthlessness and with impoliteness. Furthermore, he links them with a status quo that might jeopardize teacher dignity - which is both culturally and historically a highly valued Asian trait. This association appears to be not only Lee's personal viewpoint. It became increasingly apparent as the study progressed that such beliefs are pervasively and integrally embedded in the broader sociocultural fabric of Singapore life of which, it has been argued in this research, the classroom is a cultural microcosm.

Mr Lee's statements are of utmost importance to this study because they bring clearly into focus the paradox that has emerged as the nexus of the study. Namely, that although there is a clearly identified need to improve science teaching in Singapore and that the new Lower Secondary Science project was one means of pursuing this goal at the lower secondary level, the purported ideology of the program appears to be in conflict with pervading societal norms concerning teacher/student relationships.

At the classroom level, the teacher acts as a role incumbent in the teacher/student role set, and in so doing exhibits behaviors which have not only been influenced by his or her pedagogical training, but also by the application of this pedagogy within the Singapore context. Similarly, students exhibit behaviors which are reinforced through their peer groups and through their homes as appropriate to the classroom role set. For, as Hall (1977) claims:

> ... no matter how hard man tries it is impossible for him to divest himself of his own culture, for it has penetrated to the roots of his nervous system and determines how he perceives the world. Most of culture lies hidden and is outside voluntary control, making up the warp and weft of human existance. Even when small fragments of culture are elevated to awareness, they are difficult to change, not only because they are so personally experienced but because people cannot interact at all in any meaningful way except through the medium of culture. (Hall 1977, pp. 188-189).

It would seem that the very nature of the new Lower Secondary Science program in so far as it required new types of reciprocal teacher/student role relationships in the classroom setting, may appear not only impractical but also incompatible with teachers' understandings of their role as science teachers. Teacher/student roles pre-empted in an inquiry approach to science teaching, for instance, require of teachers that they assume a stance of the 'unknowing' in their mutual pursuit with their students in solving problems and testing hypotheses (Atkinson & Delamont, 1977). It requires that teachers will pose questions rather than provide answers and, more importantly, that instruction will be student focussed rather than teacher directed. Clearly, this mode of instruction is incongruous with established teacher role behaviors characterized in Phase I of this study. Other role behaviors axiomatic to inquiry teaching tend to increase ambiguity and disperse authority and control within the classroom. This ambiguity would, in turn, impose increased autonomy on the teacher and, at the same time, dislocate the authority systems in which the teachers role perceptions are apparently embodied.

Given teachers' perceptions of the sources and expressions of authority explained earlier, it appeared that the purported ideology of the new program was, in a broader sense, incongruous with the modus operandi of the highly centralized educational system where the lines of authority to which the teacher is subject are clearly defined and unidirectional. Attempts to bring about change under such circumstances would disrupt established networks of mutually reinforcing student/teacher and teacher/system relationships.

But any claim made here that there is a direct and exclusive link between failure on the part of the teachers in this study to assume role behaviors consistent with inquiry-based teaching and the socio-cultural milieu of Singapore is made with reservation. Such a claim is confounded by the fact that the LSS program is ideologically similar to programs which have experienced little success even in countries in which teacher/student role relationships are characteristically more open and discursive. What can be said for the case of Singapore, however, is that the task of changing teacher/student role and role relationships in line with those advocated by the curriculum developers of the LSS program is exacerbated by the cultural context. Hence, without attending very carefully to the issue of role and role relationships in the implementation process, it would be predictably difficult and probably a very slow process to implement such a program with visible success.

The Implementation Process in Retrospect

Having discussed parameters of the user system and the difficulties of implementing the Lower Secondary Science program in such a system, let us now examine the processes of curriculum implementation and diffusion as they apply to the change effort that was researched. First of all, in spite of all of the current literature avaliable on alternative models of curriculum implementation and diffusion, there appeared to be no clearly defined model used in the implementation of the new LSS program. The implementation strategies used merely involved pilot testing the materials, modifying them and distributing the final version to schools.

Notwithstanding the time constraints imposed on the LSS curriculum writing team, members of the team accepted some responsibility for monitoring the use of the trial materials in the pilot schools; but this was done in a very loose and informal manner. There appeared to be no systematic evaluation procedure for the actual use of the trial material in the instructional setting. Monitoring from the standpoint of the writing team involved soliciting verbal feedback from teachers on the merits of the materials and, according to one informant, the focus of this feedback was most often that of discussing practical problems of the experiments rather than fundamental issues concerning the program.

In the implementation process, little attention was given to the process by which the ideology of the new curriculum could be transfused into the existing framework of the user system and what, if any, systemic changes would need to take place to support the intended change. Furthermore, there appeared to be little attention given to potential barriers to the kinds of knowledge assimilation necessary for implementing the program in light of characteristics of the user system.

