SOCIAL AND CULTURAL INFLUENCES ON STUDENTS' RESPONSES TO SCIENCE IN A SOLOMON ISLANDS SECONDARY SCHOOL

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ABSTRACT

In this examination of social and cultural influences on a range of responses to school science in a Solomon Island secondary school, three levels of analysis are used. At one level there is a comparison between students within the school, looking for effects from personal background characteristics. This is the dominant level of analysis of school science achievement, first through statistical correlation, but then through an attempt to understand how the experiences associated with the characteristics found to be significant may exert an effect. Two effective mechanisms are examined: the promotion of a relevant cognitive skill, and the generation of attitudes.

The examination of attitudes also makes use of the second level of analysis: comparison between observations with these Solomon Island students and observations made elsewhere by other workers. This level of analysis also dominates the investigation of the development of selected scientific concepts among the students.

The third level involves a comparison between students in the school concerned and those in other schools in the country. Difficulties with obtaining data from other schools leave this as the least used level of comparison in the thesis.

An examination of the position of science in the students' worldview fits into none of these levels, being largely descriptive, not comparative. The position of science relative to other sources of interpretations of the world is the major concern of this section.

Gender and rural/urban background are found to be the major sources of differences in response between the students. It is suggested that, even where these characteristics can be shown to be associated with cognitive differences, explanations of their effect are most usefully sought in terms of experiences, opportunities and expectations that are social and cultural in origin.

In the area of conceptualisations of physical phenomena, similarities and differences are found between these Solomon Island students and those from other cultures, suggesting that such conceptualisations are determined partly through a common human physiology responding to a common physical world, and partly through the influence of culturally available sources of interpretation.

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Two preliminary notes

1) Verbal or written quotations from students are accredited using a three part code, e.g. 23/F/87

The central letter simply denotes Male or Female. The last two figures give the individual's entry-cohort year, i.e. the year in which he or she entered secondary education, whether this was initially at King George VI School or not. The first two figures are then an identity number within the cohort and gender group thus established.

Quotations from interviews are, whenever possible, given with a date. No date is given for quotations from written material.

2) The abbreviation K G VI is commonly used throughout for King George VI School, the school in which the majority of work for this thesis was carried out.

CHAPTER 1 ORIGINS, INSPIRATIONS AND DIRECTIONS

1.1 Origins

While teaching science to secondary school students in Kenya, a concern arose as to whether the social and cultural backgrounds of the students influenced their notions of the nature and purpose of science, their attitudes towards it and their performance in it. The concern was a practical one since it was felt that if such influences exist there could be implications both for the curriculum and pedagogy.

Circumstances eventually dictated that it was with students in the Solomon Islands rather than in Kenya that such influences were sought. As a science teacher in a Solomon Islands secondary school I was in a position to observe students closely and continuously for a considerable period of time, but my position also imposed severe limitations on the scope of my investigations. Solomon Islands secondary schools are very scattered and transport is difficult, so it was effectively impossible to gain access during term-time to schools other than the one in which I was teaching. This meant, therefore, that this study was very largely restricted to the students in just one secondary school.

Given the small number of secondary schools in the country, it is doubtful whether the term "typical secondary school" has much meaning in Solomon Islands, but the school in which this research was carried out - King George VI School - is certainly not a candidate for that label. A more complete account of the education system, school types, and of King George VI School in particular, appears in later chapters, but four characteristics of the school which are important in distinguishing it from others in the country can be briefly summarised here: it is situated in the only major urban area in the country; it is not under the control of any Church; its students are selected from the very best performers in the highly competitive secondary selection examination; and finally, it is very well resourced in terms of both equipment and staff, particularly in the science department.

It was decided to adopt a "broad brush" approach to the investigation, looking at general issues illustrated by particular instances, rather than concentrating in great detail on a smaller area. There are two basic reasons for this. The first derives from the origins of this research in the practical concerns of a teacher to improve effectiveness of instruction. It was felt that this concern is most usefully addressed through a broad approach than through paying exhaustive attention to a single aspect of science teaching and learning, provided this breadth does not lead to excessive superficiality. The second reason stems from the dearth of any educational research in the Solomon

Islands which might have revealed more specific areas of concern. The investigation was influenced by a belief that any useful piece of research should throw up as least as many questions as it answers, and it was hoped that the work might highlight interesting problems and concerns, both within the Solomon Islands and in a wider context, for future research.

1.2 Some recent trends in science curriculum development

It is useful briefly to review some of the important trends and developments in science education in both the developing and industrialised world in recent years, and to discuss some general issues relating to science, technology and culture. This is being done to give an indication of the framework within which the thesis was both conceived and developed: a theoretical framework and a framework of practical importance to a science teacher. Although the relevance of some of the points being discussed may not be immediately obvious, they are intended as a background against which the thesis should be read, and it is hoped the relevance of the issues will become clear as the thesis develops.

The period from the late 1950s to the early 1970s saw the coincidence of major science curriculum development projects in the United States and United Kingdom with the gaining of independence of many former colonies. Post independence euphoria and general optimism about the prospects for economic development led to great expectations from education in newly independent countries. Human Capital Theory was perhaps the dominant theoretical perspective which encouraged the assigning of causality to correlations between levels of education and economic development, demonstrated, for example, by the study of Harbison and Myers (1964). Science education was granted a particularly important position since it was seen as the key to the provision of the medium and high level scientific and technical manpower so desperately lacking and deemed so necessary for development (UNESCO, 1961; Knamiller, 1984).

Given these high expectations of and demands on science education, it is no surprise that newly-independent developing countries sought to introduce new science curricula, embodying the latest paradigms, that would lead them into their brave new world. With a general absence of indigenous curriculum development expertise and infrastructure, they were obliged to turn to the developed nations - generally the former colonial power - which just happened at the time to be producing a plethora of new science curricula. An era of adoption and adaptation was inevitable (Ingle & Turner, 1981; Lillis & Lowe, 1987). Perhaps in science more than in most other subjects, this process of curricular adaptation was seen to be relatively non-problematic since science was perceived as being culturally neutral, a subject of universal truths:

> "Modification is not drastic in the subject matter of chemistry and physics programs for international use as they consist largely of international constants. Chemical reactions are the same in North America as in Australia and the principle of the lever is the same in India as it is in Italy."
> (W.V. Mayer, quoted in Maddock, 1981: 4)

Further support for the viability of this process came from the dominant "realist" epistemology and philosophy of education of the time, as epitomised by Phenix (1964) and Hirst and Peters (1970). This allocated a central position in the curriculum to knowledge, rather than the knower, with knowledge seen as a reflection of an objective reality (Ingle & Turner, 1981). (This centrality of knowledge is obvious, for example, in the above quotation from Mayer, which makes it clear that it is the subject that is taught, not the child.) Thus science, as one of Hirst's "forms of knowledge", is characterised by distinctive concepts, logical structure, and methods of enquiry and testing of propositions - a "scientific method". These are characteristics of the form itself and as such are universal, not related to any particular social organisation: wherever it is practised the nature of science is the same, determined by its logic and the world external to human existence.

The borrowing of metropolitan science curricular ideas was further made easy by the elitist nature of secondary education in the immediate post-independence era: an elitism left over from colonial times, but convenient to maintain for the present (in practice, anyway, for the post-independence rhetoric was of equality) while the concern of secondary education, particularly in science, was still the training of cadres of modern technicians. In the United Kingdom, at least, science had been a subject for the upper echelons of the educational world, not for the masses (Layton, 1975), and the initial curriculum development projects of that era, such as Nuffield Science, were aimed at the upper ability ranges (Young, 1976).

Early high expectations were soon disappointed as the expected economic take-off did not take place. Human Capital Theory as an explanation of the role of education in development gave way to, or was at least supplemented by, Modernisation Theory as propounded by Inkeles and Smith (1974). This proposed a more widespread intellectual modernisation as a prerequisite for development, and it was easy to see science as the epitome of modern thought, with its emphasis on rationality, exactness, and the critical examination of evidence. Science in schools was now to be seen as an important training in mental skills that must be made available to all secondary school students, not just to those who would go on to scientific careers. Its role in preparing future technical manpower remained, however, and the dual demands on science curricula, which remain a problem to this day, were born: a science for all and a science for the specialist within the same curriculum, for at least part of secondary education (Fensham, 1985; Layton, 1986). Sylvia Ware (1992) has summarised this recent history of science curriculum development as comprising two waves. The first wave was content-based and aimed at specialists, while the second has been concerned with "science for all students" and placed an emphasis on application and social relevance.

Perhaps most significantly, the late 1970s and 1980s were characterised by a deterioration in the economies of many newly independent countries that were the hardest hit by global recession. This was accompanied by an increasing disillusionment in the industrialised world in the scope for rapid development, and an unwillingness to provide vast amounts of aid for educational projects which did not seem to be having the expected effect. Under such pressures there were concerns for the effectiveness of education which ultimately led to the opening up of the "black box" of schooling. Instead of education being analysed in terms of inputs and outputs to and from a featureless black box, it became essential to understand the processes going on that linked those inputs and outputs, the teaching and learning processes within the classroom[1]. In this situation, psychology, sociology and anthropology become important tools - even in the eyes of economists - for the understanding of how the quality of education can be improved. There is still a dearth of studies of the processes taking place at school and classroom level in developing countries, in contrast to the input-output correlation studies which seemed to offer "quick-fix" data, but there does seem to be a movement in that direction.

1.3 Views of the learner of science

Early curriculum development in science was based more on the logic of the subject than on the psychology of the learner, and it was probably the work of Shayer and Adey (1981) more than any other which demonstrated the mismatch between the cognitive demands of these syllabuses and the cognitive development of the target students. Despite growing criticisms and dissident voices, from the USA in particular, the dominant cognitive psychological theory of the time was undoubtedly due to Piaget. His detailed analysis of a child's conceptual development into stages offered an opportunity for an ordering of material in science courses that could be given psychological justification and ought, hence, to offer the greatest possibility of effective transmission (Shayer & Adey, 1981). A rapidly growing body of Piagetian studies in non-European cultures seemed to offer a framework for the rationalisation of syllabus content in all societies, with the results of these studies perhaps rather eagerly interpreted as supporting the essential cultural independence of Piaget's ideas, requiring at most some adjustment of time scales for stage attainment.

At the same time, however, some of the more sensitive investigations were casting doubt on these conclusions. Among these, one of the most interesting - not least because it was one of the earliest - was the study of the Kpelle by Gay and Cole (1967). The subtlety of their study undoubtedly owes a lot to the combination of psychology and anthropology which allowed a more thorough understanding of the culture of the subjects to inform the search for and analysis of their handling of mathematical and scientific concepts. The more culturally aware studies began to establish the importance of the context in which subjects were asked to perform tasks, and the relevance of those tasks to their everyday life. This resonated with criticisms derived from studies in industrialised societies, such as those of Donaldson (1978), and from educators who had seen Piaget's stage theory as too restrictive, perhaps most notably Bruner.

Almost before Piagetian analyses and orderings of curricula had begun to be established, a bid for the centre stage in science educational theory was being made by the "constructivist" school[2]. The basic tenet of this school is that each individual constructs his or her own meanings and models of the world through assessments of everyday interactions with it, so that by the time a child begins to receive formal scientific instruction, he or she has already developed understandings of many physical processes and concepts which may conflict with those accepted by science and taught in the classroom. These variously labelled "alternative conceptions" or "misconceptions"[3] prove very resistant to change, and have considerable influence on the understanding of science developed by the child. As a consequence it is essential for the teacher to be aware of the child's initial notions of the world in order to effect any significant change in them. This constructivism perhaps offers less in the way of a novel psychological theory of learning than a pedagogically useful guide based on other cognitive theories. In this respect, Kelly (1955) and Ausubel (1968) are frequently quoted as the theoretical inspirations, but there are undoubtedly elements strongly reminiscent of Piaget's notions of assimilation and accommodation too (Driver, 1983), and the constructivist investigatory methodology owes a lot to the Piagetian clinical interview for its inspiration (Solomon, 1993).

1.4 The social context of learning

One of the most serious criticisms of both the Piagetian and constructivist approaches to learning is that they both pay too little attention to social and cultural influences on cognition. The child is seen to arrive at his or her own analyses and understandings of the world as if operating in a cultural vacuum, lacking any external sources of interpretation or models. This is not just a simplification, it is a totally incorrect view of the process by which individuals arrive at meanings for the world around them:

> "To treat the world as an indifferent flow of information to be processed by individuals each on his or her own terms is to lose sight of how individuals are formed and how they function."
> (Bruner, 1990: 12)

This weakness has been cogently attacked by Joan Solomon who, while not dismissing the personal element in reflection and construction, points out that "belief in our own ideas is astonishingly hard to form or to maintain without the collaboration of others" (Solomon, 1987: 63). She criticises the constructivists for failing to consider the social explanation for their observation of the robustness of children's misconceptions. Drawing on the sociology of knowledge of Berger and Luckmann (1967) and Schutz and Luckmann (1973) she argues that children's interpretations of nature owe more to their ability to interchange perspectives and meanings with others than to any reliance on rationality. This explains both the empirically observed irrationality of the inconsistent ways in which children apply their ideas, and the persistence of these ideas as they are continually reaffirmed through social exchange. The circumstances under which new experiences are met or new information obtained are also extremely important. School science lessons may be relatively ineffectual in changing children's existing conceptions because these were learned in circumstances which are much more highly charged emotionally than those met in the school classroom or laboratory. If we are to understand how children learn (or fail to learn) science concepts, we must appreciate how the school learning situation compares with the socialisation procedures of the students' out-of-school life which will reach into the classroom situation.

An account of the construction of scientific knowledge by learners in schools which recognises the social nature of the process inevitably has both theoretical and methodological implications for research. Ethnomethodological studies, and other forms drawing on anthropology and sociology, are likely to be seen as more relevant than - or at least as an important supplement to - the psychometric techniques which have dominated. Although the concern remains the conceptual understanding constructed by the individual, that individual must be located in a social framework which influences and ultimately legitimates the constructed meanings. Certain socio-cultural factors have been singled out as potential causal mechanisms for specific phenomena: language, urbanisation, formal educational institutions, literacy, for example. These rarely act in isolation from each other however, so there remains a problem of separating causal factors (Cole & Scribner, 1974).

But to discuss culture and cognition in these terms is to place them in two distinct spheres and look for connections between them, causal links from "culture" to "cognition". Cole and Scribner (*op cit*) have argued against this simplistic model, insisting that the two are intermingled and inter-causative. It is a short step from this position to one which treats cognition itself as an aspect of culture, not merely as some sort of consequence of it. Cognitive style or abilities could be considered as much a part of culture as beliefs are, and we look for mutual support between various aspects of culture, including cognition, in situations where cultural change is slow, or for contradictions and antagonisms between aspects - once again including cognition - in situations of more rapid cultural change[4].

In schools we aim, among other things, to bring about cognitive change and as a consequence we are effecting cultural change, but we are only one of many influences on culture, and our effectiveness will depend on the power of schooling relative to these other agencies and on the degree of harmony or of dissonance between school and other cultural forces. In societies where the majority of the population have had a significant amount of education for two generations or more, the cultural fit of schooling with wider society is likely to be better than it is in countries in which the educated are a minority. (Although there are of course still many conflicts in industrialised, developed societies: see, for example, Willis (1977) for a classic example of this.) Lancy (1983: 195) has argued that Western-style education can be considered to be "supracultural" in the sense that it initiates its recipients, after a sufficient dosage of it, into a "world culture", but the same point could be expressed rather differently by stating that Western-style education carries with it elements of a Western-style culture which has achieved a position of dominance in the world.

1.5 Science and culture, and the culture of science

Adey (1982) has suggested that, in schools, science tends to be seen as <u>the</u> vehicle of cognitive development. Certainly, cognitive development as described by Piaget relies heavily on the mastery of tasks, concepts and processes which play an important role in mathematics and science and, as pointed out earlier, theories of cognitive development have often come to inform the process of curriculum development in science very closely. Lancy (1983: 208) suggests that the scientist using formal, logical principles is the model for Western society of how the thinker-problem-solver should go about his or her business, whereas other societies may have different models. (See also Finnegan & Horton, 1973.) It seems clear, therefore that the learning of science is an induction into a particular form of culture, or an induction into a particular form of an aspect of culture; this may then either be accommodated with other aspects of the learner's culture where there is an unsatisfactory fit, or be kept distinct from these aspects as the learner switches between two cultural modes according to context. The science classroom can be treated as an example of what Angela Little (1991) calls a "cultural arena" and the processes and outcomes understood in terms of the meeting of two cultures. To treat science as culturally neutral or culturally impotent in the sense that it has no impact on the learner's wider culture is a mistake and a misunderstanding of the nature of science.

Wolpert (1992) identifies two basic sources for such misunderstandings, associated with two consequences relevant to this thesis. One source is the failure to distinguish science from technology: the two are often spoken of in the same breath today, but their close association began only in the nineteenth century, and thousands of years of technological development has taken place in societies all over the world without any input from scientific theory. This confusion between the two concepts is partly responsible for the notion put forward by both Malinowski (1948) and Lévi-Strauss (1966) that scientific thought is a characteristic of all societies, even the most primitive.

The second source of misunderstanding is the equation of "common sense" with rudimentary scientific thought, expressed by Thomas Huxley in his well-known remark: "Science is nothing but trained and organised common sense" (quoted in Mackay, 1991: 126)[5]. Wolpert suggests that a formal account of the way in which common-sense knowledge arises is provided by George Kelly's Personal Construct Theory (Kelly, 1955): an interesting suggestion because Kelly's theory is one of the key inspirations for the constructivists (Driver & Oldham, 1986; Sutherland, 1992)[6]. Kelly developed his theory within a framework of "man as scientist" (Kelly, 1958, 1963) and this is reflected in the way constructivists have referred at times to children's ideas about the world as "children's science" (Driver, 1983). Wolpert rejects this labelling of common-sense ideas about the world constructed by children as "science", arguing that the difference between science and common sense knowledge is a qualitative one, and not merely a matter of degree or of refinement of the same processes. Common-sense knowledge is a distillation from experience, but it is not the product of a conscientious, critical and methodical search for knowledge; it may be modified in the light of experience but experiences are not deliberately sought out to put it to the test. Modifications to common-sense knowledge may serve individual psychological and emotional purposes, or purposes to do with maintaining social identity, rather than, for example, extending the applicability of that knowledge.

It is easier to argue that common-sense knowledge is not science than it is to state what science is. The debate on the nature of science is, of course, vast and cannot be entered into here in any detail. What is important for present purposes is that science, as it has become practised, has undergone its most significant developments within European culture of the last five hundred years or so: the Scientific Revolution. This statement is not intended to claim a European monopoly on the history and development of science. Mesopotamia, Egypt, Greece, the Islamic World, India and China all played a part in a five thousand year history, but it must still be accepted that the explosion of science to its present status is a relatively recent development based in European societies. Even Joseph Needham, who did so much to establish the credentials of Chinese science in the West, admitted that it lacked a vital ingredient that appeared uniquely in Europe during the Renaissance and allowed subsequent development to what he termed "modern science" to emphasise the break that occurred with ancient and medieval science:

> "When we say that modern science developed only in Western Europe at the time of Galileo in the late Renaissance, we mean surely that here and then alone there developed the fundamental bases of the structure of the natural sciences as we have them today, namely the application of mathematical hypotheses to Nature, the full understanding and use of the experimental method, the distinction between primary and secondary qualities, the geometrisation of space, and the acceptance of the mechanical model of reality. Hypotheses of primitive or medieval type distinguish themselves quite clearly from those of modern type."
>
> (Needham, 1969, quoted in Graham, 1973: 49. See also Needham, 1981: 63-64)

Einstein picked out two achievements as the basis of what he called Western Science: "the invention of the formal logical system (in Euclidean geometry) by the Greek philosophers, and the discovery of the possibility to find out causal relationship by systematic experiment (Renaissance)" (Mackay, 1991: 80)[7]. It is significant that the two eras identified by Einstein as producing these crucial achievements are two which are commonly suggested as being central to the development of modern European culture as a whole. A third important influence on European culture is Christianity, and various cases have been put for the role of Christianity in fostering the development of science: generally either that it encouraged reasoned discussion and debate, or that it allowed the possibility of the existence of laws controlling nature. This influence of Christianity on science has been a point of disagreement (Wolpert, 1992: 48-51), and certainly there is a long history of conflict between scientific and Christian institutions, but an element of the Judaeo-Christian heritage can perhaps be identified in the form and direction that Western Science has taken: the distinction that the Book of Genesis makes between man and nature, and the Divine granting of dominion by man over nature. Thus the natural world is presented as being there for human beings to control and exploit, and an understanding of the operation of nature gained through science places us in a better position to do so[8].

The aim here has not been to suggest that modern science is a culturally-determined product, but rather that its development and practice have historically occurred within a certain cultural environment. During this process, science and European culture have developed together. When modern science is introduced into a new culture, it carries with it the effects of that development:

> "The civilization that first advances from proto-science to science will have only the problem of adapting to the Scientific Revolution itself; all others must adapt also to the alien civilization from which it reaches them, which is less and less like themselves or any other agrarian civilization, including the Europe of the past."
>
> (Graham, 1973: 69)

The teaching of science is an activity with important cultural consequences. Layton (1986) argues that attempts to reduce the conflict between science and indigenous cultures - to achieve "cultural congruence" - have usually resulted in the "debasing of the currency" by making the science that is taught so context-specific that its status is reduced and those being taught it are disadvantaged. He suggests there are just three possible approaches to the problem:

(1) Teaching an international, decontextualised and abstract science for specialists only, while denying access to the majority;

(2) Developing an increased understanding of indigenous knowledge, not to value it but the better to be able to replace it;

(3) Accepting the culturally impregnated nature of present-day science while drawing on it to construct an alternative form that assimilates indigenous knowledge and reflects local values.