Alongside the earlier assertion that there was no clearly defined implementation model is an equally important assertion with respect to the inadequacy of resources with which the change agents prepared teachers to teach the program. From the evidence available to the researcher, there was clearly a large investment in the development of curriculum materials compared to a correspondingly small investment in providing inservice experiences to prepare teachers to teach it.

Due to limited time, the inservice program concentrated on cognitive attributes of the LSS program rather than on the processes of science. As far as inservice trainers were concerned, the program relied heavily on volunteer instructors who were not, by profession, teacher educators. Moreover, as argued earlier, the attitude of some of these instructors toward the inservice participants was demeaning and thereby detrimental to the possibility of promoting positive teacher attitudes towards the new LSS program. What is perhaps worse, however, the volunteer inservice instructors openly showed value preference for cognitive learning and they neither explained nor modelled exemplary inquiry teaching strategies.

Areas for Further Study

In so far as this research undertook to investigate change in teacher/student role and role relationships from a holistic, ideographic standpoint, there were many questions which could not be addressed through this mode of inquiry but, as an outcome of the research findings, now present themselves as questions which deserve attention.

The most obvious question is, of course, that of the broader impact of the program in educational settings other than the target schools used in this research. The schools used in the research were from the mid-range category as far as school outputs is concerned. The question now emerges as to whether the program is being implemented more successfully with students in more prestigious schools or in higher streams (30) or, in fact, in schools in which students have fewer problems with the English language.

Another major question that emerges concerns whether and how teachers who have become so atuned to the didactic approach to teaching can be brought to a point that they will be ready to change in favor of the types of teaching roles implicit in inquiry teaching. It was argued earlier in this paper that the teachers in this study never consciously confronted the necessity to alter their teaching roles. Questions which emerge with regard to this premise are: what would happen if teachers' awareness was heightened and what would be the comparative effect of intervention techniques such as modelling of inquiry teaching by teacher educators, critiquing of alternative instructional approaches, or action research through videotaping and stimulated recall (31).

But perhaps the most urgent and germane question to ask is simply whether or not an inquiry/guided-discovery program is appropriate to the Singapore educational system or whether, in fact, attempting to implement this type of program is self-defeating from the outset. This question hangs on a broader issue of national priorities as far as the purposes of science education is concerned. Over the past twenty-five years, science education in Singapore has been heavily politicized as critical to the building of a scientifically literate manpower. Science learning at the lower levels of schooling has been commonly viewed as cumulative and preparatory for higher levels. As far as the cooperating teachers in this study are concerned, this attitude was prevalent across teachers and over time. For, even though science curricula at the primary levels have purportedly adopted an inquiry philosophy, curricula at the higher levels are still tied to an external examination system in which memorization and reiteration of principles is valued and rewarded.

The issue of how various individuals at different levels of he education system perceive the purposes of science learning and the relationship between these perceptions and the way teachers act out their roles in classrooms is one that is worth pursuing. The findings of such research have, of course, policy-making implications for science learning at all levels.

Significance of the Study

The present research is unique in three ways: Firstly, it is one of very few studies of curriculum change to incorporate preimplementation and post implementation data. Secondly, it is perhaps the first long term ethnographic case study of curriculum change to be conducted in a developing Asian nation. The study will therefore contribute to the body of case study literature in Singapore and to the literature on science curriculum implementation in general. Thirdly, the study is unique in the sense that, through the data analysis process, it attempts to seek a relationship between components of change theory and role theory through ideographic inquiry. It is anticipated that an in-depth inquiry of this nature, in the context of a specific educational innovation, will inform both educators and role theorists on the extent to which existing teacher role behaviors should be accounted for in implementation strategies.

The study therefore has practical applications in that it can provide new knowledge regarding potential focii of curriculum implementation strategies. The research findings suggest, for instance, that by studying teachers' normative role behaviors both in context and relative to changes expected of them as they implement a new curriculum, inservice experiences and curriculum implementation strategies can be designed prescriptively.

Implications for Practice

As evidenced by the foregoing discussion, the study has raised germane issues relating to the planning and conduct of inservice experiences which imply a greater diversity of teacher educator roles. It has been argued in this report that change agents and teacher educators act counter-productively if they ignore the realities of the user system, particularly as they apply to the teacher/student role set. Similarly, teacher educators who act merely as instructors to communicate the content and methods advocated in new curricula but who do not model teacher behaviors expected of teachers in implementing such curricula have little chance of making any impact on teacher behavior.

Rather, both change agents and teacher educators would benefit from assessing and reacting to information regarding the teacher's immediate and broader environment that influence predominating practices. Likewise, it is important for change agents to become familiar with the extent to which the innovation is consonant with prevalent teacher role perceptions. Similarly, an in-depth analysis of values and practices operant in the user system can begin to provide the kind of information necessary for change agents and teacher educators to become sufficiently familiar with dimensions of the target population. By developing a profile of teacher concerns as advocated in this report teacher educators may then be able to design inservice exper- iences which address these concerns and are directed at arousing teacher readiness for change along the lines of the innovation in question (Gremli, 1983b).

In light of the research findings and the ensuing discussion, it would seem appropriate for change agents and teacher educators to develop and apply skills through which they: (a) work with teachers in a way that will help them develop the kind of inner resources to enable them to accept a greater degree of ambiguity and risk in their classrooms; (b) work within social networks existing in schools to maximize organizational health as well as peer and administrative support; (c) provide counselling relationships which are sensitive to teacher concerns; (d) work as equals with teachers as action researchers, encouraging teachers to critically examine their practice in a non-threatening environment (see Brown and McIntyre, 1981); and (e) charge themselves with the task of becoming sufficiently skillful in provoking and sustaining productive communication among teachers, administrators and change agents.

In conclusion, attending to the dispositions and attributes of teachers within the dynamic and static aspects of the unique sub-cultures in which they operate professionally is an essential component of a curriculum change process. Similarly, the curriculum change process should be mutually regarded by change agents, teacher educators and teachers alike as an opportunity to engage in a professional growth experience with the common goal of meeting what has become one of the greatest and most perpetual challenges to teachers and teacher educators alike: understanding, accepting and implementing change.

FOOTNOTES

1. Refer to Rivlin A., & Timplane, (Eds.) Planned variation in education: Should we give up or try harder? (In press)

2. The term 'dependency paradigm' is used here in the context of the world-system theory which explains the modernization-diffusionist perspective of knowledge transfer from developed to developing countries. Sociologists have argued that knowledge transfer of this nature results amounts to an intellectual dominance/dependency relationship in which the 'center' becomes the producer and the 'periphery' the consumer. Traditionally, knowledge transfer has been in the fields of technology, industry and agriculture. In recent years, in the field of education the knowledge transfer has been in education particularly in the area of curriculum.

3. The South East Asian Ministers Educational Organization (SEAMEO) has pooled its resources and made joint efforts to develop innovative curricula operating through six regional research and development centers situated in member countries. Three of these centers have been concerned with developing programs for elementary and secondary schools: they are: Regional Education Council in Science and Mathematics (RECSAM) in Penang, Malaysia; the Regional English Center (RELC) in Singapore; and The Regional Center for Educational Innovation and Technology (INNOTECH) in the Philippines.

4. Refer to annotated agenda for a Regional Meeting on 'Science for All'. UNESCO Regional Office for Education in Asia and the Pacific, September 1983.

5. ASEAN: The Association of South East Asian Nations, comprising five member nations: Singapore, Malaysia, Thailand, Indonesia and the Philippines was formed on August 8th 1967 to promote, among other things: "active collaboration and mutual assistance on matters of common interest in the economic, social, cultural, technical and administrative spheres" (Soliium 1974 p. 243).

6. Several innovative science curricula have been introduced into the Singapore school system in the past 20 years. The Singapore Primary Science Project was one such innovation. The goal of this project was to achieve an integration of English language, mathematics and science which, as a combined block of instructional time, occupied 43% of the total instructional time.

7. Use of the term 'Third World' countries here corresponds to that used by Walters (1981, p. 95) which is cited in the bibliography. Most recently, however, Singapore has been ranked among what is called the NIC'S or Newly Industrialized Countries.

8. One notable exception was the 'two child family' which was promoted by the Singapore Government through the Family Planning

Board. A small family with only two children ('boys or girls') is a significant cultural departure from the traditional Asian value of cherishing large families.

9. There are three major Asian constituent cultures in Singapore namely: Chinese, Malay and Indian comprising approximately 76.7% 14.7% and 6.4% of the population respectively. The remaining 2.2% of the population is described as coming from 'other backgrounds'.

10. Two examples of these incentives: (a) children whose parents were sterilized after the second child become entitled to priority enrollment in the school of their choice; (b) married couples applying for a government Housing Development Board apartment as an extended family (with one or more parent who would live with their children in a three generation household) were assured priority resulting in a much shorter wait in their new home.

11. Fred Erickson has identified the following alternative terms used for ethnography: "naturalistic description", "field work" or "field studies", "phenomenonological enquiry", "symbolic interactionist", "ethological", "microethnographic" (Smith and Geoffrey (1968) "constructivist studies", (Magoon 1977) and "constitutive ethnography" (Quoted from a paper delivered at the annual general meeting of the American Educational Research Association, Toronto, Ontario, Canada, March 29th 1978)

12. The proposal that the teacher/student role set has the most enduring impact on the teacher was made because teachers have the greatest vested interest and spend the majority of their time interacting in this role set. Also, the teachers' success (particularly in the Singapore system) tends to be measured by the success of students in class and school examinations.

13. To try to obtain an objective picture of events in science classrooms the researcher chose to undertake two sets of observations for each teacher making a total of ten in all for the duration of Phase I of the study. These were conducted during January to March (which is close to the beginning of the school year) and September to November (which is close to the end of the school year).