The first of these is increasingly seen as unacceptable while the third may demand faith, imagination and expertise that are rarely found. The second is undoubtedly the commonest approach at present and this thesis, to the extent that it gives pointers for practice, is written within such a framework.

1.6 Science, technology and school science

The point has been made that technology, in its broad sense of the production of usable objects, does not necessarily involve science, but it must also be accepted that in the present-day world the two are very much associated. Modern technology, and developments in older technologies such as agriculture, are all science-based and there are clear demands for the increasing integration of science and technology in schools (Lewin, 1992) as science is recognised as an essential aid to technological development. That there are cultural implications from technology changes is surely beyond dispute; one has only to examine the cultural impact of technological revolutions such as the growth of arable agriculture or the European industrial revolution to see this; or in the developing countries of the twentieth century one might pick out communications technology as an example of technological innovation having profound cultural implications. Despite the scientific base for much modern technology, however, one does not have to be scientifically literate or aware in any sense to be able to use and have one's life changed by much of the technology that has become part of the world. In general one would not expect the cultural impact of scientific literacy to be the same as that of technology. To be educated in science may involve, in part, being aware of the scientific principles which lie behind some technological devices and processes, but even more significantly it involves adopting an attitude to knowledge, a "theory" about the nature and status of knowledge, which may differ very significantly from the cultural norm of one's society. (An extreme example of this contrast between views of knowledge is provided by the study of Nepalese children by Dart and Pradhan (1967) in which they found that the children believed that there was no possibility of the production of new knowledge: all possible knowledge already existed in the minds of wise teachers and the most one could hope for was to learn this from them.) To be educated in science involves adopting a scepticism towards "facts" which demands certain standards of empirical evidence and rigourously logical argument, generally expressed through mathematical symbolism. It involves a curiosity and an endless desire to understand at increasing levels of subtlety, which leads to the framing of hypotheses, and it demands a careful and precise testing of these hypotheses. Perhaps most fundamentally, it involves the rejection of personal authority and tradition as arbiters of truth[9]. These characteristics apply to the treatment of knowledge at the everyday level in few, if any, societies and do not, as a consequence, describe what we generally refer to as common sense knowledge. It is tempting to suggest that Huxley's equation of science with refined common sense is a consequence of the particular intellectual environment in which he was raised. His notion of common sense would probably not correspond to that of society as a whole.

The cultural impact of new technologies is dependent on the nature of the particular technology - and is not a concern here - but what is relevant for the purposes of this thesis is the question of whether exposure to modern technology does render the individual more receptive to science teaching in some way, cognitively or affectively. One could speculate on the form this "sensitisation" to science might take if it does occur: an increased curiosity perhaps, or an increased awareness of possibilities; or perhaps, somewhat more mundanely, an increased awareness of certain scientific principles through exposure to them in a more simplified and apparent form than is provided by the natural world. Whether the effect exists or not, and the form that it takes, are matters for empirical investigation. In a non-industrialised country, there is probably a greater range in the levels of individual exposure to modern technology than elsewhere. One basic division in the population in a country like Solomon Islands, for example, would be between rural and urban dwellers, with the latter generally to be expected to be more familiar with modern mechanical and electrical devices. But gender and socio-economic status may also be important. In the rural areas of Solomon Islands one of the few pieces of machinery commonly met is the outboard motor, but this is exclusively the domain of the men, not the women. In the capital, Honiara, motor vehicles are common, but it may be the economically more advantaged children (or perhaps the children of mechanics), boys and girls, who are more familiar with them at the level of exposure to their mechanical workings, through changing a wheel or through watching or helping with work on the engine. One concern of this thesis, therefore, is to look for evidence of possible effects of exposure to modern technology on students' responses to school science, accepting that sometimes it may only be possible to imply this exposure rather than to describe it explicitly.

1.7 The structure of the thesis

The overall aim of this thesis is to improve the understanding of how the K G VI students' responses to science are influenced by aspects of their social and cultural backgrounds. This includes a search for points of consonance and dissonance between the world of school science and the students' everyday world, an examination of the degree of support provided by everyday experiences for various responses to school science. The terms "social" and "cultural" are deliberately used together, with no attempt to distinguish them or to allocate an exact meaning to either. The everyday experiences of the students in this study are a consequence of both their social and cultural positions, which are themselves inter-related. It could perhaps be argued that what are generally accepted as social descriptors - level of education, urban or rural residence, parental occupation, even gender - are important determinants of the sort of experiences to which individuals are exposed, and that "culture" refers to the framework available for the interpretation of these experiences. In a society such as Solomon Islands, and particularly for these educated young people, however, these "social" categories are themselves important sources of culture in a rapidly changing social end economic environment. This point will be returned to shortly in the discussion of the analysis of responses.

In line with the broad aims for this thesis outlined at the beginning of this chapter, the term "responses to science" is taken to apply to a wide range of outcomes. At the most superficial level, it is taken to mean the students' performance in school science examinations; but beyond this are attitudes to science and the extent to which science penetrates the students' worldview.

There are different levels too not only in the responses themselves but in the process of their analysis. Responses can be compared between students within the sample - those in a single secondary school - attempting to find patterns linking these responses with aspects of the students' backgrounds. At another level, the responses from students in this one school can be compared with those from other schools within Solomon Islands. It has already been pointed out that, in practice, scope for this level of comparison was very limited. Finally, comparisons can be made between observations made with the King George VI School students and those reported from elsewhere in the world. In this case, emphasis is placed on the students' experiential and cultural unity, rather than their differences. Although all three levels of analysis may be used with any "response", the balance between them will vary.

It is inter-student comparisons, within King George VI School, that predominate in the analysis of performance in school science, although limited comparisons with other Solomon Island schools and with general patterns observed in other societies are also made. This is taken as the starting point for the investigation of responses, in chapter 4: a starting point because the school examinations' sampling of scientific knowledge and skills can be taken as an assessment of a superficial competency in the culture of science, without giving any information on the level of cultural penetration.

The student background categories used for analysing performance are gender, home location, rural/urban experience, primary school location and performance, and parental occupation and education. While these may be seen as social or socio-economic categories, they also define a framework which, within the Solomon Island context, does much to establish an individual's cultural identity. There are considerable cultural variations between and within islands in the country, and anthropological accounts of these, where available, were consulted. It must be recognised, however, that anthropologists tend to avoid the sort of "contaminated" cultures to which the students in this study belong[10]. Improved communications, increased mobility and inter-group marriage, and the widespread influences of Christianity and education have done much to reduce cultural differences and the importance of traditional cultural forms (generally referred to by the Pidjin word *kastom* which is then Anglicised to "custom"), at least as far as the educated, younger generations are concerned. Two important homogenising cultural influences relevant to this study are the position of the King George VI School on the edge of the only major town in the country, and the fact that the school is a boarding school, so that the majority of the students live together for more than three quarters of each year. The very diversity of cultures within the country would tend to make some generalisations at least advisable for the purposes of analysing responses, but for these students, generalisations are clearly defensible. Gender, urban or rural residence, and parental status are social characteristics around which generalised cultural patterns can be built, and an understanding of these patterns was developed through observations and interviews rather than relying too heavily on anthropological reports.

Having identified some of the factors which are linked with achievement, the task is to go below this surface performance to look for mechanisms through which these factors may work. Two possible types of mechanism are investigated: a cognitive and an affective. A detailed investigation of cognitive functioning is beyond the scope of this thesis but, in chapter 5, one aspect of cognition - spatio-mechanical reasoning - is examined for possible influences on performance in science. The aim is to decide whether such reasoning could play a part in determining science achievement and could account for the variations observed. The chapter then aims to understand how experiences associated with the variables seen to correlate with performance might lead to differential cognitive development in this spatio-mechanical field.

The two chapters following that examine affective responses to school science and to science in general. These are treated as responses which are valuable in themselves and could form teaching objectives in a science course, but they are also examined to see whether they too could be determinants of performance. The primary emphasis in analysis here is inter-student, and so attitudes to science are compared among students, using the same sort of categorisations of student background that are used with performance (although some comparisons beyond King George VI School are also made). Once again, there is an attempt to understand how attitudes arise within each of the socio-cultural divisions of the analysis.

One of the influences that the recent constructivists have had on approaches to learning in science is to shift attention away from notions of underlying cognitive structures or functions and on to an examination of the actual interpretations that children come to hold of scientific ideas. Chapters 8 and 9 reveal this influence by presenting analyses of the development of the students' understanding of three concepts: animals, burning and vision. The aim remains one of looking for possible socio-cultural influences on the formation of concepts, but the emphasis in the level of analysis here shifts more towards a comparison with findings from other cultures. Although divisions such as gender are recognised and used in the analysis, the main concern is to treat the students as representatives of a generalised, Solomon Island culture, distinguishable in some way from other cultures. Clearly this will allow only very broad cultural statements to be made.

During an interview, one of the most competent of students in King George VI School admitted that although she understood certain ideas that she had met in school science, she did not actually "believe" them. Here was a student who achieved very highly in science, and declared that she enjoyed the subject, indicating that her competence and enthusiasm could not necessarily be interpreted as an acceptance of the epistemological validity of science. In her particular case, it was a clash between science and her religious beliefs which had led to the doubt, but the general point is that science is only one source of knowledge and interpretation of the world that these students respond to. An attempt to understand just how science fits in with two other such sources - *kastom* and Christianity - is made in chapter 10 of this thesis. This chapter differs from the others in that it is descriptive rather than comparative. Inter-student comparisons within the school are very limited and none are made with studies in other cultures. The aim is largely to place the responses that have been examined in the rest of the thesis within the students' broader epistemological context.

My position as a science teacher in the school in which this investigation was carried out may have brought certain disadvantages when it came to examining aspects of the students' beliefs that they might have considered to be "unscientific". These disadvantages were easily outweighed, however, by the advantages of having relatively easy access to the students, and close contact with them, over a considerable period of time. This gave opportunities to try out a variety of instruments in the investigation of any particular problem, and to develop those which appeared to offer the most useful or reliable data. Access to data was given priority over methodological purity, and both qualitative and quantitative methods were employed.

Before beginning an account of the King George VI students' responses to science, it would be sensible to attempt to place them in some context. With this end in view, the next two chapters are dedicated to providing brief physical, demographic and economic outlines of the country. They introduce the reader to the country's educational system, the school in which this study was carried out, and the students who are the subjects of it.

CHAPTER 2 NATIONAL, SCHOOL AND CURRICULUM CONTEXTS

2.1 The Solomon Islands in Melanesia

Initial contact with both anthropological and educational literature can easily leave one believing that "Melanesia" is synonymous with "Papua New Guinea". That country has certainly been the location for the vast majority of Melanesian studies, and in at least one case, a work purporting to be an account of aspects of Melanesian culture deals exclusively with the peoples of Papua New Guinea (Stephen, 1987a). In ethnogeographical tradition the term Melanesia actually applies to a chain of islands on an arc of the Earth's surface extending for some 5000 km from New Guinea in the north west to Fiji and New Caledonia in the south east: from the Equator to the Tropic of Capricorn. Solomon Islands occupies the central part of this arc. As with so many former colonial territories, the political boundaries of the country make little geographical or ethnographical sense. In the north west, only a nine kilometre strait separates the Shortland Islands from the large island of Bougainville, which is geographically part of the Solomon Islands but politically part of Papua New Guinea. Through language, culture, trade and kinship the peoples of the Shortlands are linked with those of southern Bougainville while having much less in common with their nearest neighbours in modern Solomon Islands, with whom they are now politically linked. In the far south east of the country, the remote islands of Tikopia and Anuta are physically closer to the larger islands of Vanuatu than to those of Solomon Islands, and the inhabitants of these islands are Polynesian, not Melanesian.

The term "Melanesian" was coined to distinguish the darker-skinned inhabitants of this part of the Pacific from their lighter-skinned neighbours to the north and to the west, the Micronesians and the Polynesians. Even by this criterion, however, there is enormous variation among Melanesian Solomon Islanders. In the west one finds truly black-skinned, black-haired peoples, while in other parts skin colour may be a very light brown, with hair sometimes being ginger or even blond. Nor can linguistic unity be claimed for the region: the languages of Melanesia are now recognised as belonging to two distinct groups, Papuan and Austronesian, both of which types are found in Solomon Islands (Whiteman, 1984a: 89-90). Melanesia is perhaps the most linguistically diverse region of the world, with sixty four languages, many with multiple dialects, being recorded in Solomon Islands alone (Laracy, 1989: 161-162)[1]. This diversity also appears in other aspects of culture. For example, kinship systems may be patrilineal, matrilineal, double unilineal or cognatic; traditional religions may or may not have an ethical component; political systems are generally non-stratified, but not always so (Chowning, 1977;

Hogbin, 1964: 88; McElhanon and Whiteman, 1984a; Chao, 1984). As a consequence, some anthropologists have questioned the validity and usefulness of "Melanesia" as a category (Chowning, 1977; Keesing and Jolly, 1992). One wonders whether some of the social features claimed as characteristic of Melanesia are identified more in an attempt to find cultural unity in a population previously defined on vague racial grounds than because they are in fact unique to it[2].

As "Melanesia" declines in popularity as a useful concept with anthropologists, however, it seems that it is being increasingly used as a political rallying cry and source of identity. Chowning (*op cit*) notes that popular calls to do things "the Melanesian way" are becoming more common, but she sees this as generally ill-defined, or similar to the ways of most small-scale societies. If there are any distinctive elements of a Melanesian approach to affairs, personal experience suggests these may include an abhorrence of action which leads to public shame for any individual, a tendency to avoid direct personal conflict, and the desire to see decisions made by consensus rather than being imposed or put to a vote. This last policy has the advantage of reducing individual responsibility and, hence, minimising potential personal conflict from recriminations.

No understanding of life in present-day Melanesia is possible without an awareness of the extended kinship support system generally known as the "*wantok* system". The term *wantok* derives literally from Pidgin for "one language", but Mary MacDonald (1984a: 221) suggests that it is better thought of as "a metaphor derived from language and applied to the field of human relationships." Its use in practice varies with circumstance: it may at times include only very close kin, but it is capable of almost indefinite extension (Shaw, 1981). The common language implicit in the name may be a vernacular but may also be a *lingua franca* such as Pidgin. It may be the use which is made of a language which is the core of mutual understanding rather than the language itself:

> "in a limited sense, *wantoks* are people who have a common language, while in a broader sense, *wantoks* are people who understand and support each other"
> (MacDonald, 1984a: 221).

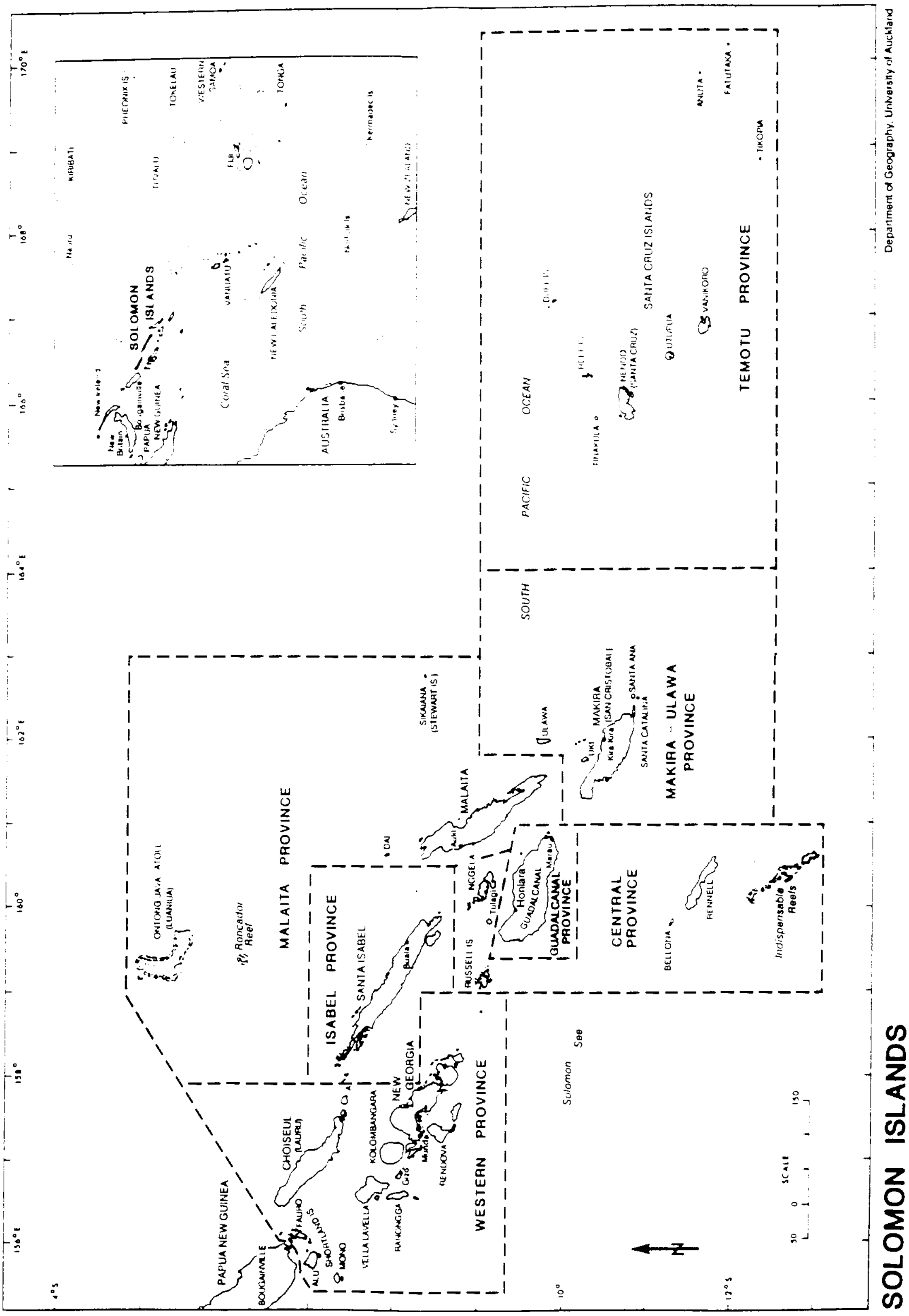
This support, and the accompanying responsibility, are particularly important for Solomon Islanders away from home: on plantations, in Honiara, or in boarding school, for example. Because of the potential for favouritism, corruption and inefficiency in such a system, debate on its merits is common, but it remains a pillar of social organisation.

2.2 Geography and demography of Solomon Islands

(Unless stated otherwise, demographic data is taken from the 1986 Census of Population, sometimes with extrapolations based on growth rates given therein: Solomon Islands Government, undated)

The 28370 square kilometres of land in Solomon Islands comprises many dozens of islands, but six major islands, or island groups, account for the majority of this land and hold the majority of people: Choiseul, the New Georgia group, Santa Isabel, Guadalcanal, Malaita, and Makira (Figure 2.1). All of the larger islands, and many of the smaller ones, are mountainous and covered with dense forest, with much of the coastline fringed with mangrove swamps. Only on Guadalcanal are there significant plains, and these are largely given over to commercial oil palm plantations. As a consequence of the rugged nature of the islands, there are very few roads, and only two stretches of significant length are tar-sealed: along the north coast of Guadalcanal and between Munda and Noro, on New Georgia. Travel between villages is largely on foot or by boat. On most islands, settlement tends to be along the coast, although both Santa Isabel and Malaita have some long-established villages in the interior. Inter-island travel is mainly by more-or-less-regular shipping services or by light aircraft to about thirty airstrips around the country. For the more remote

Figure 2.1 Solomon Islands: provinces, main islands and provincial centres (from Laracy, 1989: viii-ix)



regions, such as parts of Temotu Province, radio communications can be an important link: either short-wave radios based at strategic points such as police posts or the national broadcasting system, SIBC, which has a daily time for "service messages". Telephone communications between islands, where telephones exist, are excellent, thanks to a recently opened satellite link.

The 1986 census produced a figure of 285176 for the total population of the country, distributed by province as shown in Table 2.1

Table 2.1 Solomon Islands population by province

Province	Population	Area in km^2	Popn. Density
Western	55250	9312	5.9
Isabel	14616	4136	3.5
Central	18457	1286	14.4
Guadalcanal	49831	5336	9.3
Honiara	30413	22	1382.4
Malaita	80032	4225	18.9
Makira	21796	3188	6.8
Temotu	14781	865	17.1
TOTAL	285176	28370	10.0

The vast majority of this population were classified as Melanesian (94.2%). Polynesians (3.7%) are found mainly in the outlying smaller islands to the north, east and south, although a significant number also live in Honiara. A British government resettlement scheme in the 1950s and 1960s brought Micronesians from the Gilbert Islands (now Kiribati) to Solomon Islands. These formed 1.4% of the total population in 1986 and live almost exclusively in Western province or in Honiara. A small but commercially significant Chinese population is also almost exclusively located in Honiara, as are the majority of Europeans, who are in the country for a variety of reasons.