14. A teacher questionaire was administered during Phase I of the study to a 'shadow group' of teachers who were colleagues of the cooperating teachers. The cooperating teachers were excluded because it was felt that if they read the content of the questionaire they may become sensitized to the purpose of the research and they would no longer be suitable as cooperating teachers. The questionaire was administered by the Senior Science Teacher in each school. A sample of the questionaire can be found in Appendix F.

15. The Cambridge Examination Syndicate administers the basic recognised qualification in Singapore, ie: the General Certificate of

of Education, Advanced or 'A' level and Ordinary or 'O' level. These examinations are sat by students who continue their education to the fourth, fifth, and sixth years of secondary school. The 'O'level serves as a screening process to select students who will continue to pre university level. The 'A' level exam selects students for tertiary institutions.

16 Use of the word 'over' in 'twenty over' is a colloquial expression - it can refer to any number over twenty up to twenty nine!

17. Students who are streamed into the extended stream in the Primary School take eight years to complete their Primary School education.

18. Situational frames are high context units of cultural analysis defined by E. Hall (Beyond Culture, 1977) as ways of breaking down cultural activity into understandable units: 'The situational frame is the smallest viable unit of a culture that can be analyzed, taught, transmitted or handed down as a complete entity'.

19. See: Etic and emic standpoints for the description of behavior. In Pike K. (Ed.). Language in relation to a unified theory of human behavior. (publisher?

20. Two sets of observations were undertaken at approximately the same time of the year and, where possible, parallel or similar topics were chosen.

21. Personal communication: Yeoh Oon Chye, then Deputy Director of the Curriculum Development Institute of Singapore, February, 1982.

22. Reports of the LSS package were featured in The Straits Times on June 2nd. 1982, in The New Nation on June 4th 1982, and in The Sunday Times on December 26th 1982.

23. The fact that the practical sessions in energy were run differently from the other sessions made have had something to do with influence exerted unwittingly by the researcher. Wishing to reciprocate the cooperation shown by the members of the LSS writing team, the researcher shared an instructional unit design on energy relationships with the curriculum writer responsible for the physics section of the curriculum. The format used in the inservice course corresponded to the format used to introduce learners to energy concepts in the design.

24. Since it was not possible to carefully match sessions in which the same topic was taught in the two phases of the study (for one thing, the topics changed somewhat with the introduction of the new curriculum) topics that were as close as possible were selected. Also, recognising that teacher behaviors may change somewhat over the course of the year as he/she became more familiar with the class, the times of the year in which the observations were conducted were matched as closely as possible.

25. The term 'collective temperament' is used here to describe the general disposition of a class as a unit and it is mentioned because, as explained in the test of the research, it was observed to have an effect on teacher behavior. Attributes which seemed to contribute to the collective temperament of the class included general restlessness and talkativeness, tendency to engage in tasks in an immediate and cooperative manner and to remain on task with a moderate amount of teacher control.

26. Use of 'discrepant events' is an instructional strategy used to engage students in problem solving experiences involving scientific concepts. Students are shown a demonstration of some sort that will be discrepant with their existing understandings of natural phenomena. As a result of wanting to seek an explanation to the event, the teacher will guide a group of students to give an explanation. A dramatic episode would have the same effect except that instead of being shown a demonstration, students are presented with a written scenario.

27. The one exception to this observation was a teacher/instructor who is a practicing lower secondary science teacher. This teacher has a educational background different from the norm for lower secondary science school teachers. He holds a B.Sc. in physics from the former Chinese medium university. This individual happens to be such an outstanding, highly motivated teacher that he recently won a scholarship to continue his studies overseas.

28. Op. cit. Note 14.

29. The article was: Gonzales, P.C. (1981) Teaching Science to ESL students, extracted from: <u>The Science Teacher</u>, <u>48</u>(1) 19-21.

30. By the time students reach the lower secondary level they have already been subjected to two streaming exercises. They are streamed according to perfomance in nationally based examinations at the end of the third and sixth years of Primary School. This means that there is a considerable difference in academic level of students in the various levels of streaming. This has had an effect on the implementation of curricula.

31. Stimulated recall is a procedure used to enable teachers to reflect upon and evaluate various aspects of their practice. The procedure involves teachers listening or watching audio or video tape replays of their teaching. The teacher will stop the tape at certain points in the lesson and recall their thought processes at those key points. For more details on this procedure refer to Kagan, N., et al. (1967) <u>Studies in human interaction: interpersonal process recall by videotape</u>. Occasional Paper. Michigan State University. East Lansing, Mi.