Of those aged 14 years and upwards, only 24.3% were recorded as working for money (34.8% of the male population and 13.0% of the females). Almost half of these (46.4%) were employed in agriculture, forestry or fisheries, reflecting the country's dependence on these sectors for income. Copra, cocoa and palm oil have generally been the main commercial agricultural products, but with the uncertainties in world prices for these products, timber and fish have become increasingly important exports. (The increasing exploitation of these last two natural resources has become a subject of intense public debate in the country and has had an impact on school syllabuses in both science and social science.) Although exact figures are difficult to give, it has been estimated that about 75% of the population depends on subsistence agriculture (Bray and Packer, 1993: 169). The 1991 *per capita* GNP was US$ 560, which is the lowest value for any country in that region[3] (OECD, 1992: A93-A94). Solomon Islands appears in the United Nations list of least developed countries. This status is not really determined by the *per capita* GNP, which is much higher than many others on this list, but reflects the general lack of development of human and physical resources and services.

The annual population growth rate was given in the 1986 census as 3.5%, so that by 1992 the population of the country was probably in excess of 350000. This high growth rate is also reflected in the overall youth of the population, with 47% being under the age of 14. The provinces of highest population density were also the ones with lowest growth rates, basically indicating emigration under population pressures. Most of this population movement is to the capital city, Honiara (growth rate 6.8%), and the areas of Guadalcanal close to Honiara. The movement of population from Malaita is particularly noticeable, with several new villages and squatter settlements established in or close to Honiara being entirely inhabited by Malaitans. These have presented problems for the provincial and town authorities, and have been the source of much friction and ill-feeling between Malaitan immigrants and the local population (Alasia, 1989). The people of Guadalcanal feel they are losing much of their land to immigrants from other islands and, along with other Solomon Islanders, they tend to regard the Malaitans, in particular, as dour and aggressive:

> "Malaitans ... are often taciturn towards outsiders, have a fierce pride, and adhere to a surprising degree to their own unique, local customs. Their sexual puritanism, the readiness with which they

> react to insults or perceived improprieties, and the vigor they show in pursuing quarrels and vengeance do not endear them to other Melanesians who tend to regard Malaitamen as gratuitous troublemakers."
>
> (Ross, 1973: 46)

Honiara is the only settlement in the country which can be regarded as truly urban. The 1986 census gave a population of 30413, but, if the 6.8% growth rate of the previous ten years has been maintained, the 1992 population could be more than 45000. The only other settlements with a population over one thousand in 1986 were Gizo, in the west, with 2331, and Tulagi, in Central Province, with 1281, but even the larger of these is little more than an enlarged village, with a port, a few administration offices and a handful of shops. Auki, the provincial capital of Malaita, is also comparable with these two in terms of facilities, although its population in the 1986 census was below one thousand. Overall, 84% of the population was classed as rural, while Honiara accounted for a further 11% (Solomon Islands Government, undated: 108-109).

Honiara is quite simply different from anywhere else in Solomon Islands. Students who saw Honiara for the first time when they came to secondary school there have told me of the shock that they felt, picking out the traffic, the shops and, particularly, the huge numbers of people from all parts of the country congregated in one place, as their most vivid initial impressions. Tarmac roads, four- and five-storeyed buildings, supermarkets, cinemas, video libraries, factories, a large port and an international airport, tourist hotels, nightclubs and discos, all make the capital very urban in nature and unique in the country. In 1986 Honiara accounted for 91% of the country's electricity consumption, 83% of telephone lines, 95% of private motor vehicle registrations, 73% of the overseas shipping tonnage, and 76% of all salaries and wages paid in the country (Solomon Islands Government, 1987: 115-132). On the eastern fringe of Honiara, next to the main road from the town to the airport and adjacent to a rapidly expanding light industrial area, stands King George VI School, the students of which are the subject of this study.

2.3 The education system of Solomon Islands

2.3.1 Development and description

The British colonial government took little interest in education until after World War II, preferring to leave it entirely in the hands of various missions. This probably reflected, at least in part, a lack of interest in the country as a whole since it was of little commercial or strategic value to the colonial power; although government revenue was also extremely limited and considered inadequate to establish schools (Bugotu, *et al*, 1973: 16). It was not until 1947 that a Department of Education was set up and not until 1953 that the government opened a primary school under its own direct control (Wasuka, *et al*, 1989: 100-106). This school was King George VI School, but it did not become a secondary school until 1956, and until 1966 it was on Malaita, rather than at its present site in Honiara.

An uneasy relationship between the churches and the central government, over the question of control of education, continued until 1975, just three years before the country obtained independence (Wasuka, *et al*, 1989: 106-107). The government then took over full responsibility for all primary education while retaining a previously established partnership with the churches over the running of secondary schools: the schools received government subsidies in exchange for allowing government control of the curriculum and teaching standards. King George VI remained under total government control[4].

Educational expansion has been rapid since independence in 1978, but the 1988 primary enrolment figure was still only given as 73%, in 485 primary schools (Bray and Packer, 1993). (It is not clear how this enrolment figure was actually arrived at or what it means in practice. A closer look at enrolment figures appears below.) A high population growth rate and a widely dispersed population, often in small isolated villages, both mitigate against efforts to increase enrolment (MEHRD, 1991: 7). Some direct mission and private control of schools remains. Of particular importance for this study, since they provide a substantial number of students to King George VI School, are two high-cost private schools in Honiara: Chung Wah, and Honiara International School (formerly Woodford School).

After six years of primary schooling, children sit the Secondary Selection Examination, with papers in English, maths and verbal reasoning, but only 26% of primary school leavers obtain a place in secondary school (AIDAB, 1992: 10). There are two types of secondary school: National Secondary Schools (NSS) and Provincial Secondary Schools (PSS). The NSS are the older-established schools, offering a five year academic education. The first PSS were established in the late 1970s after a national debate and an educational review committee, reporting under the title "Education for What?", argued for a greater emphasis on practical skills and locally relevant knowledge in education (Bugotu, *et al*, 1973: 44-46). The PSS, therefore, offered a curriculum which emphasised mechanics, agriculture, business and the village economy (Wasuka, *et al*, 1989: 106-108).

Although of later inception, the PSS now outnumber the NSS at 12 schools to 8 and account for 67% of Form 1 to Form 3 places in secondary school (AIDAB, 1992: 10). Until recently, however, no PSS had places beyond Form 3 (and even the NSS were not able to take all of their own Form 3 students back into Forms 4 and 5). A further selection examination, consisting of papers in English and Mathematics only, is given at the end of Form 3 and successful students from both NSS and PSS may continue to Form 4. In 1991, however, only 30% of all Form 3 students obtained Form 4 places (AIDAB, *op cit*).

As is so frequently the case, once PSS and NSS became parallel forms of schooling rather than alternatives, PSS often came to be regarded as "second chance" schools and the academic curriculum began to receive greater emphasis than was originally intended. Science education provides an example of this process in action. Science did not appear on the PSS curriculum as a distinct subject, although aspects of science were covered in mechanics, agriculture and home economics. PSS students entering Form 4 in NSS, therefore, experienced problems in science lessons because of their inadequate background. Pressure from NSS science teachers and the Science Curriculum Development Officer gradually forced the introduction of science on the PSS curriculum, albeit in a somewhat diluted form compared with the NSS curriculum. Recognition of the failure of parallel secondary schools has forced the government to opt for the eventual conversion of all PSS to NSS (MEHRD, 1991: 3)[5].

After five years in secondary school, students sit the Solomon Islands School Certificate (SISC) examinations, which were introduced in 1978 as a locally administered and locally set replacement for Cambridge School Certificate. This change had been recommended by the "Education for What?" report, which stated that the Cambridge curriculum was "largely irrelevant to the needs of the majority of students in the Solomons" (Bugotu, *et al*, 1973: 57). SISC was seen as a way to obtain greater relevance in the curriculum through local control. All students sit examinations in the four core subjects of English, mathematics, science and social science, together with (generally) two or three optional subjects. The syllabuses and question banks for all subjects are prepared by secondary teachers themselves, sitting on subject panels which are under the direction of curriculum development officers based at the Curriculum Development Centre, in Honiara.

SISC results are used to select students for continuation into Form 6. The numbers entering Form 6 have been very strictly controlled and based on estimations of future manpower needs. (The Ministry of Education and Human Resources Development, or MEHRD, has responsibility for manpower planning.) Until 1989, King George VI School was the only school with an officially recognised Form 6[6]. The numbers admitted were kept at approximately forty for science subjects and twenty for arts. Probably in reaction to political pressures, the government opened a second Sixth

Form in 1989 at the only other NSS that is totally government funded, Waimapuru School in Makira. This was followed by the Church of Melanesia sponsored school, Selwyn College on Guadalcanal, taking Form 6 students in 1991. In 1992 a total of 136 Solomon Island students sat the Pacific Senior School Certificate examination at the end of their sixth-form course. This compares with 452 entrants for the Form 5 SISC examination of the previous year (figures provided by the Selection & Guidance Unit, MEHRD, Honiara). About 30% of Form 5 students, therefore, find a place in Form 6. The majority of sixth-formers follow a science-based course: 88 sat for physics, for example, in 1992, compared with 35 for geography or 47 for economics.

The number of students going on to further education after the sixth form, and the courses which they follow, is determined more by the number of scholarships available from various sources than by the interests of the students or their performance in examinations. A few enter the Solomon Islands College of Higher Education (SICHE) in Honiara, but most of those obtaining tertiary places go overseas, to the University of Papua New Guinea, the University of the South Pacific (Fiji), or to Australia or New Zealand.

2.3.2 Enrolment figures and patterns

The data available in the 1986 census are particularly relevant to this study: those children in primary standards one to six at the time of the census included all those who would enter secondary school between 1987 and 1992, who in turn included the bulk of the subjects of this research. This census also provides the most reliable, detailed, and easily-obtained figures. A second set of figures is available in the results of the 1988 Primary School Enrolment Survey (Solomon Islands Government, 1989) and, unfortunately, there are serious discrepancies between these two sets[7]. Since a full national population census is likely to have been invested with more expertise and care than a questionnaire sent out to primary schools, the census data will be taken to be more reliable, but the difficulty in obtaining accurate statistical data in the Solomon Island context should be noted.

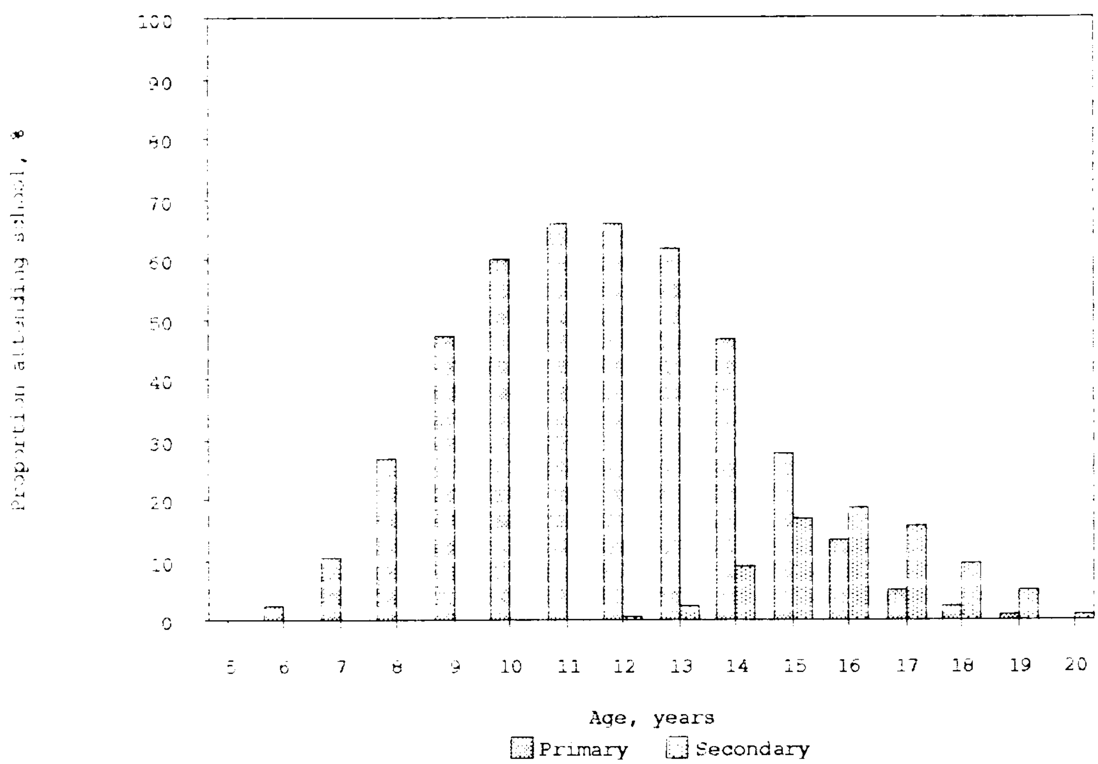
For a country in which the age at which children actually start primary school varies considerably (so that there is always a large spread of ages in any one year-group or standard) it is difficult to choose an age range that can be used as a base for calculating an enrolment rate. Even if there is an official target age-range for primary schooling, enrolment expressed as a proportion of the number of children in this range is not a useful indicator of what is actually happening when much of the enrolment is outside that range.

One solution to this problem is to use a "modified reference population" to allow for the fact that children may enrol at different ages[8]. This method was used to give an enrolment rate of 74.8% in 1981 (Solomon Islands Government, 1982: 6-7), but even this figure must be treated with caution. There are contradictory population figures within this report which could give a value of 77.8% (cf. pp 7 & 10), and a later set of statistics gave the 1981 enrolment rate calculated in this way as 72.3%, rising to 83.1% in 1984 (Solomon Islands Government, 1984: 7).

An alternative way of examining enrolment data is to construct an "enrolment profile", which graphs the proportion of children of each age which are at school. This is perhaps not quite so convenient, in that it does not consist of a single figure which can be used for, say, examining trends over time. It does, however, include more information about the school population than does the single value and, furthermore, provided the spread of ages over which the majority of children enrol is not longer than the primary school course, the peak enrolment rate taken from this graph is at least as good an indicator as that calculated using a modified reference population.

Using the 1986 data (Solomon Islands Government, undated: 203-211), such profiles have been constructed for both primary and secondary enrolments in Solomon Islands as a whole and are shown in Figure 2.2.

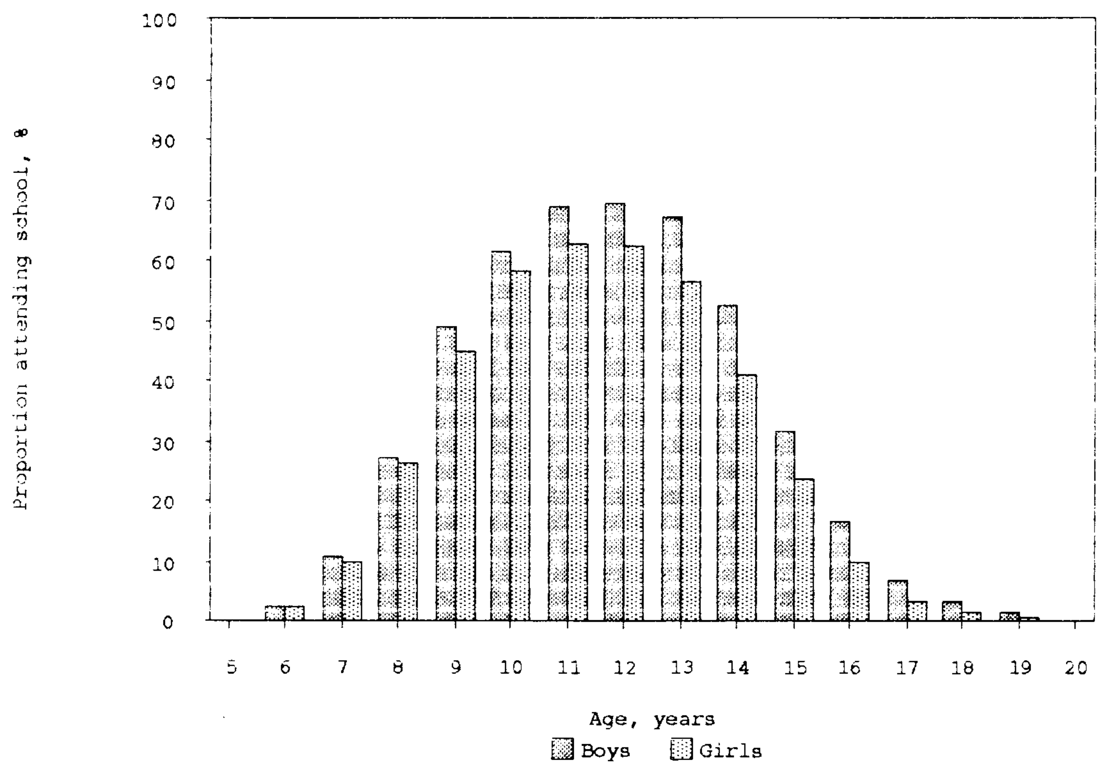
Figure 2.2 National school enrolment profiles, primary and secondary school, 1986



The primary school profile peaks for eleven and twelve year olds, 65.9% of whom were attending primary school in 1986. Using the raw data and a modified reference population (for an age range of 7 to 15 years, rather than 6 to 14, to allow for the fact that the census took place at the end of the year, not the beginning) a primary school enrolment rate of 67.5% can be calculated, very similar to the profile maximum[9].

The census data also reveals considerable variations in profiles by gender and by region. The primary school data for the whole country are re-displayed separately for boys and for girls in Figure 2.3.

Figure 2.3 National school enrolment profiles, primary school only, boys and girls, 1986



At all ages except the very youngest, the girls' enrolment rate is lower than that of the boys, and the difference increases with age: at eight years the difference is 0.5%, at ten it is 3.2%, at twelve it is 7.1%, and at fourteen it is 11.6%. This increase may be due to a greater drop-out rate for girls or it may show that the enrolment rate for girls is improving with time, or a combination of these two.

A single set of figures gives no indication of which of these is happening. Data from the 1984 report of educational statistics certainly suggest that there had been no consistent improvement in girls' enrolment rates in earlier years, leaving the suspicion that what is being observed is a lower progression rate for girls (Solomon Islands Government, 1984: 33)

Regional variations are very pronounced. The extremes are represented by Western Province and Malaita Province. The primary enrolment profiles for these two provinces are given in Figures 2.4 and 2.5, with girls and boys displayed separately once again.

Figure 2.4 Western Province primary school enrolment profiles, boys and girls, 1986

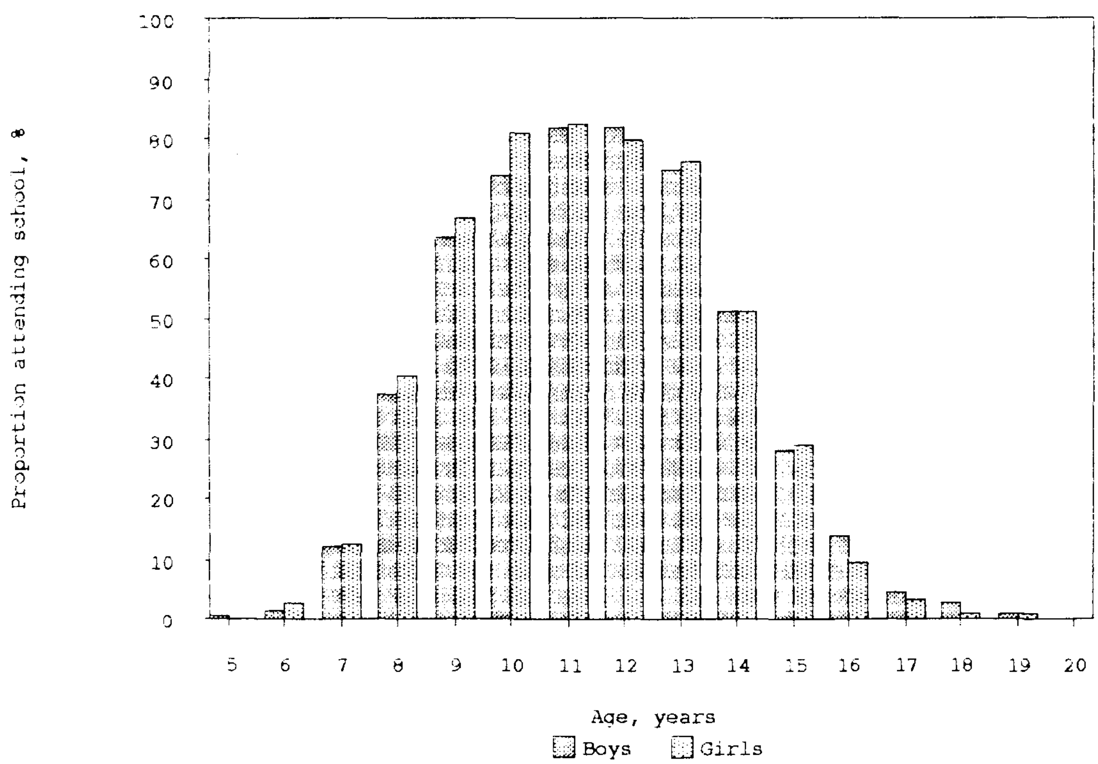
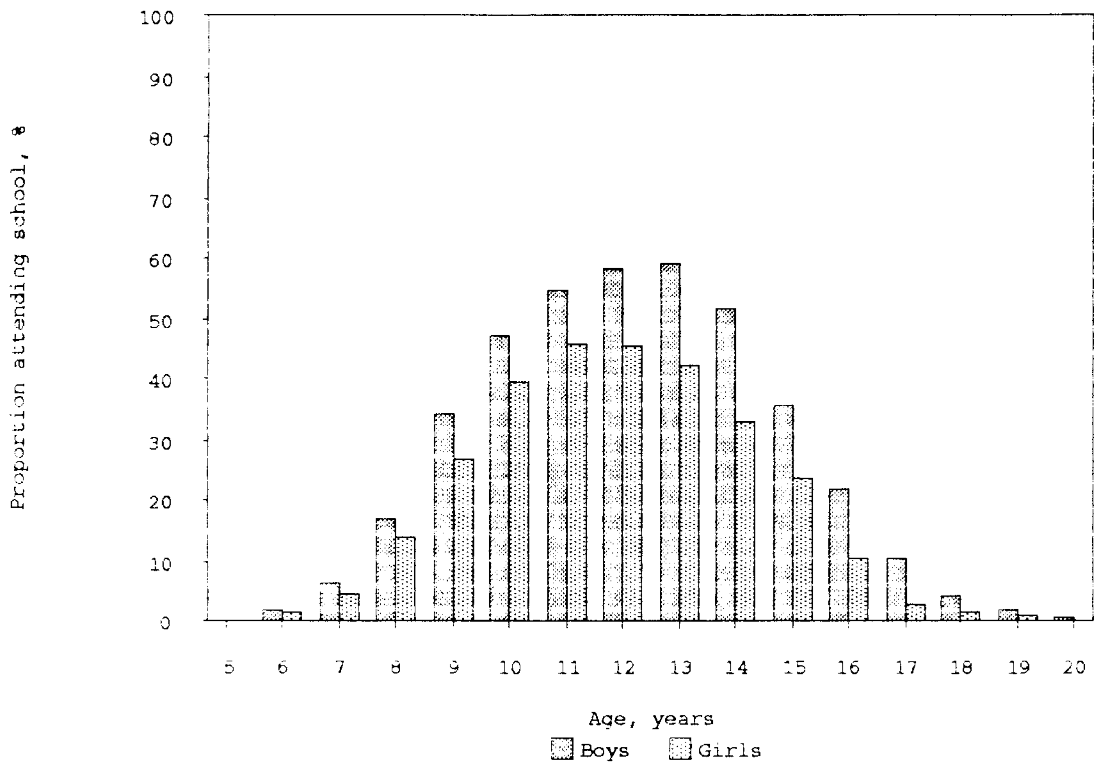


Figure 2.5 Malaita Province primary school enrolment profiles, boys and girls, 1986



The low overall enrolment rates, and the very low rates for girls in particular, are clear in the Malaita profiles[10]. There are two causes likely to be at work here: low overall development levels and the very low status given to women in Malaita[11]. As mentioned earlier, Malaita is one of the few islands with a significant inland population, and the interior of the island is extremely mountainous, difficult terrain, making communications and development difficult. The people of the interior, in particular, have hung on to traditional ways of life and belief systems more strongly than most others in Solomon Islands (Ross, 1973; Keesing, 1982), although Malaitans in general are renowned for upholding *kastom*. In interviews with students, it was only Malaitans who made remarks such as this:

> "Back in my village, most of the girls, they don't go to school, because their parents say educating girls is just wasting time. They should stay back and do the housework"
> (30/F/88, 6/3/92).