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APPENDIX A

APPENDICES

TARGET CLASS - ss/83

PARENT'S OCCUPATION
(According to the class register)*

1. Housewife
2. Hawker
3. Temple medium
4. Housewife
5. Labourer
6. Housewife
7. Labourer
8. Technician
9. Clerk
10. Taxi Driver
11. Unemployed
12. Housewife
13. Unemployed
14. Taxi driver
15. Unemployed
16. Housewife
17. Unemployed
18. Bus attendant
19. Housewife
20. Laundryman
21. Hawker
22. Icecream seller
23. Labourer
24. Shoemaker
25. Abattoire worker
26. Shopkeeper
27. Factory manager
28. Baker
29. Lorry driver
30. Businessman
31. Housewife
32. Housewife
33. Housewife
34. Fisherman
35. Doctor
36. Private investigator
37. Labourer
38. Electrician
39. Businessman

* Note: The occupation denoted here is that of the parent that registered the child in school. Hence: if 'housewife' is listed, the female parent registered the child. In this case, the occupation of the male parent (which may give the most accurate picture of the socioeconomic group of the family) was unavailable.

APPENDIX B

Teacher Code :		T/yq	T/es	T/ud	T/nd	T/ss
PHASE I	IA FEB-APR/83	8hrs. 40min. Measurement	6hrs. 30min. Measurement Density	7hrs. 55min. Measurement	5hrs. 30min. Physical + Chemical Changes	8hrs. 20min. Measurement
	IB AUG-OCT/82	4hrs. 45min. Mass, Volume Density	5hrs. 45min. Light; Reflection Refraction	5hrs. 30min. Physical + Chemical Properties; Mass, Weight + Density	4hrs. 20min. Forces; Atmospheric Pressure	3hrs. 05min. Review for examinations
PHASE II	IIA FEB-APR/83	8hrs. 10min. Measurement	Measurement Weight + Mass	5hrs. 10min. Measurement	2hrs. 20min. Measurement Properties of Matter	4hrs. 0min. Measurement
	IIB AUG-OCT/83	6hrs. 40min. Elements Mixtures + Compounds	8hrs. 0min. The Work Principle Mechanical Advantage	7hrs. 30min. Energy	10hrs. 40min. Energy Electro-magnetic spectrum	Teacher declined to participate further in the study

Figure 2: CHART TO SHOW ACCUMULATED AMOUNT OF TIME AND TOPICS OBSERVED FOR EACH TEACHER IN EACH PHASE OF THE STUDY

APPENDIX C

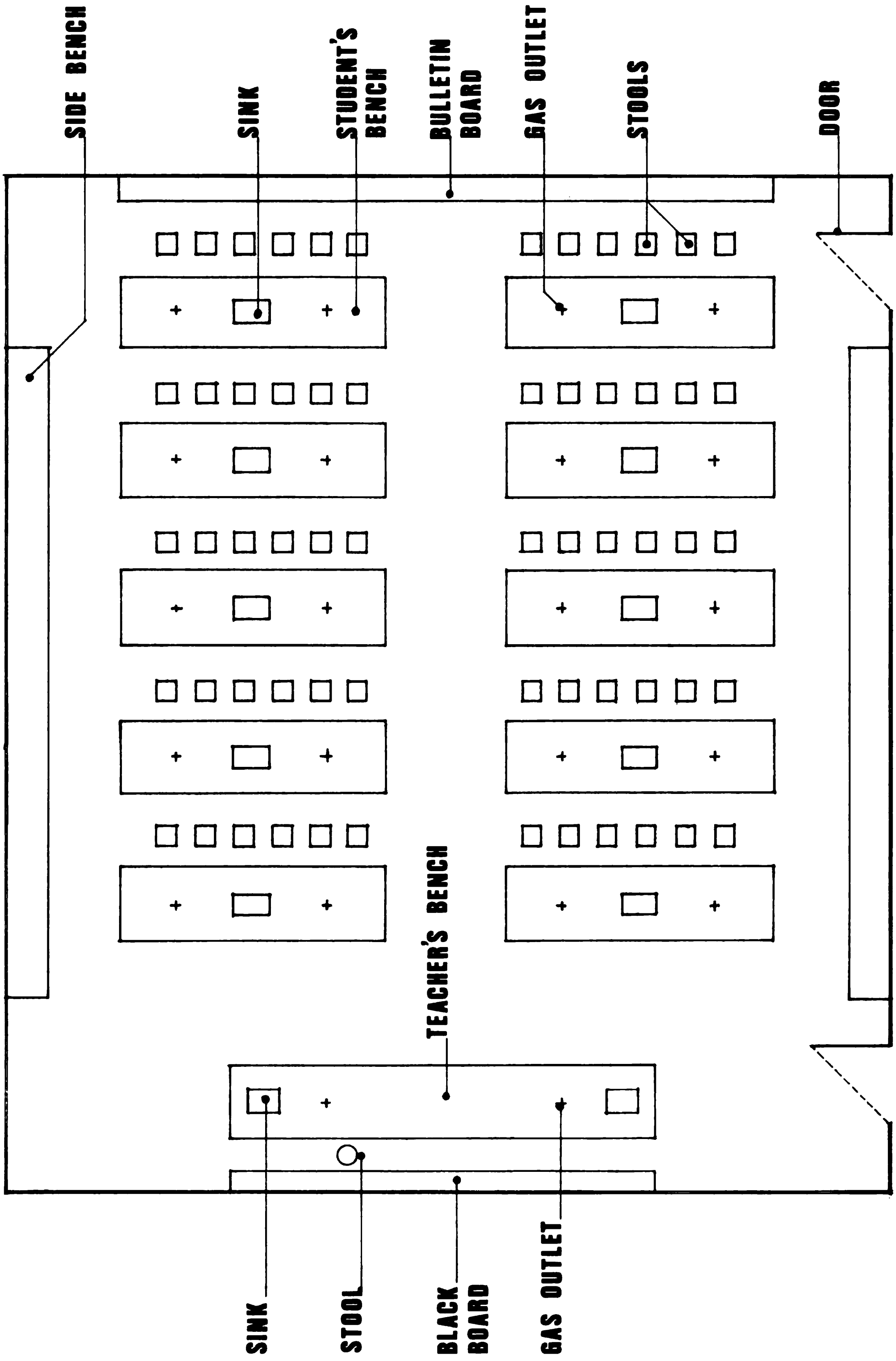


FIGURE 3: DIAGRAM TO SHOW PLAN OF SCIENCE LABORATORIES

APPENDIX D

GENERAL SCIENCE TEST
SEC. ONE.

Name: ____________________ Class: __________

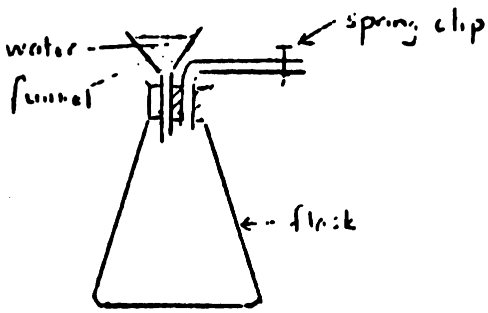
Date: __________

Section A.

Select the most suitable answer indicated in A, B, C, D and write the corresponding letter in the brackets provided.

1. A crucible containing lighted kerosene was floating on water. A gas jar was inverted over the crucible. The mouth of the gas jar was under water. The water in the gas jar rose one-fifth of the way up because
   A. the kerosene cooled the air in the gas jar.
   B. the kerosene combined with the water.
   C. a part of the air had been removed from the gas jar.
   D. the water expanded during the experiment. ( )

Questions 2 - 5 refer to the apparatus below:



2. If the spring clip is closed and the water is poured into the funnel as illustrated above, the water will
   A. not be able to enter the flask.
   B. begin to boil.
   C. shoot up like a fountain.
   D. flow into the flask. ( )

3. The behaviour of the water in Q. 2 is caused by
   A. the shape of the flask.
   B. the air present in the flask.
   C. a vacuum in the flask.
   D. air dissolving in water. ( )

4. If the clip is open, the water will
   A. enter the flask.
   B. turn to ice.
   C. break the funnel.
   D. remain in the funnel. ( )

5. All the above observations show that
   A. air has weight.
   B. the flask is heavier than air.
   C. air is a light substance.
   D. air occupies space. ( )

6. The second lightest element is
   A. carbon dioxide.
   B. argon
   C. helium.
   D. hydrogen. ( )

7. Argon is used for filling
   A. ballons.
   B. electric bulbs.
   C. airships.
   D. fish tanks. ( )

8. The vast ocean of air that surrounds the earth is known as
   A. outer space.
   B. the solar system.
   C. the atmosphere.
   D. an eclipse. ( )

9. A common feature of rusting and burning is that they
   A. give out oxygen.
   B. need oxygen.
   C. lose weight.
   D. need carbon dioxide. ( )

10. Air is regarded as a mixture because
    A. We can breathe in air.
    B. Air may be separated easily into its different parts.
    C. Air may be compressed.
    D. Air may be liquefied. ( )

11. Heat is a form of
    A. force.
    B. energy.
    C. electricity.
    D. mass. ( )

12. Geothermal energy is actually
    A. heat from the decay of living matter.
    B. solar energy trapped in the earth's crust.
    C. the heat caused by the mining of coal.
    D. the heat of the earth's interior. ( )

13. Tidal power comes from high and low tides caused by
    A. the earth's rotation.
    B. the moon's attraction.
    C. the sun's energy.
    D. the pull of the earth. ( )

14. Electricity may caused by
    A. letting light fall on a thermocouple.
    B. sunlight shining on an accumulator.
    C. turning a coil of wire near a magnet.
    D. letting a strong magnet lie still within a coil of wire. ( )

15. A turbine may be turned by
    A. passing steam through it.
    B. using magnets to attract it.
    C. letting wind to blow on it.
    D. lowering it into the open sea from a boat. ( )

16. A dynamo works only when
    A. the sun shines on its solar panels.
    B. steam is passed into its coils.
    C. electricity is passed into it to turn it.
    D. its magnets are rotated within its coils of wire. ( )

17. Our greatest natural source of heat energy comes from the
    A. burning of coal gas,
    B. burning of wood.
    C. moon.
    D. sun. ( )

18. A torchlight battery stores
    A. electrical energy.
    B. chemical energy.
    C. light energy.
    D. heat energy. ( )

19. Which one of the following does NOT store chemical energy?
    A. a torchlight cell.
    B. a lamp bulb.
    C. food.
    D. candle wax. ( )

20. Give the energy change that takes place when an electric motor is switched on
    A. kinetic $\longrightarrow$ electrical.
    B. chemical $\longrightarrow$ heat
    C. electrical $\longrightarrow$ kinetic.
    D. potential $\longrightarrow$ kinetic. ( )

Section B.