Despite having the poorest enrolment rates, Malaita, by virtue of its large population, does contain a large proportion of the total primary school population of the country, second only to Western province in 1986 (23.0% to 23.7%). Furthermore, the low levels of development in parts of the interior contrast strongly with certain of the coastal regions, particularly around the northern end of the island and along some parts of the western coast. People from these areas are often considered to be very ambitious and industrious, and Malaitans are very well represented among the élites of the country. While still holding much of *kastom* to be important, they have been successful in the modern economy and have migrated to many parts of the country in search of employment or land.

The official selection processes operating in the education system are harder on girls than on boys. In 1986, 41.4% of Primary Standard 6 pupils in the whole country were girls. The same cohort sat SISC in 1991 and the girls then formed only 31.3% of the total. This had fallen to 27.2% among those sitting the Form 6 PSSC examination a year later. Improvement in the position of girls is very slow: the 1988 Standard 6 proportion of girls was still 41.4% (Solomon Islands Government, 1989), and the proportion sitting SISC in 1991 had only improved from 29.0% in 1989. Overall, 44.3% of primary school pupils were girls in 1986, only a slight increase from 37.8% fourteen years earlier (Bugotu, *et al*, 1973: 24)[12].

2.4 King George VI School

King George VI School is one of only two National Secondary Schools which are fully government-run, the other being Waimapuru School on Makira. It began as a primary school in 1953 near Auki, on Malaita, became a secondary school in 1956, and moved into new buildings on its present site on the eastern edge of Honiara in 1967. The facilities on this new site were so substantial in extent and construction that the 1973 Educational Policy Review Committee criticised them as over-elaborate and a waste of funds (Bugotu, *et al*, 1973: 39, 107). This committee saw the school as establishing a *de facto* two-tier system, with the less well built and funded church-run schools in the second rank, and it recommended that the school be turned into a sixth form and teacher training college (*ibid*: 104). The school's existence came under threat again in the late 1980s when the neighbouring Solomon Islands College of Higher Education decided it needed the site and its buildings for its own consolidation and expansion. Public pressure combined with financial constraints to force the abandonment of this plan, but the school does not always get clear public support. The very fact that the school is not under church control encourages public suspicion that the moral welfare of the students cannot be adequately supervised. The churches, and Christianity in general, enjoy very high prestige in Solomon Islands and the 1973 committee was quite content to see all academic secondary schooling remain in their hands[13].

There are places for 515 students in the school, made up as follows:

Form 1: 3 classes of 35 each - 105
Form 2: 3 classes of 35 each - 105
Form 3: 3 classes of 35 each - 105
Form 4: 2 classes of 35 each - 70
Form 5: 2 classes of 35 each - 70
Form 6: 3 classes of 20 each - 60

The actual school role fluctuates slightly throughout the year, due to drop-outs and transfers, but the attraction of the school's facilities and academic prestige (tempered by the suspicions mentioned above) ensure that numbers are always close to the maximum. The majority of the students are boarders and the ratio of boys to girls entering the school in Form 1 is usually about three to two. A more detailed description of the students is given in the next chapter.

The curriculum followed by the school is essentially that prescribed by the Ministry of Education: a compulsory core of English, mathematics, science and social science, with a range of electives. All students in Forms 1 to 3 take agriculture, business studies, art, religious instruction, woodwork (boys only) and home economics (girls only). From Form 4 onwards, the none-core subjects become optional, in various combinations, with the exception of business studies, which remains compulsory.

These subjects are fitted into a timetable of eight forty-minute periods per day, five days a week. Lessons run from half past seven until half past one, to avoid the hottest part of the day. Afternoons and evenings include sessions for "preparation". Sports, manual work around the school compound, and clubs and societies are also allocated time in the afternoons. Over the years, various arrangements have been tried to fit in extra religious instruction, with students being taught by representatives from the particular Church to which they belong. These arrangements have generally not met with much success because of a poor response from some of the Churches responsible. Services are also organised within the school on some Sundays. Most of the week-end is free time for the students, except for work and preparation periods on Saturday morning. Various "entertainments" are organised for Saturday evenings.

The amount of time allocated to each subject is generally close to the recommendations of the Ministry of Education, with the exception of science, which is given a slightly more generous share in Forms 4 and 5: eight periods per week instead of seven, giving it the largest allocation of any subject in the school at that level. This small difference is perhaps not very significant in itself, but its origins are revealing. In Forms 4 and 5, the science syllabus contains elements of biology, physics and chemistry. In many schools all of these are taught by one teacher and contact with these teachers suggests that they teach them in series: some weeks on biology, then time on chemistry, etc. The existence of Form 6 in King George VI School, however, gave rise to the need for specialist laboratory facilities and teachers who regard themselves as specialists in one or two of the branches of science. As a consequence, Form 4 and 5 science topics are taught in parallel: biology being covered at the same time as physical science by specialist teachers in specialist laboratories. With the teachers of both branches demanding equal time and wanting only double periods, the allocation became two lots of four periods.

The total number of teaching staff in the school also varies, but is generally around thirty. The proportion of these that are expatriates has been decreasing over the years: in 1987 there were eleven expatriate teachers but by 1992 the number had fallen to seven. The majority of these expatriates have been British, recruited under the Overseas Development Administration, but as British support for the school has declined, shortfalls in local teacher supply have been made good by relying on American Peace Corps volunteers.

The greatest dependence on expatriate teachers is in the science department. Out of a complement of six to eight science teachers, there have generally been four expatriates in recent years. Local graduate science teachers in particular have been in short supply and have rarely stayed in the school. The handful that have taught in the school have all either been tempted out of education altogether by better conditions or have been promoted out of the school after a very short period of teaching: to the Curriculum Development Centre or to the Ministry of Education itself.

The British involvement in the school has also included grants for equipment and books, so that the school is probably better-equipped than any other in the country[14]. Video players, overhead projectors, duplicators and photocopiers are all available, and the school has a large, relatively well-stocked library. The science department in particular has benefited from equipment grants, to the extent that a science teacher arriving from a United Kingdom school was able to comment that the department was better equipped than the one he had just left! Computers are just beginning to be available in the school, although the initial emphasis has been on teacher rather than student use.

2.5 An outline of the school science course

Although the primary school curriculum includes science, the secondary science syllabus was devised on the assumption that it would be the students' first contact with the subject. From conversations with other science teachers, Ministry of Education staff, and students, this would appear to be a sensible assumption for the majority of students. Both the content and the quality of any science teaching given in primary schools appears to be very variable and dependent on the interests of the teacher. Some elementary botany and occasional astronomy were the main topics that the students could remember covering in most schools - although there was a tendency for a little more to be done by some of the Honiara schools.

The secondary science course was developed locally, but almost entirely by expatriates working through the Curriculum Development Centre or Science Teachers Panel. They produced the syllabus and wrote the Form 1 to Form 3 materials: a series of booklets for student use, together with some teachers' guides. These booklets were intended to encourage student practical work by including recommended "Activities", although these tend to be of a very prescriptive nature. A New Zealand course text book was recommended for the Forms 4 and 5 course, but this was supplemented by other texts at King George VI.

The course was essentially a knowledge-based approach to science, but from 1988 onwards at K G VI, there was an attempt to place a greater emphasis on skills and investigation, while still being obliged to remain within the official syllabus outline. From 1990 onwards, attempts were made to take similar directions at a national level, although, once again, the course content could not be radically changed without entering into a complex process for which it would have been difficult to obtain permission[15]. Attempts at change were, therefore, effected by regrouping the material under process and theme headings, such as "Observing and Classifying", "Changing and Growing", and "Structure". Some of the suggested practical activities were made more open-ended in nature, although it was recognised that some of the science teachers lacked confidence with less prescriptive activities.

Within K G VI, student practical work always received considerable emphasis, and teachers were encouraged to be rather more innovative than the student booklets suggested. The presence of adequate equipment, and experienced teachers who could provide advice and support for less experienced colleagues, made this strategy realistically possible.

The course was based on a spiral curriculum model, although some teachers in K G VI felt that the turns of the spiral were too close together, so that there was considerable repetition of content. Some liberties were taken with the order and depth of coverage within the school in order to meet such criticisms - and others, such as too early an introduction to certain difficult topics.

The premature introduction to difficult topics had arisen through a desire to provide a "complete" science course for those students who would leave after Form 3. In practice, this meant that they received an over-crowded, academic, non-applied science course of doubtful benefit. Once again, liberties were taken with this at K G VI to reduce the content, and similar moves were eventually made at a national level. Although the original brief for the production of the national science syllabus had been to provide a "science for all" course[16], there were always severe pressures from the upper end of the system to provide a specialist type of course. Ultimately these pressures arose from the need to send Form 6 students overseas for tertiary science education, and this influenced choices for the local syllabus. Although this syllabus did contain references to applications of science, these were largely as an afterthought, rather than as a basis for selection or organisation.

Local relevance of the material in the course was quite limited, particularly in the physical sciences. Exemplification was drawn from local sources whenever possible in the student texts, but local relevance was not given much prominence as a guide to selection of content. The exception to this lay in the environmental and ecological sections of biology. (Biology accounted for about 40% of the syllabus, with physics and chemistry taking the remaining 60%.) A considerable amount of material for use in these sections was produced locally, and flexibility was built into the syllabus to allow locally pertinent ecological studies.

The facilities at King George VI School, the presence of specialist staff, and an emphasis on science in the timetable must be borne in mind when examining the performance of the school's students in School Certificate (SISC) science examinations. In 1991, for example, they accounted for 54% (19 out of 35) of the highest level grades (grade A) allocated in the country as a whole, despite forming less than 15% of the examination candidates (67 out of 451) (Figures from the Selection and Guidance Unit of the

Ministry of Education). It is to an examination of the backgrounds of these students that do so well that we shall turn next.

CHAPTER 3 THE K G VI STUDENTS: BACKGROUNDS

3.1 Obtaining background information

Since the school administration, in recent years, had not been very consistent with its record keeping, the main source of general background information on the students was a personal questionnaire given to as many as possible: response rates of over ninety percent, and generally over ninety five percent were obtained for each year group. This questionnaire went through two or three versions as problems were identified with some of the questions being asked. (See Appendix 1 for two versions of this document.) It asked for information on, among other things, the student's age, home, primary schooling, experience of Honiara, and the education and occupations of both parents. There were problems with some of these areas.

The difficulties encountered in trying to determine the students' homes can be illustrated by some extracts from interviews held with students:

JL: Where is your home?
SS: You mean my island?
JL: Well, if I say 'Where is your home?' what do you think of?
SS: Malaita.
JL: Which part of Malaita?.
SS: West.
JL: When it's the school holidays, where do you go?
SS: Mbokonavera. [Part of Honiara]
JL: So, really, you live here in Honiara?

SS: Yes.
JL: And you were brought up in Honiara, were you?
SS: Yes.
JL: Have you ever actually lived back in Malaita?
SS: No.
JL: Do you go there very often?
SS: No.
JL: Have you ever been there?
SS: Yes.

(05/F/88, 23/3/92)

JL: Where is your home?
SS: Er... it's ... Village or ...?
JL: If I simply ask 'Where is your home?' what is your first answer to that?
SS: White River. [Honiara]
JL: That's where you live most of the time, is it?
SS: Yes.
JL: So, during holidays you go back to White River?
SS: I live there, but during holidays I go to Isabel.
JL: So when would you be at White River?
SS: School times.
JL: But you are a boarder?
SS: Yes.
JL: So you mean if you go for a weekend or something like this?
SS: Yes.

(18/M/89, 4/2/91)

JL: Where is your home?
SS: My father comes from Ranongga and my mother from Choiseul.

(35/M/87, 4/8/91)

In general, it seems that "home" is taken to mean the place of origin of one's parents, whether or not one lives there or has ever even visited there. It is possible, and actually quite common, to have two "homes": one for each parent. On the other hand, there are students who do see their home to be the place in which they actually live, irrespective of where their parents came from; this is uncommon, but occurs notably for some students who were born in Honiara and still live there. In contrast, it is not unusual for students to have obtained most or all of their primary schooling in Honiara by living with a *wantok*, while their parents remained at the "home" which the students still give as their own. Such students may only have visited their parents once a year during this time. Some students who live in Honiara with their parents will visit their parents' home once a year only, usually during the Christmas holiday, and they may or may not identify that place as their own home. Some have a strong sense of identity with their - or their parents'- home island while others find such visits an unwelcome culture shock:

> "We have to change our behaviour in ... er ... what we say, the way we act, the way we ... especially the way we dress, and the way we address the elders of the village and ... food as well. Because sometimes they ... this feast ... custom ceremonies. We have to eat this food. Sometimes we don't like the food, but we must show respect."
>
> (27/F/88, 30/4/92)

As a result, it is not always clear what information is being given in an answer to the question "Where is your home?" The original intention of the question was twofold: to obtain an indicator of possible cultural identity through links with an area and its people, and to help gauge the degree of exposure to urban life. The uncertainty over how the students were interpreting the question, however, made it difficult to be sure how much information was being obtained on either issue. For the majority of students the answer did actually correspond with the place in which they had lived for most or all of their life, but for many it gave no idea of their actual experience of a place. In an attempt to clarify what was being asked for, the questionnaire asked "Where do you live?", rather than "Where is your home?", but it became clear that several students were treating the question as if it had actually been the latter. Ultimately, it was decided that the individual's primary school history was a better indicator of the urban experience part of the original aims.

It had originally been hoped to obtain information on levels of parental education, and the earliest questionnaire contained questions on this. The response rate was poor, however, in that, in any entry-cohort, between 30% and 35% of students did not know their father's educational level; and between 34% and 43% did not know how much schooling their mother had received. Furthermore, follow-up on the questionnaire cast doubts on the reliability of the information given by some of those who stated parental educational levels. A brother and sister, for example, gave different responses from each other for both their mother and father, and, in interviews, some students admitted they were not entirely certain about their answers.

The other aspect of the students' backgrounds on which it was difficult always to get reliable information was the occupations of their parents. Various wordings were tried: What work does your father do?, What is your father's occupation?, What does your father do for a living?; but there was always a tendency for those whose father is a subsistence farmer to leave this blank, or to write, "He does no work" or, "He has no job". After following up several such responses it was realised that a blank almost always meant "subsistence farmer" and could be interpreted as such. Other causes, such as family break-up, or death, were rarer, and the latter was dealt with in the later version of the questionnaire.

More of a problem than this, however, was that several students did not know what work their fathers or mothers did. The place of work was generally known, but sometimes not the nature of the work. This has meant that only broad categories of occupation can be given, to avoid having too many being described as "unclassifiable". It should also be remembered that some students have spent significant parts of their lives living with a *wantok* in Honiara in order to go to primary school there. This may have provided them with a temporary, but significant, home experience very different from that which might be implied by the father's occupation.

These problems over the accuracy of children's reports of parental occupations and education have been noted elsewhere. In a review of studies from the USA, UK and Australia, Dianne Looker (1989) found that non-response rates in some US studies were in excess of 40% for sixth graders reporting on their fathers' education, and the accuracy of reports from those who did respond was not always very high. She found that the response rates and accuracy did improve for older students and was higher for those children who were actually living at home with the relevant parent. In view of these findings, the apparently poor responses of the K G VI Form 1 students (i.e. seventh graders), mostly living in a boarding school, away from home, are not so surprising.

More detailed information on the backgrounds of a smaller number of students was obtained from semi-structured interviews given to ninety six individuals from Forms 3 and 5 in different years. This interview was quite wide-ranging in content and included questions about home background, how time was spent at home and at school, attitudes to aspects of school, job aspirations, and attitudes to some traditional beliefs and practices. The final version of the interview schedule is given in Appendix 2, but it must be remembered that there was some evolution over time, and that many of the questions simply provided starting points for developments which depended on the individual's responses.

3.2 Student data and backgrounds: basic statistics

In early 1992, of 515 students on the school roll, 199 (38.6%) were girls. 83% were boarders, although girls were less likely to be boarders than boys: 76% of girls compared with 87% of boys[1].

The proportion of girls admitted into the school in Form 1 each year has, excepting one unusual year, remained similar for some time, although may be showing a slight downwards trend. The survival rate of girls at the next selection point, from Form 3 into Form 4, is similar to that of boys, although more often lower than higher (Table 3.1).

Table 3.1 Admission and survival rates for girls in King George VI School

Admission year	Proportion of girls	
	Form 1	Form 4
1987	43%	39%
1988	32%	31%
1989	44%	46%
1990	42%	35%
1991	41%	-
1992	39%	-

The average age on admission to Form 1 is about thirteen and a half years for both boys and girls, with the youngest eleven and the oldest sixteen, or occasionally seventeen. Most, but not all students can now give a date of birth, but statements about age must sometimes be treated with caution. One girl who gave a date of birth that made her sixteen years old on admission to Form 1 in 1987, gave her age as eighteen some four years later.

The origins of the students, as given in response to the question "Where do you live?", are shown in Table 3.2 In this table, the category Gua/Cen, applies to those who gave their home as either Guadalcanal or those parts of Central Province which are close to Guadalcanal (Russell Islands, Savo, Florida Islands).

Table 3.2 Responses to "Where do you live?", by year & sex

	Proportion of students from each area, %									
Adm Year:	1988		1989		1990		1991		1992	
Sex:	M	F	M	F	M	F	M	F	M	F
Honiara	34	58	28	48	45	65	39	64	39	62
Malaita	28	21	33	17	37	12	39	12	32	21
Western	19	6	23	17	8	7	9	17	5	3
Isabel	10	15	10	13	0	9	4	2	10	0
Gua/Cen*	9	0	5	2	8	2	5	5	8	13
Other	0	0	2	4	2	5	4	2	6	3

* Guadalcanal (excluding Honiara), or those parts of Central Province which are close to Guadalcanal: Russell Islands, Savo, Florida Islands

The majority of students in the school give Honiara or Malaita as their home; Honiara alone is home for more than half the girls taken in most years. Western Province has become particularly under-represented in recent years despite the fact that nationally it has the highest, or second highest, number of primary school pupils of all provinces.

The students' primary school histories were categorised by making two main divisions: Honiara and non-Honiara schools. The latter will be referred to as "Rural" schools, which may be thought to be something of a misnomer since it includes schools in towns such as Gizo and Auki as well as truly rural village schools. This categorisation was made because primary school history is to be used largely as an indicator of urban experience, rather than of quality of primary schooling. It can be justified because of the extreme contrasts already mentioned between Honiara and the rest of the country, other towns included. In terms of socialisation experiences offered, a town like Gizo is probably closer to a village than to Honiara. The Honiara primary school category is then subdivided into government schools and the high-cost private schools (Chung Wah and Honiara International School). Finally it is necessary to consider those students who have had a mixed primary school experience, between Honiara and non-Honiara schools. From three to five years (out of six) in a Honiara primary school is classified as "Mostly Honiara", while only one or two years' schooling in Honiara is considered "Mostly Rural". (Obviously, three years out of six in Honiara is not "mostly" Honiara at all, but the division is made taking rural schooling to be a base upon which Honiara experience may have an effect.) Table 3.3 gives a summary of the primary school backgrounds of the students.