Fill in each of the following blanks with the correct word.

1. ______________ is thw ability to do work.

2. ______________ tnergy is the eaergy that is stored in a body which is not moving.

3. ______________ energy is the energy of motion.

4. Four common forms of energy are ______________, ______________, ______________ and ______________.

5. ______________ ______________ are the products of animal and plant matter that decayed many millions of years ago.

Total: 18 marks, 2 each

Name the form of energy present in :

ENERGY

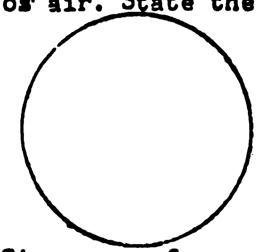
1. a piece of rock placed on the top of a cliff ______________
2. a chicken on the dinner table. ______________
3. an oven bakimg some cakes. ______________
4. an iron when it irons clothes. ______________
5. a stret:hed rubber band. ______________
6. a bullet just shot from a gun. ______________
7. the spring of a wound-up watch. ______________

SectionC

1. Name the 5 rare gases present in air.

____

2. Divide the given circle into sections to show the relative composition of air. State the % present in each case. (10 marks)



3. Give a use for each of the following inert gases: (4marks)

a) Helium: ____

____

b) neon: ____

____

4. a. State 2 prope-ties of air. (3 marks)

b. Descibe an experiment to show that air has weight. (6 marks)