Table 3.3 Primary school backgrounds of students entering K G VI, by admission year and sex

	Proportion of students, %									
Adm year:	1988		1989		1990		1991		1992	
Sex:	M	F	M	F	M	F	M	F	M	F
HP	19	27	8	23	17	29	29	40	16	44
HG	6	33	13	23	19	37	8	19	23	10
HM	12	9	10	8	4	5	11	7	6	10
RM	6	3	5	2	8	0	5	5	5	0
RA	53	27	59	44	51	29	47	26	47	31
OS	4	0	5	0	2	0	0	5	3	5
Totals:										
Honiara	37	69	31	54	40	71	48	66	45	64
Rural	59	30	64	46	59	29	52	31	52	31

Key to codes: HP: 6 years in private schools in Honiara
HG: 6 years in government schools in Honiara
HM: 3 to 5 years in Honiara schools
RM: 4 or 5 years in Rural schools
RA: 6 years in Rural schools
OS: Primary schooling overseas

The problems with classifying parental occupations have already been mentioned. In Table 3.4, fathers' occupations are categorised rather coarsely, with "white collar" covering all non-manual work, from clerk to bishop or permanent secretary.

Table 3.4 Fathers' occupations for K G VI students, by admission year and sex

	Proportion of students, %									
Adm year:	1988		1989		1990		1991		1992	
Sex:	M	F	M	F	M	F	M	F	M	F
WH	57	64	56	56	49	55	53	79	58	66
MS	21	12	13	15	12	18	8	8	8	13
MU	0	3	2	2	2	0	2	3	3	0
FF	22	15	26	17	33	16	27	8	26	16
X	0	6	3	10	4	11	10	3	5	5

Key to codes: WH: white-collar
MS: skilled manual
MU: unskilled manual
FF: subsistence farmer/fisherman
X: unclassifiable or not stated

A minority of the students' mothers are wage-earners, mostly in non-manual work. The proportion is generally between 33% and 40%, with the 1991 girls showing an exceptionally high figure of 49%.

3.3 A comparison with other schools

In order to make a comparison, in some respects at least, between King George VI students and those in other Solomon Island schools, the basic background questionnaire was given to the Form 1 entrants in four other secondary schools. The particular schools used were more a result of opportunity than choice, but a reasonable balance of types and locations was obtained. The two National Secondary Schools for which information was obtained were Goldie College, a United Church-administered school in Western Province, and Waimapuru School, the only other government-run school, which is in Makira. Provincial Secondary Schools were represented by Luasaleba in Temotu, and Pawa, off the coast of Makira. Administration of the questionnaire in these schools had to be entrusted to third parties, so there was no opportunity to follow up responses that were problematic in any way. The information obtained is summarised in Table 3.5.

Table 3.5 A comparison of aspects of student backgrounds in five secondary schools, 1990 intake

	National SS			Provincial SS	
	KGVI	Waim-apuru	Goldie	Pawa	Luas-aleba
No. of students					
Boys	60	53	32	50	62
Girls	44	31	24	46	41
% Girls	42	37	43	48	40
"Local" residence,* %					
Boys	53	29	75	85	97
Girls	68	26	92	94	98
Primary schooling, %					
Rural: Boys	58	87	75	86	98
Girls	29	77	79	98	100
Honiara: Boys	40	13	25	12	0
Girls	71	19	21	0	0
Father's occupation, %					
White collar: Boys	49	38	50	18	18
Girls	55	48	46	26	32
Manual: Boys	14	4	19	4	13
Girls	18	13	25	2	7
Farmer/Fisher: Boys	33	49	25	56	63
Girls	16	39	13	30	51
Not stated**: Boys	4	8	0	18	2
Girls	11	0	0	41	2
Unclassifiable: Boys	0	2	6	4	5
Girls	0	0	17	0	7

Notes

* "Local" residence is taken to be residence within the same province as the school. For King George VI School, Honiara, Guadalcanal, and the nearby islands of Savo and the Russell and Florida groups are taken to be local.

** Experience with K G VI students has shown that the majority of "not stated" cases for the father's occupation can be taken to be subsistence farmers. It seems likely, therefore, that the proportions of both boys and girls at Pawa PSS whose fathers are subsistence farmers are much higher than indicated. This conclusion would also tend to be supported by the high proportions from this school who reside locally and attended rural primary schools. The "unclassifiable" cases are definitely not subsistence farmers; these responses show that the father is a wage-earner, but simply give insufficient detail about his work.

The largely local recruitment to most of the schools is very noticeable. The exception is Waimapuru, but this is almost inevitable given the relatively small population of Makira Province itself. A large proportion of the students entering Waimapuru in 1990 were from Malaita: 42% of the girls and 25% of the boys; in this respect the school is similar to King George VI. This situation is not surprising, given the large population on Malaita, the comparative closeness of both schools to Malaita, and the fact that the only NSS on Malaita itself is Su'u, which is run by the strict, protestant South Seas Evangelical Church - a possible deterrent to other denominations. The high level of local recruitment to both of the Provincial Secondary Schools is not surprising, since this is just what these schools were established to do. The remoteness of Temotu province from the rest of Solomon Islands also contributes to the situation at Luasaleba.

The high proportion of students from Honiara primary schools in King George VI could be understood in terms of this local nature of secondary school recruitment, but this is a simplification of what is actually happening. Given the high demand for places at the school, it can generally choose from the very highest performers in the selection examination, and Honiara primary school students have the highest average marks in this examination (e.g. see Solomon Islands Government, 1984: 8). The presence of many Honiara-based students in the school must be understood at least partly in terms of this state of affairs and not just as a "local recruitment" phenomenon.

It is clear from Table 3.5 that the National Secondary Schools' enrolment is dominated by children from non-manual family backgrounds. In this respect, King George VI School is similar to the others, and different from the Provincial Secondary Schools, which are taking in a much higher proportion of those from subsistence farming families[2].

3.4 Student backgrounds: more detail

3.4.1 Town and country life

One experience which King George VI School does give to all of its students is that of an urban environment: an experience that has been claimed to be important for cognitive development and overall "modernisation" (e.g. Redfield, 1953; Dasen, 1972; Hallpike, 1979; Musgrove, 1982). For between ten and twenty per cent of the students each year, entry into Form 1 entails their first visit to Honiara. The impact of this should not be underestimated. Children who have never been out of Isabel before, for example, will never have seen a motor-car. Even those who have seen lorries, and perhaps the occasional car, in somewhere like Gizo or Auki can be overawed by the traffic density in Honiara, the crowds of people, the buildings, and the rest of the urban scene:

> "My first time, I feel, you know, excited. But when I reached Honiara I ... I became a bit afraid because of ... I saw many people, for my first time, and I see a lot of trucks. I've seen them in Gizo, but not too many trucks.
> (02/F/89, 1/5/91)

> "I felt ... I felt I was ... I was ... First of all I was ... When we are in Malaita, you used to wear same clothes all day but here in Honiara we have to be ... dress up nicely and neat ... clean. [Laughs] So I found it a bit difficult. Now I came with some money, so I bought things for myself. ... Because I was scared of the ... people who were ... who have work and they dress up so neatly and nicely and ... I saw myself and I was a bit lower than them. [Laughs]
> (13/F/88, 6/2/92)

The girl quoted in the second extract felt quite at ease in Honiara by the time she had reached Form 5 ("I feel like ... I'm just the same as them"), and had decided she would like to live in town after leaving school. Most of those students who had been in her position in Form 1 felt that they had adapted and lost their fear within a few weeks, the fear sometimes turning to fascination. The presence of *wantoks* in the school had often been a great help in this period of settling-in.

Although responses to a taste of urban life varied, there was certainly no universal conviction among the students from out of town that it was superior, no overall, undiluted admiration or irresistible attraction. Several students felt that life in Honiara was easier, with "Not so much hard work, like going to the garden" (04/F/87, 11/9/91), or just generally more convenient, "because it's easy to go from place to place" (11/F/89, 11/3/91); but the opposite opinion was also expressed:

> "Because all you need are there [on Isabel] ... to build your house or ... you can make a garden, then you can live there"
>
> (46/M/88, 18/5/92)

A large proportion complained that Honiara is too busy, too dirty, too noisy, too dangerous, or, commonly, just too crowded. For many of those who were brought up there, however, these conditions were familiar and acceptable:

> "I'm not used to the village; I spend most of my time in town"
>
> (01/F/87, 11/9/91)

Perhaps surprisingly, only a few students felt that Honiara offered them more activities. Even some Honiara residents felt that life in the village was more interesting, although this opinion was often based on impressions from once-yearly visits, and probably had a lot to do with temporary novelty:

> "Because there I can learn new things, whereas here I always do the same thing, in Honiara. ... Like going out in the gardens, things like that. Whereas here I just wake up in the morning, do the same things, sleep at night"
>
> (28/F/88, 27/2/92)

Life in the village was more likely to be seen as free from restrictions and rules, particularly by those who had lived mostly in Honiara:

> "I'm free to do a lot of things. You don't follow time mostly."
> (23/F/87, 23/8/91)

> "Because the life there is more ... carefree and different like Honiara where it's dangerous and you have to stick by rules for not getting into accidents and things like that."
> (38/F/89, 7/5/91)

Only one student complained of a lack of freedom in the village. This was a Malaitan boy who complained that "There's a lot of superstition in the village", which limited his freedom to go wherever he wanted, because of the presence of *tabu* sites that must not be entered (08/M/89, 16/5/91).

To judge from the frequency with which it was mentioned, however, the most significant difference between Honiara and elsewhere perceived by the students is that life in Honiara needs money, and life in the villages does not. This is not necessarily judged to be a bad thing, but it does mean that a job becomes a necessity of life in Honiara. But then Honiara is seen to be the most likely place to find a job, so many students were prepared to contemplate or even welcome life in the town, just as long as they could find the job which they felt an education prepared them for:

JL: Where would you rather live, Honiara or Nggela?
SS: I think I prefer Nggela.
JL: Why?
SS: Because when I stay at home ... life is ... gooder than in town ... better than in town.
JL: In what ways is it better?
SS: I mean the ... living. When I stay here it seems that if you have money then you ... do anything, but in home you just ... life is free.
JL: When you get a job ... If you had a choice of a job in Honiara or the same job elsewhere, out of Honiara, where would you rather be?
SS: I think here.
JL: In Honiara?
SS: In Honiara.
JL: So if you had the money you'd be quite happy to live in Honiara?
SS: Yes.

(56/M/88, 17/2/92)

Given the option, however, very many would prefer to find work outside Honiara, particularly if this meant being back at home. The attractions of the town are frequently not as strong as those of family, friends, and familiarity: these all provide a sense of identity to be preferred to the anonymity of town. Hence the tendency, mentioned earlier, to give the parents' island of origin as home, whether one lives there much or not:

SS: I think it's better to go back home.
JL: Why?
SS: Because ... because ... I can ... There's my land down there.
JL: You've got some land there?
SS: Yes, I've got the tribe's land.

(33/M/89, 14/2/91)

JL: Where do you prefer living, Mbambanakira or Honiara?
SS: Mbambanakira.
JL: Why?
SS: I have land there and it's where my family is.

(27/M/88, 12/3/92)

It is also clear, however, that there are some for whom familiarity now means Honiara. They have been brought up in the town, and the village is slightly alien, demanding an adjustment in behaviour. They remark on how they have to be careful of their dress and their behaviour when they return to the village, or on how they have to be reminded of village social etiquette. These are perhaps the first generation for whom this is true, and they remain a minority. They sometimes express a fascination in customs and stories from the village, and a visit may be enjoyed because it is a change and they may be treated as special, but they see their future as an urban one.

Urban and rural situations offer different possibilities and opportunities for activity. Students were asked how they liked to spend their time at home, and from listening to the responses, the impression one gets is of a wider range of options and a more active time for those in the rural areas, compared with those who live in Honiara. Playing netball, volleyball, soccer, cricket, going swimming or fishing, playing with canoes, walking into the bush, visiting friends, going on picnics, going hunting: these were the common answers about how free time was spent in the villages. Honiara residents said that they read books, walked around town - sometimes shopping, more frequently just walking - visited friends, listened to music or watched films or videos. Only occasionally did students have particular interests: one Honiara boy enjoyed trying to mend electronic equipment and playing with small electric motors; one Honiara girl played the piano, while weaving and sewing were pastimes of two rurally-based girls.

3.4.2 The gender divide

Throughout this study, it will become clear that gender is an important division in many spheres, in and out of school. It certainly plays an important part in the structure of life outside school, and the division of labour along gender lines is one clear illustration of this.

Virtually all students were expected to help with work when at home, although only about a third of them felt they were asked to do a lot. In a few cases, students were granted a privileged position among siblings because of their education or because visits home were infrequent, but for one boy this led brothers and sisters to demand he did more, to make up for his absence! Out of Honiara, both boys and girls help in the "gardening" ("garden" is used rather than "farm") but each has different tasks. The boys will help the men with the physically heavier work of clearing the forest, and other aspects of establishing a garden, and they may also have other responsibilities there, depending on custom and particular family conditions. The girls will do some of the planting, the weeding and the harvesting. Collecting firewood could be the work of either group, but the housework - cooking, cleaning, washing - is invariably left to the girls[3], unless family structure intervenes:

> SS [a boy]: I'm expected to help in the garden. The vegetable work is gardening. And also when we ... when we have ... er, things to eat ... for example, protein and things like that, we go fishing and ... also help in the cooking since ...
> JL: So you can cook, can you?
> SS: Yes, because ... because, according to our custom at home, girls are the ones who do the cooking, but since we do not have any sister, we have to help our mother do the cooking and things like that.
> (43/M/87, 4/8/91)

Although a few boys, and occasionally a girl, insisted that the boys do more work because they do the heavier work, the majority of both boys and girls agreed that the girls are expected to work harder. Attitudes to this situation varied:

> JL: Are your brothers and sisters expected to work as much as you, or more than you, or less?
> SS [boy]: I think they are expected to work quite hard than me.
> JL: Why do you think that is?
> SS: They are the only girls in my family. They have to help my mother cooking ... fetching water.
> JL: The boys don't help with the housework?
> SS: No.
> JL: Do you think that's right, that the girls do all the work?
> SS: Yes ... I think that's alright.
> (27/M/88, 12/3/92)

> JL: What about your brothers, are they expected to do as much work as the girls?
> SS [girl]: No, they are not expected to do very much work as girls.
> JL: Why is that?
> SS: Because our custom ... Boys are not the ones to

> do much work. Girls are the ones who do work.
> JL: Do you think that's fair?
> SS: No.
> JL: Do the girls ever complain about the fact that the boys don't do so much work?
> SS: Sometimes they complain but it appears that these are our custom.
> (20/F/88, 28/2/92)

An interesting response from one girl, when asked why her brother was not expected to do as much work as his sisters, was: "Maybe because we respect our ... I mean, brother, you know" (26/F/88, 30/4/92). In this context, "respect" certainly implies the brother's superiority and this usage was common among the boys in particular:

> SS (boy): Girls are expected to respect everyone in the family.
> JL: But boys aren't?
> SS: [Laughs]
> JL: Is that right? When you say "respect", do you mean ...
> SS: They must act as inferior and the boys are superior.
> (39/M/87, 12/9/91)

The inferior status afforded to women in Melanesia has commonly been commented on by anthropologists (Chowning, 1977), with Malaita in particular, in Solomon Islands, worthy of note:

> "If male-female antagonism is a Melanesian idiosyncrasy, it is a Malaitan obsession"
> (Ross, 1973: 120).

This antagonism manifests itself as a strict separation of the sexes, traditionally accounted for by the weakening and polluting effect of female procreative power, but justified in practice by an ideology of female inferiority. Writing of the Baegu of the interior of North Malaita, Ross says:

> "Baegu men do not in real life appear to fear women or contamination by women ... Avoidance is based on devaluation of female qualities: the belief that although they may be hard workers and good mothers, women are stupid, lacking in talent and moral fibre, and not to be trusted."
> (Ross, 1973: 121)

Such an extreme attitude was not found (or not admitted to) among the students of King George VI School, but comments from both girls and boys indicated that many of them did have backgrounds in which the notion of male superiority is ingrained, and that this carried over to some extent into their life at school. It was often claimed, for example, that arguments at school between boys and girls started because a girl had dared to answer a boy back, an action that is strictly against *kastom*. Sometimes, a boy would deliberately set up a situation which would allow him to reprimand a girl. In the following excerpt, notice how the Malaitan girl being interviewed seems to accept the boys' superiority and places the blame on the girl in a situation in which a boy is flagrantly exploiting *kastom* and his position:

> JL: Would you say that the girls and the boys in your class get on quite well together?
> SS: Not quite.
> JL: What is it that goes wrong?
> SS: The girls ... the girls don't respect the boys,

so the boys get angry. They say some nasty words to the girls.
JL: When you say "don't respect the boys", in what way? What do they do that shows they don't respect them?
SS: The girls start to say things to annoy the boys. And, for example, the boy sits down and a girl comes ... Because in my area, if the boy sit down and a girl walk past and he puts his leg upwards and the girl go over the leg, then that's very bad.
JL: And you think here the girls don't respect that, they climb over?
SS: Yes. [Laughs]
JL: Do you think that's very wrong?
SS: Yes.
(19/F/88, 12/5/92)

It was commonly, but not universally, reported by both sexes that boys had the right to give orders to girls from the same extended family, or even beyond, and expect those orders to be obeyed. It was generally considered either improper for a girl to give instructions to a boy or, if she did so, then compliance by the boy was at his discretion. During interviews, girls frequently claimed that, at school, boys would try to "boss the girls around" and would get angry if the girls either answered back or refused to do what they were told. Many of the girls saw this as merely teasing or attention-seeking pretence and admitted that the girls would also tease the boys to provoke a reaction. Occasionally it was clear that this behaviour was more than "normal" adolescent teasing and the boys would actually hit the girls out of anger. Some boys confirmed that this happened but it was probably quite rare. In fact, the majority of students felt that relations between boys and girls in the same class were good, especially later in the school when they had been together for some years.

This cultural unacceptability of women giving orders to men did occasionally lead to problems for female teachers. On two separate occasions sixth-form boys (both Malaitans) confided to me that they found it very difficult to take instructions from a female teacher. They were both apologetic about it, recognised that it was "wrong", but felt that it had been so much a part of their upbringing that they could do nothing about it. Such situations were rare, however, and the majority of both boys and girls interviewed expressed no preference for either male or female teachers.

There is a danger here of giving a false impression of the total dominance of the girls by the boys. Most interviewees, of both sexes, agreed that the girls generally had less freedom than the boys to do as they want at home, but this situation should not be over-stated. A key to understanding here is the second way in which the word "respect" was often used - by both sexes, but more frequently by the girls - which was to indicate a mutual or reciprocal respect: "They respect us and we respect them" (23/F/87, 23/8/91). This is a respect for a well-defined, distinct social space for each sex. It involves the observance of behavioural rules and taboos that preserve this distinct space. This is particularly noticeable in the relationship between brother and sister, a relationship in which students felt mutual respect was especially important and governing which there are clear rules, doubtless originating in incest taboos. Strict rules limiting interaction between opposite-sex siblings have been reported from different parts of Solomon Islands: for example, Scheffler (1965: 78-79) from Choiseul, and Hogbin (1964) from the hill people of Guadalcanal[4]. A student gave this example from his home, the Weather Coast of Guadalcanal:

> JL: Over in Mbambanakira, do you think custom ideas are still quite strong?
> SS: Yes, they are quite strong.
> JL: Which ideas do you think are still very strong?
> SS: For example, if you live in home in a small village, then if you know that your sister is living in the village and nobody else is living in the village, then you have to go somewhere.
> JL: So you couldn't stay on your own ...
> SS: You couldn't stay on your own with your sister in the village.
>
> (27/M/88, 12/3/92)

There has been considerable erosion of these traditional rules and taboos within the school, and just as the physical environment of Honiara is a shock for some students when they arrive from the countryside, so the social environment of the school can be a problem for them[5]. Most students seem to adjust to, and welcome, the greater freedom of contact between the sexes that is allowed in the school, although a small proportion of both boys and girls did state that they would have preferred to have been in a single-sex school.

Adjustment to the notion of equality of esteem in these social contacts was clearly more difficult for some.

These two lines of social division - rural/urban residence and gender - have been selected for particular clarification because they turn out to be important divisions too in the patterns of responses to school science that are discernible in the K G VI students. These patterns are the subject matter of the following chapters, the first of which describes attempts to find just which of the known background characteristics of the students are indicators of achievement in school science.

CHAPTER 4 RELATIONS BETWEEN BACKGROUND AND PERFORMANCE

4.1 Assessing backgrounds and performances

The aim in this chapter is to examine the relationships between aspects of the students' backgrounds and their performance in school science. Performance in science will be judged from school examinations, generally given twice a year, and from the external Solomon Islands School Certificate science examination results. Parental education and occupation, primary school location and performance, and gender are the personal background factors which are considered for possible effects on performance.