APPENDIX E

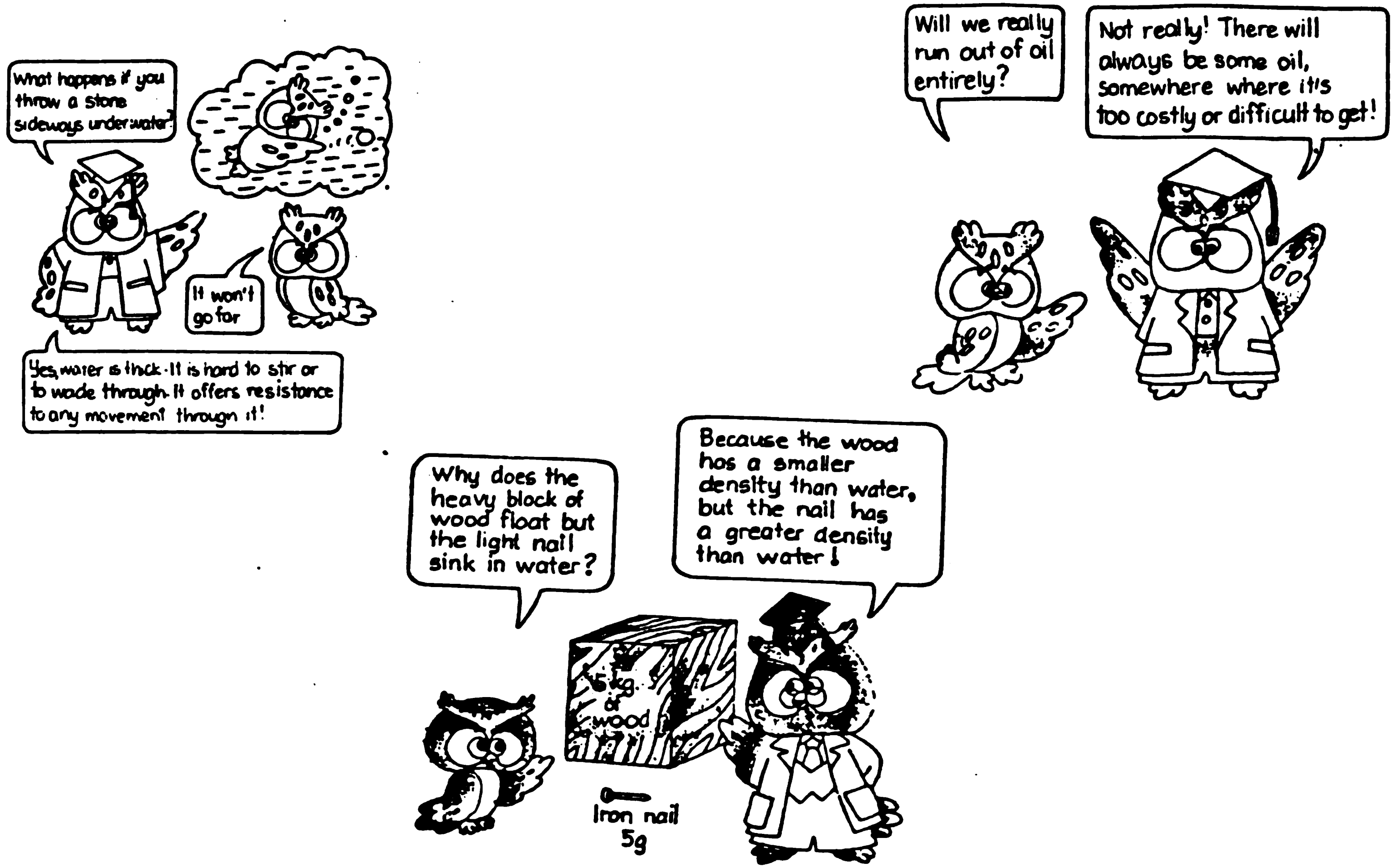


FIGURE 4a: CARTOONS THAT REINFORCE TEACHER-AS-INFORMATION-PROVIDER ROLES.
(Source: Exploring Science, LSS Student Textbook, 1983)

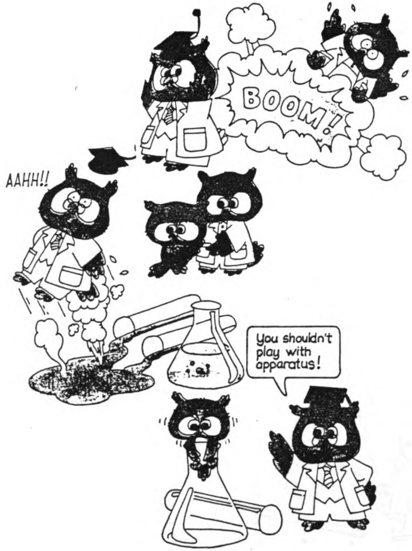


FIGURE 4b: CARTOONS THAT REINFORCE TEACHER-AS-DISCIPLINARIAN ROLES.
(Source: <u>Exploring Science</u>, Student Textbook,1983)

FIGURE 4c: CARTOON THAT MODELS A QUESTIONING TECHNIQUE WHICH IS MORE APPROPRIATE TO INQUIRY TEACHING.
(Source: Exploring Science, LSS Student Textbook, 1983)

APPENDIX F

TEACHER READINESS FOR CHANGE
ASSESSMENT INSTRUMENT

A ACCEPTING TECHNOLOGICAL CHANGE

Please comment on the following opinion:

Among teachers there is a lack of general acceptance of the changes that technology has brought to school instruction.(1) Hand-held calculators are owned by many children but they are seen by most teachers as an inappropriate way to learn arithmetic.(2) Instructional television and computer-aided instruction are seldom considered as a potentially useful addition to the school programme.(3) The largest barrier is cost, but apart from this, members of the teaching profession are generally opposed to technological change.(4)

** Notice that each statement in the paragraph has a number after it. Please refer to the statements as you respond to the following questions.

a) To what extent do you think this statement is accurate?

____

____

____

b) Do you think your opinion would be typical of the views of your colleagues?

____

____

____

c) Do you think your opinion would correspond to that of your school principal?

____

____

____

B ANTICIPATING A NEW PROGRAMME

Please consider this dialogue between two teachers discussing a new program.

1. Mr. 'K' : Well it will be a lot more work in the beginning, but I'm glad we are adopting the new program[1]. It should help us to make science more interesting[2].

2. Miss 'Y' : But is this really a new curriculum or is it the old one with a face lift?[3]. With the new programme a lot of the important topics are cut out and we'll have to spend more time preparing for science experiments[4]. Will we really have time for all that?[5] Besides, with such large class sizes how can we allow students to do the experiments themselves?[6]

3. Mr. 'K' : You're right - we should set our priorities and spend time where it should be spent[7]. Even though the programme has been piloted there's no guarantee that it will work for us[8]. But I'm willing to give it a try as long as they don't expect us to go to too many training sessions and workshops[9].

4. Miss 'Y' : I don't see how we can conduct those class discussions when the students have a language problem[10]. Besides I'm worried about my classes being able to pass the exams at the end of the year[11]. Its no good spending the whole year playing around and at the end of the year the whole class fails their exam[1

5. Mr. 'K' : I agree with you, but we have to start somewhe and I have to admit that my classes find their textbook both difficult and boring[13].

** Notice each statement has a number following it. Please refer to the statement number as you respond to each of the following questions.

(a) **Are any of the opinions expressed above similar to your own?**

(b) **Do you find the concern about trying out a program for the first time to be typical of how most teachers feel?**

(c) **Please comment on any or all of the statements above if you feel strongly about them.**

I would appreciate any additional comments you would like to add. (Please refer to statement number)