4.1.1 Parental education and occupation

The difficulties experienced with obtaining precise information on parental education and occupation were mentioned in chapter 3. In any one year-group, between 35% and 45% of students could not give information on either their mother's or their father's level of education, or both. This poor response rate led to the topic being dropped from the later version of the questionnaire, which, it will be shown later, was a mistake.

Father's occupation was classified as one of white-collar (higher), white-collar (lower), manual skilled, manual unskilled, or subsistence farmer. Allocation to the first two categories was made on the basis of an estimation of occupational status and likely required educational level, but choices were not always clear-cut. Doctors, accountants, lawyers, senior civil servants, secondary and tertiary level teachers, for example, were taken to be white-collar (higher), while clerical workers and primary school teachers are examples of the white-collar (lower) group, but it cannot be claimed that the boundary line was sharply defined, and there was undoubtedly a certain arbitrariness in the categorisation process. Any attempt to produce a more detailed socio-economic categorisation, or to tighten up the simple categories used, was not defensible, however, in view of the inability of many students to give a reliable or detailed description of the nature of their fathers' work. Very few students indeed fitted into the 'manual unskilled' category, so they were dropped from the analysis.

The proportion of mothers who are wage-earners was generally below 40% and although these were categorised, whenever possible, as either white-collar or manual, the numbers in the "manual" category were usually too small for reliable quantitative use. A coarser classification was therefore adopted, with mothers described as either in modern sector employment or not. Where the mother is the family bread-winner, because for some reason there is no father or the father is not working, the mother's occupation was used in place of the father's to assign a socio-economic status.

A reservation made earlier about the interpretation of parental occupation must be repeated. It is quite a common practice for a child to live with a relative, either permanently or during primary schooling; or conversely, for the child to remain at home in the village while the father works in Honiara. Thus, for example, one girl could report to me that although her father is a subsistence farmer with no formal education, she herself received all of her primary schooling in Honiara, where she lived with an aunt who is a teacher, and went home only once a year. Her home experience clearly cannot be considered to be the same as that of a student whose parents are similarly uneducated and who remained in the village for all of her primary schooling. Some such situations were picked out from apparent anomalies between home, parental occupation and primary school location; others were revealed in interviews.

4.1.2 Primary schooling

Primary school location is, unfortunately, a proxy for two variables which are difficult to disentangle. By distinguishing between primary schools in Honiara and those in rural areas, some indication of exposure to urban life is given. It is also clear, however, that Honiara primary schools tend, on average, to offer a higher quality education. A survey carried out in 1989 (Goodes & Mattiske, 1989) revealed the superiority of Honiara primary schools, both in terms of facilities and qualified teaching staff[1]. As a consequence, any relationship between performance and primary school location is rather difficult to interpret. Some indication of the effect of school quality compared with mere urban experience can be obtained, however, by subdividing the Honiara schools into high-cost private schools and those that are government-run. The former are better-equipped and tend to attract the best-qualified teachers, although some government primary schools also have well-qualified teachers.

It was also felt that some of the possible primary school quality effects would be taken care of by including performance in the secondary school selection examination results as one of the predictor variables. Several problems arise from this, however. One is that this information was not available for all of the students admitted in Form 1 in any one year: a significant proportion were taken in after the initial selection process, and selection examination data for these later entrants was rarely forwarded to the school. Secondly, it was clear that the scores in any one year were not directly comparable with those from any other year. Thirdly, these scores cannot be treated as independent of the other factors considered in the analysis of science performance.

4.1.3 Performance in school science

Performance in science is most easily measured using results from examinations given in the school twice yearly, at the end of each term. The weakness of this is that these examinations could be of uncertain quality, both in terms of the language of the questions and the extent to which the questions actually tested what they purported to test. Within the science department of the school, however, there had been a programme of exam quality improvement. This had three aspects: the checking of all examinations by an experienced member of staff before use, with suggested corrections and modifications discussed with the original setter; an analysis of performance, question by question, after use; and the establishment of a question bank of successful questions for future use. It was felt that by 1990 the internal examinations could be taken as a reliable assessment of the students' ability in the science that they had been taught, and results from that year onwards are used below. 1990 was also the year in which new secondary school selection examinations were introduced, scored on an entirely different basis to earlier ones, and giving a reasonable degree of discrimination between successful candidates for the first time. That year, therefore, was a particularly convenient point at which to start analyses.

A further source of information on science performance among the Form 5 students was the Solomon Islands School Certificate (SISC) science examination scripts, access to which was kindly granted by the Selection and Guidance Unit of the Ministry of Education. These are particularly useful for making comparisons between the performances of K G VI students and those from other schools, allowing them to be put into a national context.

4.2 Form 1 science performance

In any one year-group, or entry-cohort, the number of students in certain categories - such as girls from subsistence farming backgrounds - was too small to make statistically valid comparisons possible. It was therefore necessary to combine the results from several years' examinations. As mentioned above, 1990 marked a change in the secondary selection examination that gave useful data for the first time, as well as being the year by which it was felt internal examination data could be used with some confidence. By 1992 - effectively the last year of data collection - three entry-cohorts had sat the Form 1 end-of-year examinations, providing the largest available group among whom comparisons can be made. For this reason, the first part of the performance analysis looks at the results from Form 1 science only. This will be extended later to older students, but with smaller populations presenting problems with statistical significance.

4.2.1 Organising the data

The results for the Form 1, second term science examinations were standardised to give a mean of 50% and a standard deviation of 15% for each of the 1990-, 1991- and 1992-entry cohorts. These were then combined. The same procedure was carried out with the secondary school examination scores for the three separate papers, English, maths and reasoning, with these standardised scores then added to give a total score. It was realised that this was a suspect procedure since neither the science examinations nor the selection examinations were the same in the three years. It can be justified to some extent, however, if it is assumed that different years' intakes are, on average, quite similar, and the examinations, though different in detail, are similar in form and subject matter[2]. All examination scores were converted to Z-scores for the analysis.

No parental education data had been collected for the 1991 and 1992 cohorts, so this variable was ignored in the initial analysis. Those for whom some background information was missing were removed from the sample (secondary school selection examination score being the commonest omission). It was further decided to ignore the very few students who had received just one or two years primary schooling in Honiara since it was felt that they did not fit comfortably into the rural/urban schooling divide that was imposed. This left a total of 228 students (130 male and 98 female), the data for whom were subjected to an ordinary least squares multiple regression analysis.

4.2.2 The analysis

The search for any influence of primary school location on science score was made difficult by the very uneven distribution of those locations: 85% of both boys and girls in the sample came from either Honiara or Malaita primary schools, with the remaining 15% being spread over six other provinces. The average score for those from Honiara primary schools was, however, clearly higher than that from any other province, which suggested that a simple division into Honiara and non-Honiara primary schooling might be justifiable. Such a dichotomous variable used for primary school experience would be at least partially an indication of urban experience. In order to look for possible influences arising from differences in primary school quality within Honiara, however, a three-way division of primary schooling was made: Honiara government schools, Honiara private schools, and rural schools. Primary schooling at one of the provincial urban centres did not seem to be a significant factor. For example, the mean science mark for boys from the whole of Malaita was 49.7%, compared with 48.6% for those who had attended primary school in the provincial centre, Auki, and 60.0% for those who had been at Honiara primary schools.

Using Honiara government primary schooling as the base category, the normalised science score (NSCI) was regressed against Honiara private primary schooling (PSHP) and all rural primary schooling (PSRA), giving the following results:

Table 4.1 Normalised science score against primary schooling, 1990-92 cohorts

	ß	't' value	p
PSHP	0.100	0.576	NS
PSRA	-0.372	2.322	<0.025

This suggested that a simple division of the primary school data into Honiara and non-Honiara was sufficient. The former was taken as the base category, coded 0, and the latter coded 1.

For the father's occupation data, subsistence farming was taken as the base category and NSCI was regressed against skilled manual (FOMS), white-collar lower (FOWL), and white-collar higher (FOWH) to give these results:

Table 4.2 Normalised science score against father's occupation, 1990-92 cohorts

	ß	't' value	p
FOMS	0.017	0.074	NS
FOWL	0.158	0.920	NS
FOWH	0.587	3.250	<0.005

In the light of these figures, father's occupation was treated as a dichotomous variable, FOCC, with higher white-collar coded as 1 and the rest taken to be the base category. This now gave four dichotomous variables for the analysis:

Table 4.3 Dichotomous variables for performance analysis

Variable	Coded 1	Coded 0
Gender (GEND)	Female	Male
Primary schooling (PSCH)	Rural	Honiara
Father's occupation (FOCC)	Higher white-collar	Others
Mother's occupation (MOCC)	Employed	Not employed

The regression of NSCI against these four variables produced the results shown in Table 4.4.

Table 4.4 Normalised science score against four dichotomous student background variables

	ß	't' value	p
GEND	-0.768	4.231	<0.001
PSCH	-0.422	2.876	<0.005
FOCC	0.174	1.180	NS
MOCC	0.208	1.562	NS

Constant term = 0.318
Variance in NSCI accounted for = 18.5%

It seems that the tendency for white-collar fathers and working mothers to be associated with Honiara primary schooling reduces their independent contribution to performance to statistical insignificance. Interaction effects between gender and the other variables were sought for, but only that between gender and mother's occupation (GEND*MOCC) produced an effect that was at all significant:

Table 4.5 Significant dichotomous student background influences on normalised science score

	ß	't' value	p
GEND	-0.921	6.324	<0.001
PSCH	-0.544	4.363	<0.001
GEND*MOCC	0.377	2.029	<0.05

Constant term = 0.561
Variance in NSCI accounted for = 18.6%

The GEND*MOCC variable has value 1 only for girls whose mothers are in modern sector employment. The relatively low significance attachable to the moderately high value of the coefficient ß for this variable must be at least partially due to the small number of students in this category: just 43 out of the total of 228.

The normalised total scores from the secondary selection examination (NSELT) were then introduced into the analysis. Before looking at their relationship with science scores, however, it is worth pointing out their dependence on some of the other background variables. Regression of NSELT against the variables described above produced the results shown in Table 4.6.

Table 4.6 Normalised secondary selection exam scores against student background variables

	ß	't' value	p
GEND	-0.242	1.915	<0.10
PSHP	0.484	2.830	<0.01
PSRA	-0.142	0.813	NS
FOMS	-0.384	1.727	<0.10
FOWL	0.213	1.157	NS
FOWH	0.484	1.869	<0.10
MOCC	0.033	0.243	NS

Variance in NSELT accounted for = 17.2%

In contrast to the situation for NSCI, it seems to be quality rather than urban location that is the more important aspect of primary schooling for the selection results. This is shown by the high positive correlation with PSHP, but only a weak, non-significant negative correlation with PSRA. Once again, father's occupation is an important influence. On the other hand, the gender of the individual is much less important than it is for science performance. (It must be remembered that the selection examination scores used in this analysis are not representative of the examination as a whole, since K G VI students are selected from a narrow band of the highest performers only.)

Introduction of NSELT into the regression analysis for NSCI revealed a quadratic effect (NSELTSQ). Both gender and rural primary schooling remained as significant factors, but father's occupation became non-significant (ß = 0.069), and the significance of the GEND*MOCC term was reduced to just within the 90% confidence limit (Table 4.7).

Table 4.7 Regression data for normalised science scores and significant background variables

	ß	't' value	p
NSELT	0.351	6.102	<0.001
NSELTSQ	0.122	3.088	<0.005
GEND	-0.810	6.040	<0.001
PSCH	-0.356	3.002	<0.005
GEND*MOCC	0.283	1.662	0.10

Constant term = 0.328
Variance in NSCI accounted for = 32.4%

Summarised very briefly, these data state that the best performances in Form 1 science come from boys from urban primary schools who did well in the secondary selection examination, although girls who have a working mother can make up for some of the disadvantage of their gender. Table 4.8 gives an alternative illustration of the meaning of the regression data by comparing the top 10% and the bottom 10% of students (i.e. top and bottom 23 students) in the science score ranking.

Table 4.8 Characteristics of the top 23 and bottom 23 students by Form 1 science scores.

		Top 23	Bottom 23
Girls	(Number	4	16
	(With working mothers	4	4
Primary schooling	(Honiara private	13	2
	(All rural	5	16
Father's occupn.	(White-collar	18	11
	(Farming	4	8
Mean selection exam score		171	138

4.2.3 Some discussion

When compared with data on performance in science in other countries, the above analysis reveals both expected and surprising correlations. The poorer performance by girls has generally been found elsewhere (Lapointe, Mead & Phillips, 1989; Postlethwaite & Wiley, 1992), although exceptions have also been noted (Klainin, 1989; Lewin, 1992: 69), and the differences are greater in some areas of science than in others - a point that will be dealt with in the King George VI School context later in this chapter. The rural/urban experience divide does not appear to have been widely considered in relation to performance in science, although Duncan (1989) found that urbanisation had a positive effect on science achievement for students in Botswana.

The quality of schooling, however, has been shown to be of particular importance in less developed countries (Heyneman, 1986; Fuller, 1987), and yet this is appearing explicitly in the K G VI data only in the form of urban/rural school differences which may be attributable to influences other than school quality. Differences in quality within urban schooling do not seem to be significant. This disagreement is perhaps to be expected in that studies of school effects have generally looked at the quality of the school within which the performance is being measured. In the data for this research, connections are being sought between performance in a secondary school and quality of earlier primary schooling. Table 4.6, above, reveals that performance in the primary school - as represented by the selection examination results - does in fact depend on primary school quality: hence the distinction in scores between Honiara government schooled students and those from Honiara private schools. What the data do suggest is that this advantage of attending a high-quality primary school, while increasing chances of selection to King George VI School, does not carry over into science performance within the secondary school. There are two aspects of this situation which will be examined more closely later in this chapter. One is a more detailed analysis of the connection between primary school performance and secondary school science performance, while the other is a search for school effects on science performance through a comparison between K G VI and other secondary schools.

The second effect which has been observed elsewhere but which is not shown in the present data is the influence of socio-economic status of the family on science performance. Although Heyneman's (1986) review suggested that this is of limited importance in developing countries, the second IEA study of school science claimed that "the home is still the most powerful influence on achievement" (Postlethwaite & Wiley, 1992: 131), including developing countries in its analysis. There are several possible explanations for the apparent lack of influence of socio-economic status on science performance in the present study. One is quite simply that the process of selection in favour of students from high socio-economic status backgrounds is already more or less complete by the time students arrive at King George VI School: those selected for the school are those favoured by this process. This is reflected in the high proportion of the intake from white-collar backgrounds and from the high-cost Honiara primary schools (chapter 3); the latter has already shown to be important in boosting performance at the necessary selection hurdle. This influence of family background on educational attainment (rather than achievement) has been shown in several studies: Wolfe & Behrman, 1984; Smith & Cheung, 1986, for example.

Lockheed, Fuller and Nyirongo (1989) note that the extent of family background influence on achievement depends, in part, on the school subject under consideration, with science being likely to show the least effect. Thus the findings of Heyneman and Loxley (1983), that students' background characteristics were relatively unimportant in developing countries, applied to science only, and Schiefelbein and Simmons (1981), while claiming considerable influence for family characteristics, pointed out that this seemed to be less so for science achievement than for reading. Duncan (1989) found that parental occupation and education had no clear influence on the science performance of students in

Botswana. Lockheed *et al* suggest that this effect arises because a subject like science is less familiar in Third World communities and less linked to parents' own knowledge.

Rarely mentioned in studies of achievement, perhaps because they tend to be focussed on the primary level, is the possible influence of being a boarder rather than a day student. This is probably much more common in secondary schools in developing countries than in industrialised countries, and certainly one study, in Zaïre, has shown that it reduces the significance of family background for achievement (Lanzas & Kingston, 1981). Boarding was not considered as a possible influential factor in this study because the number of day students in the school was relatively small, and they were invariably from an urban background, so that it would have been difficult to disentangle effects.

Yet another possible explanation for the lack of family background influences on performance in this study is that the data collected are simply inadequate. The crude division of parental occupation into higher and lower white-collar, skilled manual and subsistence farming, used because of the inadequacies of the data from students, may not be sensitive enough to bring out any influences. To use a more discriminatory classification system, however, would be impossible, given the nature of the student's responses, and would in any case involve making decisions about the criteria for classification that would involve a certain amount of arbitrary choice, or would depend on unsupported estimates of "status". Status allocation in developing countries can undoubtedly be problematic and dependent on local conditions; it may be further complicated by distinctions between urban and rural status systems (Niles, 1981; Jamison & Lockheed, 1987; Lockheed, Fuller & Nyirongo, 1989). It seems feasible that education may be an important aspect of parental background influencing children's school performance, but the inadequacies of the information available on this matter have already been described. Despite these inadequacies, it was decided to examine the small sample for whom parental education levels had been obtained.

4.2.4 Parental education and science performance

Father's education level was known for only 52 students in the 1990 cohort, and among these a small number did not know their mothers' level of schooling. Education levels were categorised as none (used as the base category), primary (PRI), secondary (SEC), and further (FUR). (The prefix FED or MED is added to these variable names to indicate father's education or mother's education, respectively.)

For this small sample of students, regression analysis revealed no significant relationship between science performance and father's education:

Table 4.9 Normalised science score against father's education level, 1990 cohort only

	ß	't' value	p
FEDPRI	-0.696	1.076	NS
FEDSEC	-0.620	1.064	NS
FEDFUR	0.146	0.241	NS

Table 4.10 reveals that mother's education was also of insignificant influence, with the notable exception of one category:

Table 4.10 Normalised science score against mother's education level, 1990 cohort only

	ß	't' value	p
MEDPRI	0.227	0.535	NS
MEDSEC	0.053	0.134	NS
MEDFUR	1.700	2.982	<0.005

Variance in NSCI accounted for = 16.3%

This relationship between science performance and mother's education remained when the other variables found to be significant with the larger group were introduced into the analysis (Table 4.11). Coefficient values differ from those obtained with the wider sample, but influences remain in the same direction. The apparent lack of significance for the rural primary schooling effect may be at least partially explained by the small number of those with such a background in this sample.

Table 4.11 Normalised science score against important background variables, 1990 cohort only

	ß	't' value	p
GEND	-0.914	4.081	<0.001
NSELT	0.228	1.895	<0.10
MEDFUR	0.979	2.221	<0.05
PSCH	-0.264	1.138	NS

Constant term = 0.496
Variance in NSCI accounted for = 42.2%

As a further check on the reliability of this dependence on mother's education, and to make sure that it was not simply a "cohort effect" peculiar to the 1990 cohort, data from the 1989 entry-cohort were examined. Parental education information was available for 61 students in this cohort. The dependence of the Form 1, Term 2 NSCI on mother's and father's education was remarkably similar to that observed with the 1990 cohort, as tables 4.12 and 4.13 reveal.

Table 4.12 Normalised science score against father's education, 1989 cohort only

	ß	't' value	p
FEDPRI	-0.630	0.872	NS
FEDSEC	0.042	0.060	NS
FEDFUR	0.312	0.441	NS

Table 4.13 Normalised science score against mother's education, 1989 cohort only

	ß	't' value	p
MEDPRI	0.446	1.158	NS
MEDSEC	0.386	0.934	NS
MEDFUR	1.030	2.566	<0.025

The important points in both of these sets of figures are that a consistently positive correlation with science score is associated with mother's rather than father's education, and that there appears to be a threshold effect in operation, with the mother's education becoming particularly significant only when it has included a post-secondary component. It is difficult even to speculate on possible causes of this effect, and it is clearly in need of further investigation. It is interesting to note that in its analysis of influences on secondary school science performance ("population 2"), the second IEA study chose to use father's educational background, rather than mother's, claiming that the high level of correlation between them meant that only one was necessary (Postlethwaite & Wiley, 1992: 24). The data presented here suggest that the wrong choice may have been made.

4.2.5 More detail on primary school legacies

Although it has been shown that the secondary selection examination scores are a significant predictor of science performance at Form 1, this generalised statement turns out to hide some interesting detail. This detail is revealed when the data are analysed for various subdivisions of the student body, and when the selection examination total score (NSELT) is replaced by the scores in the three separate papers: English (NSELE), mathematics (NSELM) and reasoning (NSELR). Table 4.14 shows the results of regressing NSCI against each of these three variables for the girls only and then for the boys only, using the combined 1990-92 cohort data.

Table 4.14 Normalised science score against components of the selection examination, by gender, 1990-92 cohorts

		ß	't' value	p
(a) Girls only (N =98)				
	NSELE	0.353	4.111	<0.001
	NSELM	0.325	3.675	<0.001
	NSELR	0.193	2.164	<0.05
	Variance in NSCI accounted for = 29.2%			
(b) Boys only (N = 130)				
	NSELE	0.238	2.754	<0.01
	NSELM	0.245	2.916	<0.005
	NSELR	0.057	0.655	NS
	Variance in NSCI accounted for = 11.1%			

Points to notice are that the selection examination results are a better predictor of science performance for the girls than for the boys, and that, for each group, the English and mathematics scores are of similar importance, significantly more so than the reasoning scores. The situation becomes more complicated, however, when a further subdivision of the students is made, into those from rural primary schools and those from urban primary schools, as in Table 4.15.

For urban girls and boys - but most notably for the girls - it is performance in primary school mathematics which correlates most highly with science performance, whereas for the rural girls, primary school English is more important.

Table 4.15 Normalised science score against components of the selection examination, by gender and primary schooling, 1990-92 cohorts

		ß	't' value	p
(a) Girls, rural primary schools (N=31)				
	NSELE	0.663	4.854	<0.001
	NSELM	0.211	1.517	NS
	NSELR	0.184	1.321	NS
	Variance in NSCI accounted for = 44.4%			
(b) Girls, Honiara primary schools (N = 67)				
	NSELE	0.082	0.765	NS
	NSELM	0.441	3.976	<0.001
	NSELR	0.203	1.822	<0.10
	Variance in NSCI accounted for = 27.0%			
(c) Boys, rural primary schools (N = 68)				
	NSELE	0.029	0.231	NS
	NSELM	0.024	0.192	NS
	NSELR	-0.047	0.372	NS
	Variance in NSCI accounted for = -4.4%			
(d) Boys, Honiara primary schools (N = 62)				
	NSELE	0.249	2.185	<0.05
	NSELM	0.416	3.758	<0.001
	NSELR	0.163	1.408	NS
	Variance in NSCI accounted for = 27.8%			

A tentative explanation for this is that urban students have much greater contact with English outside the classroom. Hence, at least some of their performance in this subject has less to do with ability or with effort in school than with this greater exposure to the language. (This is supported by the fact that the standard deviation of the mean English selection score is much lower for urban students than it is for rural students: English is something all urban students have to some extent, and individual intellectual differences have less of an effect.) For the rural students, on the other hand, almost their only contact with English is in school, and their ability to learn and use the language will be more dependent on general intellectual ability and effort. This in turn may influence their handling of other subjects, including science but not necessarily mathematics, for which very different intellectual skills may be useful.

This hypothesis clearly does not apply to the rural boys, however, for whom the primary school examination results give no indication of how well they will handle first year secondary school science. They present an extreme contrast with the rural girls, for whom the selection examination scores account for almost half of the variance in science scores. It seems that for the rural girls, science is a part of "school knowledge", so that their performance in school in general correlates highly with their science performance. For the boys, however, there are resonances between their "life-world" knowledge (Solomon, 1987, after Schutz & Luckmann) and the science learned in school. For the boys, and for the urban girls more than the rural girls, there are experiences in their everyday lives which are relevant to the science they learn in school, so that general academic ability takes a less prominent part in predicting their ability to cope with scientific ideas.

4.3 Performance in Forms 1 to 3

4.3.1 Relative developments

Data available for the 1990-entry cohort are the most complete for an assessment of how performance in science changes as the students progress from Form 1 to Form 3. As a measure of change in performance between Form 1 and Form 3, the difference between the standardised science examination scores in Form 3 Term 1 and Form 1 Term 2 were calculated and converted to Z-scores (NIMPSCI). These were then regressed against the variables used in the analysis of Form 1 performance: gender, primary school location, selection examination score, and parental occupation. Only for the variable GEND was a significant correlation obtained: ß = 0.488 ($p<0.05$), with just 4.8% of the variance in NIMPSCI accounted for. Inclusion of interaction terms in the analysis suggested that it was the daughters of white-collar fathers in particular who were improving, but all coefficients were statistically non-significant.

As an alternative way of assessing and representing changes in science performance, mean scores were taken for various divisions of the students in each of the science examinations from Form 1 Term 1 (F1T1) through to Form 3 Term 1 (F3T1), and these are shown in graphical form in Figures 4.1, 4.2 and 4.3. The analysis is not continued beyond Form 3 here since selection at that point changes the constitution of the cohort.

Key to Figures 4.1, 4.2 and 4.3
/h: Honiara primary schooling
/r: rural primary schooling
/w: father's occupation: white-collar
/f: father's occupation: subsistence farming

Figure 4.1 Mean science scores, Form 1 to Form 3, 1990-entry cohort, by gender

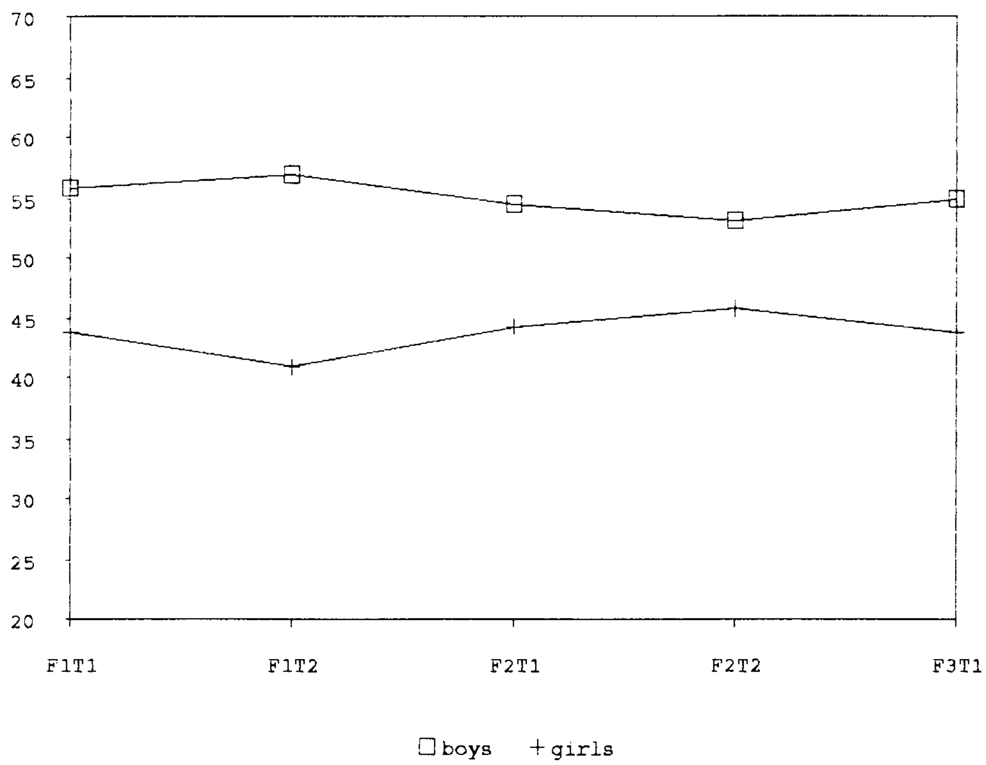


Figure 4.2 Mean science scores, Form 1 to Form 3, 1990-entry cohort, by gender and primary school background

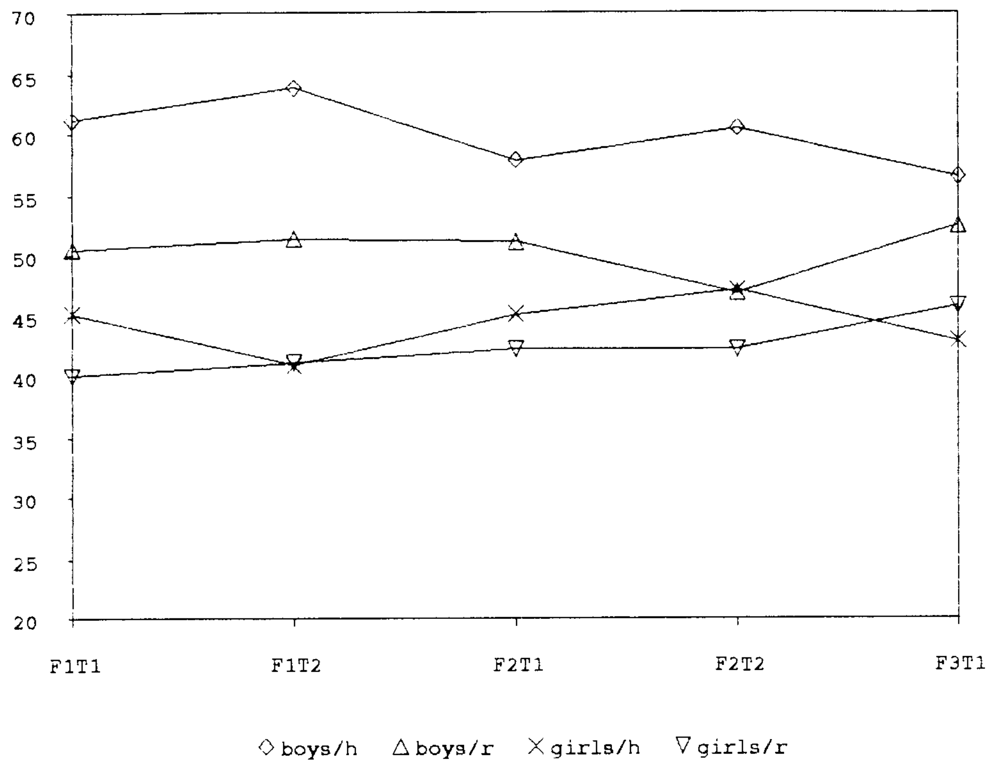
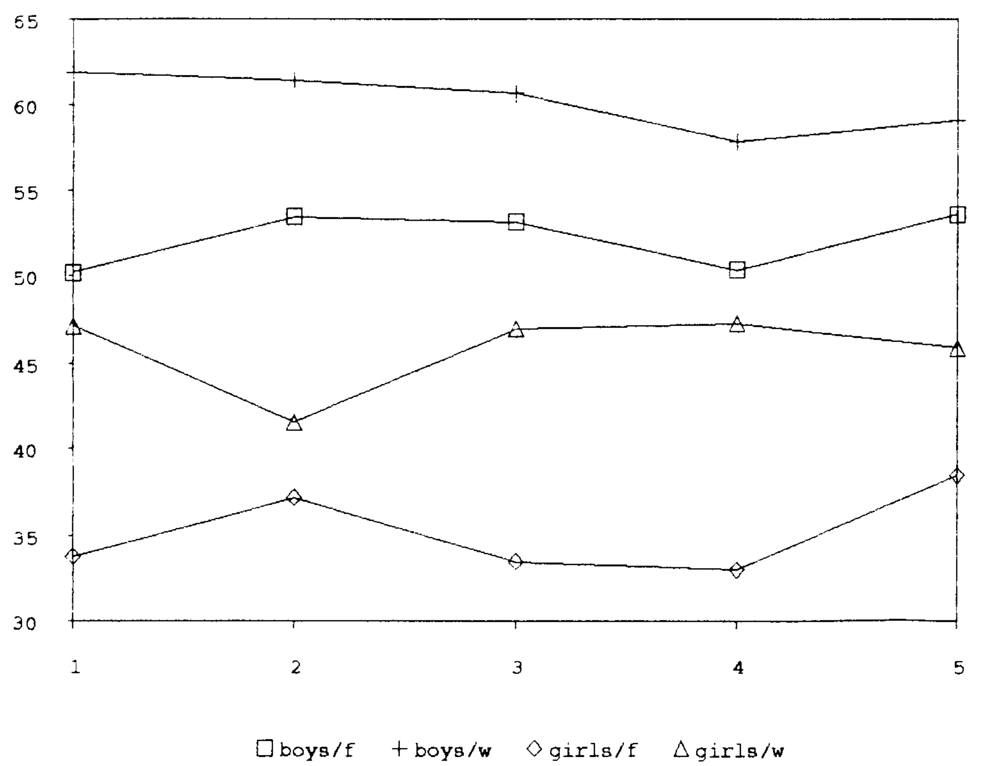


Figure 4.3 Mean science scores, Form 1 to Form 3, 1990-entry cohort, by gender and father's occupation



There is some suggestion in the graphs of a narrowing of the overall spread of scores, and hence of the gaps between certain groups, but this is small and unsteady. The Honiara-educated boys and rurally-educated girls, in particular, show slight negative and positive trends in their scores respectively. The main impression, however, is of the stability of the relative positions of the different groups. Only the girls from non-Honiara primary schools manage to change their relative standing between Form 1 and Form 3, and a closer look at the original data suggests that this improvement derives mainly from the small number of girls in this group who have fathers in white-collar occupations. Girls from subsistence farming backgrounds remain the poorest performers throughout and show no consistent upward trend in scores.

Overall, then, performance in science of various sub-divisions of students relative to each other remains fairly consistent throughout the first three years in King George VI School, and the above analysis of the results at the end of the first year can probably be taken to apply more generally to the whole of the first three years. The school may reduce some of the performance differences between groups but the effect is slight and inconsistent, and does not help the very weakest group.

4.3.2 Science and other subjects

An attempt to place science performance in the context of other subjects in the school was hindered by the lack of records in some subjects. In general, positions rather than marks were available and these, therefore, will be used to make a comparison of science with English and mathematics in the first three years of secondary schooling for the 1990-entry cohort. For each term's examination in each of the three subjects, the students were divided into a top third, middle third and bottom third, according to their examination rank. (Exact thirds were not always possible either because the total was not divisible by three or, more often, because several students shared the same rank.) The population of each of these 'thirds' was then subdivided according to gender, primary school history and father's occupation. The figures were then summed to produce a grand total distribution for each subject, which can be taken as a measure of average performance throughout the three years. This procedure produces sample sizes large enough to permit statistical analysis but removes the possibility of detecting developments in performances over the three years.

Within each of the 'thirds', each sample of students is given an index of representation by comparing its frequency of occurrence within the 'third' with its frequency of occurrence in the whole population. An index greater than 1, therefore, indicates that the sample is over-represented and an index of less than 1 indicates under-representation. A chi squared test is used to assess whether the distribution of indices for any sample differs significantly from random. These indices are given in Table 4.16.

This table clearly shows similar performance patterns for science and mathematics. These patterns can be summarised as an over-representation in the top third for boys and an over-representation in the bottom third for girls. In contrast, English reveals only slight, statistically insignificant deviations from a random distribution, with these deviations being marginally in favour of the girls over the boys. This similarity between maths and science is further revealed by correlations between scores in the two subjects for this particular entry cohort and for others. The 1987-, 1988- and 1990-entry cohorts all give quite high positive correlation coefficients for Form 3 science against maths results of between 0.72 and 0.80 for both boys and girls. Science and English on the other hand, produce generally lower, more variable coefficients between 0.35 and 0.7.

Further examination of Table 4.16 reveals that this similarity between maths and science is continued in the various sub-samples but the actual performance patterns vary significantly. Boys from all backgrounds are over-

Table 4.16 Indices of representation in English, mathematics and science for 1990-entry cohort, Form 1 to 3 ranking summed, by gender, primary schooling and father's occupation *(+ p value)*

Sample	Ranking (thirds)	English	Maths	Science
(a) <u>By gender</u>				
Boys	Top	0.89)	1.33)	1.42)
	Middle	1.10) *(NS)*	1.03) *(1%)*	0.97) *(1%)*
	Bottom	1.02)	0.64)	0.61)
Girls	Top	1.13)	0.58)	0.46)
	Middle	0.87) *(NS)*	0.97) *(1%)*	1.03) *(1%)*
	Bottom	0.98)	1.46)	1.49)
(b) <u>By gender and primary schooling</u>				
Boys/H	Top	1.47)	1.57)	1.81)
	Middle	0.99) *(1%)*	1.04) *(1%)*	0.82) *(1%)*
	Bottom	0.56)	0.37)	0.39)
Boys/R	Top	0.54)	1.09)	1.06)
	Middle	1.23) *(1%)*	1.06) *(NS)*	1.10) *(NS)*
	Bottom	1.33)	0.85)	0.85)
Girls/H	Top	1.39)	0.51)	0.44)
	Middle	0.96) *(1%)*	1.19) *(1%)*	1.15) *(1%)*
	Bottom	0.66)	1.31)	1.40)
Girls/R	Top	0.55)	0.74)	0.51)
	Middle	0.67) *(1%)*	0.47) *(1%)*	0.77) *(1%)*
	Bottom	1.70)	1.81)	1.70)
(c) <u>By gender and father's occupation</u>				
Boys/W	Top	1.36)	1.63)	1.79)
	Middle	1.20) *(1%)*	1.11) *(1%)*	0.96) *(1%)*
	Bottom	0.50)	0.25)	0.26)
Boys/F	Top	0.35)	1.36)	1.24)
	Middle	1.05) *(1%)*	0.91) *(5%)*	1.02) *(NS)*
	Bottom	1.58)	0.72)	0.75)
Girls/W	Top	1.47)	0.74)	0.52)
	Middle	0.86) *(1%)*	1.20) *(NS)*	1.11) *(1%)*
	Bottom	0.67)	1.06)	1.40)
Girls/F	Top	0.26)	0.40)	0.08)
	Middle	0.44) *(1%)*	0.40) *(1%)*	0.83) *(1%)*
	Bottom	2.17)	2.23)	2.07)

<u>Key</u>: H - three or more years primary schooling in Honiara
R - all primary schooling out of Honiara
W - father in white-collar occupation
F - father a subsistence farmer

represented in the top third for mathematics and science, but the extent of this is reduced to statistically insignificant levels for those from rural primary schools and farming backgrounds. In contrast, girls from all backgrounds are over-represented in the bottom third, to a marginal extent for white-collar girls in mathematics but to a very significant degree for rurally-educated and farming-background girls. Hence, for both of these subjects there is a basic gender division in performance on to which are superimposed home- and primary school-based patterns that are similar for boys and girls. For English, however, it is home and primary school effects which are most significant, once again being in favour of non-manual, urban children. Gender-based influences are less important, being neutral or marginally in favour of girls among urban and white-collar students, but favouring the boys among those from rural schools and farming homes. As a result, it is the daughters of farmers who achieve the least in all three subjects considered.

4.4 Science achievement after Form 3

4.4.1 Form 3 to Form 4 selection effects

Since selection into Form 4 from Form 3 is on the basis of results in examinations in English and mathematics only, one would expect, from the above analysis, that rural students, particularly girls, would be disadvantaged in this selection process. The figures support this expectation, as shown in Table 4.17.

Table 4.17 Percentage of Form 3 students returning to Form 4, combined 1988-, 1989- and 1990-entry cohorts

Sub-group	Proportion returning
All students	61.1%
Boys only	63.3%
Girls only	58.0%
Boys/Honiara pr. school	72.3%
Girls/Honiara pr. school	61.8%
Boys/rural pr. school	57.7%
Girls/rural pr. school	51.2%
Boys/white-collar	71.1%
Girls/white-collar	65.2%
Boys/subsistence farming	57.1%
Girls/subsistence farming	45.5%
Boys/rural p.sch/subs. farming	54.5%
Girls/rural p.sch/subs. farming	37.5%

The selection process clearly favours boys over girls and urban over rural - the same groups that achieve higher in science. The most disadvantaged group is clearly the girls with rural primary schooling whose fathers are subsistence farmers. Since these are also the weakest performers in science, any analysis of post-Form 3 science performance must be made with this fact in mind.

4.4.2 Biology versus the physical sciences

In Forms 4 and 5 at King George VI School, biology and the physical sciences are taught separately, usually by different teachers, and examined separately, even though the final external examination, the Solomon Islands School Certificate (SISC), mixes questions on both branches in all three of its papers. A first glance at the results for the internal examinations in both biology and physical science confirms that the pattern observed earlier, in which the boys out-perform the girls, is being repeated. For example, the Form 5, first term results for the 1987- and 1988-entry cohorts are as shown in Table 4.18:

Table 4.18 Form 5 science performance, biology and physical sciences, by gender

	1987 cohort mean score, %		1988 cohort mean score, %	
	phys. sc.	biology	phys. sc.	biology
Boys	52.1	50.4	52.4	51.1
Girls	46.9	49.5	44.6	47.5

(The results in each subject for each year have been standardised to give a mean of 50.0% and a standard deviation of 15%.)

Although the boys obtained higher marks in both subjects, the girls clearly did relatively better in biology than they did in physical science. To examine this effect more closely, the results from both cohorts were combined. The score obtained by each person in each paper was then expressed as a fraction of that individual's total (i.e. physical science plus biology) score. This fraction was then compared with the actual proportion of the total marks that were available for each subject (in this case, 0.5 for both biology and physical science) and expressed as a percentage. In this way, an indicator of the relative performance of each individual in physical science and biology was obtained: 100% for a subject indicating a score in line with the proportion of marks actually available for that subject in the total. (This may sound unnecessarily complicated compared with simply comparing the marks in the two subjects directly, but this procedure was adopted so that it could also be used in the SISC papers, and others, where each branch of science did not receive the same proportion of the total marks.) The mean performances were then calculated for various samples of the whole population, and the results are displayed in Table 4.19.

Perhaps the most remarkable figures in this table are those for the performance of rurally-educated girls in biology. In absolute terms, they are second only to boys from Honiara primary schools and the importance of biology to their

Table 4.19 Comparison of performances in physical science and biology in the Form 5, Term 1 examinations, 1987- and 1988-entry cohorts combined.

Sample *(n in brackets)*	Mean score (%)		Relative performance (%)	
	(standard deviation in brackets)			
	Phys. Sc.	Biology	Phys. Sc.	Biology
Girls *(49)*	45.9 *(13.3)*	48.6 *(13.2)*	96.7 *(9.0)*	103.3 *(9.0)*
Boys *(89)*	52.3 *(15.4)*	50.8 *(15.9)*	101.9 *(10.8)*	98.1 *(10.8)*
Girls/H *(34)*	45.8 *(13.5)*	47.1 *(12.5)*	98.1 *(8.5)*	101.9 *(8.5)*
Girls/R *(11)*	42.0 *(12.1)*	50.5 *(13.9)*	90.6 *(8.2)*	109.4 *(8.2)*
Boys/H *(33)*	56.8 *(17.5)*	55.8 *(16.7)*	101.1 *(8.8)*	98.9 *(8.8)*
Boys/R *(41)*	48.9 *(13.5)*	46.6 *(14.3)*	102.9 *(12.2)*	97.1 *(12.2)*
Girls/F *(8)*	41.5 *(9.5)*	48.0 *(8.0)*	92.1 *(7.6)*	107.9 *(7.6)*
Girls/W *(31)*	48.3 *(13.0)*	50.3 *(13.4)*	97.8 *(8.5)*	102.2 *(8.5)*
Boys/F *(18)*	48.4 *(11.6)*	48.7 *(10.0)*	99.4 *(9.7)*	100.6 *(9.7)*
Boys/W *(53)*	54.7 *(15.5)*	54.0 *(16.7)*	101.2 *(9.8)*	98.8 *(9.8)*

Key: H - three or more years primary schooling in Honiara
R - all primary schooling outside Honiara
F - father a subsistence farmer
W - father in a white-collar occupation

overall science performance is revealed by the high value of the relative performance indicator. The girls in general are clearly achieving much more successfully in biology than they are in physical science, in contrast to the boys, for whom there is only a slight bias in favour of the physical sciences. If we look at relative success in biology, the situation is a reversal of that noted in discussions of absolute success in science in general. Significant differences in the biology relative indicators are those of girls over boys (0.51 x standard deviation, $p<.01$), rurally-educated girls over Honiara girls (0.90 x *sd*, $p<0.05$) and farming-background girls over white-collar girls (0.68 x sd, $p<0.10$). For each of these three pairs, the differences in actual scores in biology are statistically insignificant. (It should be pointed out that the data in Table 4.19 have been produced by combining figures for the two cohorts in order to produce statistical significance for differences which are observed to exist in both sets of data separately.) Overall, it seems that a greater emphasis on biological content in a science course is likely to reduce the disadvantage which rural girls face.

An analysis of examination answers lower down in the school reveals similar (but not identical) patterns in relative performance, although these patterns are less distinct. Thus, in the science examination at the end of their first year, the boys in the 1991-entry cohort scored significantly higher marks than the girls overall, but only marginally higher in the biology questions. Similarly, Honiara girls did better than rural girls, and white collar girls did better than farming girls, but the differences in the biology scores were less than in the overall totals. If the performance in the biology questions relative to the rest of the paper is calculated as described above, the values given in Table 4.20 are obtained.

Table 4.20 Performance in biology questions relative to physical science questions in Form 1, Term 2 examination, 1991-entry cohort

Sample *(n)*		Relative performance in biology *(standard devn.)*	
Girls	*(39)*	115.2%	*(16.0)*
Boys	*(62)*	109.7%	*(16.5)*
Girls/H	*(25)*	113.9%	*(12.3)*
Girls/R	*(11)*	116.8%	*(21.0)*
Boys/H	*(31)*	111.0%	*(18.1)*
Boys/R	*(29)*	108.2%	*(15.0)*
Girls/F	*(4)*	114.5%	*(12.6)*
Girls/W	*(29)*	115.8%	*(17.9)*
Boys/F	*(21)*	108.2%	*(15.2)*
Boys/W	*(27)*	112.9%	*(16.8)*

In this case, the actual values of the relative performance indicators are unimportant. They show that students found the biology questions easier than those in physical science, but this could be as much to do with the questions themselves as with the students. It is the differences in these indicators between various samples that are important. The pattern in these differences is similar to that observed in the analysis of Form 5 performance if we look at gender and primary schooling only. This time, however, the differences are much smaller and statistically insignificant (although between boys and girls overall the difference just about scrapes through at the 10% level). Furthermore, the advantage offered to farming-background boys and girls is no longer visible. Although, once again, differences are not statistically significant, white-collar students, both boys and girls appear to have a slight lead: an emphasis on biology would tend to favour them rather than the farmers. For the 1990-entry cohort in their examination at the end of Form 2, very similar figures are obtained: a pattern of differences similar to that observed for Form 5, but less pronounced and with no advantage to the farming background girls over their white-collar sisters.

In view of these figures, the earlier statement on the advantages offered by an increased emphasis on biology must be modified. It seems likely that a greater biological content would be to the benefit of girls over boys and to the benefit of those from rural schools over those who are Honiara-educated. The advantage to students from subsistence farming backgrounds is not proven, however, and its appearance in the Form 5 data may be an artefact of the Form

3 to Form 4 selection process which, as mentioned earlier, discriminates against these students. The very small numbers of girls in particular from such a background does, of course, very much reduce the force of any conclusions drawn from the data; they remain more at the level of suggestion, requiring information from a much larger sample than was available in King George VI School.

4.4.3 King George VI students in a national context

Being given access to the students' SISC science answer papers for the 1989 and 1991 examinations provided an opportunity to make comparisons between King George VI students and those from other schools. The gender of the candidates was the only background information available, so the possible comparisons are limited. The examination comprises three papers: Paper 1 is all multiple-choice questions, Paper 3 is a practical paper, while Paper 2 consists of longer, 'structured' questions and accounts for sixty per cent or more of the total 'theory' marks. Detailed analysis was restricted to Paper 2, partly for the sake of simplicity and partly to avoid introducing question-type as another variable. Scores in this paper correlated very highly with overall scores, so it was felt that there was no loss of generality from this simplification. For the 1989 paper, the sample consisted of all students, but in 1991 this was reduced to being all of the girls and half of the boys. The selection of the boys was made by taking every second boy from each school after the boys' results for each school had been arranged in rank order. Results were not available for one school.

Average marks in this paper (with standard deviations), in each of the two years considered, are as shown in Table 4.21

Table 4.21 SISC science performance, 1989 & 1991, K G VI and other schools

		King George VI		All other schools	
		Girls	Boys	Girls	Boys
1989:	Mean, %	51.1	55.6	40.6	40.4
	sd	*12.2*	*14.5*	*12.6*	*13.5*
	n	*28*	*37*	*91*	*262*
1991:	Mean, %	67.5	70.1	53.8	55.6
	sd	*14.4*	*15.8*	*13.9*	*13.8*
	n	*26*	*36*	*98*	*109*

For both boys and girls, K G VI students, average scores are about one standard deviation above other students, whereas the differences between boys and girls within each group are much smaller and not statistically significant. (Despite this lack of statistical significance, the small superiority of the K G VI boys' performance over that of the girls - which is in turn larger than that noted among other students - is noteworthy as a continuation of the effect that has been pointed out for internal examination results.) In general it appears that, by this fairly advanced stage in their education, girls are performing in science just about at the same level as boys. It must be noted, however, that this situation is achieved only after selection processes have steadily eroded the girls' presence in the education system until they are outnumbered more than two to one by the boys.

Although, at face value, the results seem to support the conclusion reached be Heyneman (1986) that school factors are more significant than pupil background characteristics, this support cannot be given with confidence. It was shown in chapter 3 that a greater proportion of K G VI students came from Honiara primary schools than was the case in at least some of the other secondary schools. King George VI students are also drawn from those with the highest scores in the selection examination. Both of these two factors have been shown to be influential on science achievement. Without background information on the SISC candidates from the other schools, conclusions on the relative importance of school and home influences cannot be reliably drawn.

For further analysis, the questions in both papers were divided according to content into physics, chemistry and biology. In both K G VI and the other schools, the boys scored higher than the girls in all categories except for biology in 1989 for the other schools, and biology in 1991 for K G VI. The differences are generally small and insignificant, although the 1989 superiority of the girls in biology is just significant at the 10% level. Performance in each of the three content areas relative to their representation on the paper can be calculated as described earlier and the results are given in Table 4.22.

Table 4.22 Relative performances in physics, chemistry and biology components of 1989 and 1991 SISC Paper 2, K G VI and other schools

	Relative performance indicator (%)					
	Physics		Chemistry		Biology	
	Boys	Girls	Boys	Girls	Boys	Girls
1989						
King George VI	117.3	112.7	87.2	87.4	95.6	98.2
Other schools	108.6	102.9	90.2	87.1	100.0	104.9
1991						
King George VI	102.6	100.0	99.1	94.4	99.0	103.9
Other schools	103.7	99.3	93.0	95.3	102.6	104.0

As stated earlier, the actual values of the indicator merely reveal the relative difficulty that the students experienced with the questions. They do suggest that the chemistry questions tend to be found the most difficult, but this could be telling us something about the questions rather than the students. Examining differences between values, however, shows that the pattern observed in the K G VI internal results is displayed again here, both for K G VI students and others: the girls perform relatively - if not necessarily absolutely - better than the boys in biological questions, while the positions are reversed for physics. The position in chemistry is inconsistent.

4.5 Summary

Three correlates with science performance have been established: selection examination score, gender and urban/rural background. Links with parental backgrounds have not been clearly demonstrated, although there are suggestions that mother's education may be important, and having a mother working in the modern sector may be important for girls in particular. The disadvantage that girls, and most notably rural girls, suffer is most acute in physics, and less so in biology. King George VI School does little to counter the disadvantage that rural and female students face in handling the Solomon Islands secondary science curriculum.

A correlation is not a cause, and the next chapters of this thesis are an attempt to investigate possible mechanisms through which these observed factors may be operating. Selection examination score may be taken as an indicator of intellectual ability or as a product of primary school quality, or as both, but it is not really a factor whose influence on science performance can be investigated as such. The two basic concerns will, therefore be urban/rural background and gender.

In attempting to understand causes for the observed patterns in achievement, two broad lines of approach are possible: the cognitive and the affective. The background factors that have been shown to be correlated with performance may be encouraging differential cognitive development or cognitive styles, or they may act through the stimulation of attitudes which influence performance. It is not the intention in this thesis to provide a detailed analysis of the K G VI students' cognitive development[3], but one particular aspect of cognition was chosen, which it was felt may offer some understanding of at least some elements of the pattern of achievement. This is the subject of the next chapter, and data on the students' affective responses to science is considered in the subsequent two chapters.

CHAPTER 5 MECHANICAL REASONING AS A POSSIBLE INFLUENCE ON PERFORMANCE

5.1 The nature of 'mechanical reasoning'

'Mechanical reasoning' refers to the ability to understand the workings of simple mechanical arrangements such as levers and inter-connected wheels, such that the effect of a disturbance in one part of the arrangement on other parts can be predicted. Interest in mechanical reasoning ability arose from a curiosity about whether it might relate to performance in at least some aspects of physical science, notably 'mechanics' and the more concrete and applied topics. As the previous chapter shows, gender is one of the most important factors influencing school science performance for the students in the study and a relative weakness of the girls in the physical sciences is a characteristic of this gender-based difference. It was felt that an investigation of mechanical reasoning might help to illuminate some origins of the observed differences.

Mechanical reasoning has also been called 'mechanical comprehension', for example in the Bennett Mechanical Comprehension Test (MCT), which claims to measure "the ability to perceive and understand the relationship of physical forces and mechanical elements in practical situations" (Cronbach, 1990: 59). The Bennett MCT is much wider in scope and more complex in examples used than that which was desired and devised for the purposes of this research. It includes sections on hydraulics, structures and electricity, whereas it was resolved to restrict the 'machinery' in the test for K G VI students to levers and wheels, singly or interconnected. It was desired to place the emphasis on the skill to carry out in the imagination the manipulation of concrete objects rather than on a familiarity with complex machines, although it was anticipated that such familiarity, and general manipulative experience, would greatly influence the development of such skill. Whereas the MCT was designed to assist in employee selection, what was needed in this case was a test which was predictive of performance in at least some areas of school science. Hence this predictive ability was taken as a measure of the test validity.

5.2 Devising a test

Questions devised for use in the test were first given to a single class of Form 2 students, with some follow-up discussion on difficulties they had experienced in understanding these questions. This helped to reveal deficiencies such as poor wording or diagrams, and improved questions were then tried with other Form 2 students. The numbers involved in this trial stage were too small to make question inter-correlation exercises or other reliability tests very meaningful, but two questions were eliminated for giving a negative discrimination index. The remaining test of twenty three questions was given to 239 Form 1, 3 and 5 students (98, 88 and 53 students respectively). All the results were combined and the correlation coefficients of each question with every other question determined. Five questions with a mean correlation coefficient which was negative or insignificant at the 10% level were eliminated, leaving a test of seventeen questions. For this group of seventeen questions as answered by the 239 students, the Kuder Richardson coefficient of reliability (KR20) was calculated as 0.77. The final test of seventeen questions - to be referred to as the Mechanical Reasoning test, or MRT - is given in Appendix 3.

The MRT was administered in mid-1990 to each of three cohorts, that is at Form 5 for the 1986-entry cohort, Form 3 for the 1988-entry cohort, and Form 1 for the 1990-entry cohort. These students all sat their normal internal science examinations at about the same time. A comparison between science marks and the Mechanical Reasoning Test scores reveals significant positive correlations, particularly with physical science, as shown in Table 5.1. The physical science examination sat by the 1986-entry cohort comprised both physics and chemistry questions in the ratio of about two to one, whereas the Form 5 physical science exam taken by the 1988-entry cohort was composed entirely of questions

Table 5.1 Correlation coefficients for scores in Mechanical Reasoning Test and science examinations, for 1986-, 1988- and 1989-entry cohorts

Cohort	*N*	Science exam level	Correlation, r All science	Physical science	Biology
1986	*50*	Form 5		0.51**	0.32*
1988	*87*	Form 3	0.33**		
1988	*59*	Form 5		0.60**	0.42**
1990	*90*	Form 1	0.51**		

Significance: ** $p<0.01$
* $p<0.05$

on physics. The Form 3 and Form 1 examinations were a mixture of physics, chemistry and biology, with little chemistry at Form 1. For both of these forms, there was considerably emphasis on skills and processes so that several of the questions did not actually fit neatly into any of the traditional disciplines.

The KR20 score indicates an acceptable level of internal reliability for the MRT, while the correlations with science - notably physical science - performance confirm its validity as a measurement of an ability associated with that performance.

5.3 Test results and analysis

The performance of the 239 students who sat the test is summarised in Table 5.2.

Table 5.2 Scores in the Mechanical Reasoning Test, by entry-cohort, Form and gender.

Cohort	Form	Gender	*N*	Mean score (/17)	*s.d.*
1990	1	both	*98*	10.26	*2.84*
1990	1	male	*53*	11.33	*2.43*
1990	1	female	*45*	9.00	*2.76*
1988	3	both	*88*	12.81	*3.02*
1988	3	male	*60*	13.66	*2.86*
1988	3	female	*28*	11.00	*2.54*
1988*	3*	both	*61*	13.26	*3.09*
1988*	3*	male	*43*	14.06	*2.90*
1988*	3*	female	*18*	11.33	*2.62*
1986	5	both	*53*	14.26	*2.25*
1986	5	male	*36*	14.61	*2.03*
1986	5	female	*17*	13.52	*2.50*

* These figures are for those members of Form 3 who eventually returned to Form 4 at K G VI.

The major patterns in these figures are clear: there is a continual improvement in mechanical reasoning ability as the students pass through the school, but at each stage the boys out-perform the girls. In quantitative terms, the developments and differences can be summarised as follows.

For the girls, there is an improvement in score from Form 1 to Form 3 of 0.75 of a standard deviation and from Form 3 to Form 5 of 0.85 of a standard deviation (using data only from those Form 3 girls who returned to Form 4 for the comparison with Form 5). For the boys, the improvements are 0.88 of a standard deviation from Form 1 to Form 3, but only 0.22 of a standard deviation between Forms 3 and 5. This latter, apparently modest improvement should be treated with caution, however, since, by Form 5, a significant proportion of boys were scoring 16 or 17 marks out of 17 on the test and a 'ceiling effect' is almost certainly coming into play, as evidenced also by the relatively low value of the standard deviation for this group.

The boys' lead over the girls was 0.90 of a standard deviation in Form 1 and 0.96 in Form 3 (virtually identical at 0.97 for those who returned to Form 4). Although the difference between boys' and girls' performances in Form 5 was only 0.50 of a standard deviation, the cautionary note about a possible ceiling effect here should be remembered. (Furthermore, although ethnicity has not been used as a factor for analysis in this work, it is worth pointing out that in this particular Form 5 group - the 1986-entry cohort - the proportion of non-Melanesian girls was unusually high. Five out of the seventeen girls in the group scored 16 or 17 on the test, but all of these were Micronesian, Chinese or half European.)

In broad terms, the figures show that in the development of mechanical reasoning ability, as measured by this test, the girls remain a little over two years behind the boys as they pass through the school. This agrees only partially with the results quoted by Cronbach (1990: 180) for the Bennett Mechanical Comprehension Test, presumably obtained with United States subjects, for which "[s]cores of high school males exceed those of females on average, the difference increasing with grade level." This increasing difference is not clearly present in the King George VI School data: the girls develop mechanical reasoning ability at a similar rate to the boys, but start from a lower base.

5.4 Extending the data base

Ideally, a re-test of the 1988- and 1990-entry cohorts two years later, in Form 3 and Form 5 respectively, should have been given, to provide a better indicator of development. For practical reasons, this was not possible, but ten of the seventeen questions in the test were given to these two cohorts and the 1992-entry cohort two years later (1992), as part of a wider test. (The ten were numbers 1, 2, 3, 5, 6, 9, 14, 15, 16, 17 from the original MRT.) Marks from these ten questions taken on their own provide further data for judging development, and can also been compared with marks obtained for the same questions in the earlier test. This latter procedure essentially treats the ten questions as a shortened version of the MRT, reduced in sensitivity because of the decreased range of marks, and not checked for validity or reliability as the MRT was. They are treated as a check on the results of the main test rather than as a full re-test.

Broadly speaking, the patterns observed in the main test are repeated in the shorter version. The scores for both boys and girls increased from Form 1 to Form 3 and from Form 3 to Form 5, with the boys always remaining ahead, as shown in the results given in Table 5.3.

Table 5.3 Scores in ten selected questions from the MRT, entry-cohort, Form and gender

Cohort	Form	Gender	*N*	Mean score (/10)	*s.d.*
1992	1	both	*96*	5.41	*2.01*
1992	1	male	*60*	5.92	*2.07*
1992	1	female	*36*	4.56	*1.59*
1990	3	both	*94*	6.28	*2.31*
1990	3	male	*50*	7.36	*1.95*
1990	3	female	*44*	5.05	*2.06*
1990*	3*	both	*58*	6.84	*2.22*
1990*	3*	male	*36*	7.58	*1.89*
1990*	3*	female	*22*	5.64	*2.19*
1988	5	both	*58*	7.67	*2.13*
1988	5	male	*40*	8.23	*2.04*
1988	5	female	*18*	6.44	*1.77*

* Only those who later returned to Form 4 at K G VI

The increases between forms are less regular than in the longer test, and there is some evidence in these scores of the difference between boys and girls increasing with passage through the school. At Form 1, the difference is 1.36 marks (or 0.71 x *sd*), at Form 3 it is 2.31 (1.16 x *sd*), and at Form 5 it is 1.78 (0.91 x *sd*). The Form 1 to Form 3 increase in this difference is statistically significant ($p<0.025$), but the increase from Form 1 to Form 5 is not.

This repeated administration of part of the MRT allowed some limited, truly longitudinal analysis. For the 1990-entry cohort only, the improvement in scores in these ten questions alone between Form 1 and Form 3 was 0.98 marks (0.51 x *sd*) for the girls, and 1.58 marks (0.85 x *sd*) for the boys. The 1988-entry cohort showed improvements between Form 3 and Form 5 of 0.56 marks (0.32 x *sd*) for the girls, and 0.53 (0.25 x *sd*) for the boys.

The improvements in the 1990 cohort scores are particularly interesting when a more detailed analysis is made. Among the girls, those from rural backgrounds improved their score more than those from Honiara: an average improvement of 1.62 marks compared with 0.65. With the relatively small numbers of students in the samples, the difference is just statistically non-significant, but it is certainly of substantive interest. By Form 3, the 1990 cohort rural girls were performing as well as their urban sisters in this limited measure of mechanical reasoning, although they had lagged significantly behind in Form 1. Among the boys, the position is reversed with the Honiara boys increasing their score by an average of 2.2 marks, compared with 1.13 for the rural boys (just significant at the 10% level). This increased an already significant superiority in the average performance of urban over rural boys in Form 1.

Despite these data from the 1990 cohort, differences between rural and urban students in the cross-sectional data are less clear. In the main MRT, there is a consistent superiority of boys from Honiara primary schools over those from rural primary schools, at Form 1 and Form 3. The differences in scores, while quite large at 0.49 x *sd* and 0.36 x *sd* for Form 1 and Form 3 respectively, are just outside the 10% significance level. In the smaller, ten-mark test, these differences are larger, at 0.90 x *sd* and 0.82 x *sd*, and are significant at the 1% level. For the girls, however, there is no consistent difference superiority of urban over rural students, or vice versa, at Form 1 or Form 3. At the Form 5 level, all the differences between rural and urban students, both boys and girls, become statistically non-significant.

Overall, the evidence for Cronbach's growing differential between boys and girls is not convincing as far as the students of K G VI are concerned. Combining the data from the full MRT and the shorter version shows a mean improvement between Form 1 and Form 3 of 0.81 of a standard deviation for boys, compared with 0.50 for girls. The girls show greater improvements between Form 3 and Form 5, but the caution needed in interpreting this has already been stressed. The most that can be stated confidently for the students in this study is that both boys and girls show considerable improvement in mechanical reasoning ability as they pass through the school and that differences in the rate of this improvement are slight, probably to the early advantage of the boys but with the girls catching up somewhat later.

When discussing the Bennett MCT, Cronbach (1990: 220) also questions whether, in view of this tendency for females to score lower than males, it has the same predictive value for both. If the predictive value of the devised Mechanical Reasoning Test is taken to be indicated by correlations between it and science scores, then there are indeed differences between its value for boys and for girls, although these are not entirely consistent. For the 1990-entry cohort the MRT scores obtained in Form 1 give correlation coefficients with Form 1 Term 2 science marks of 0.32 ($p<0.05$) for the girls and 0.43 ($p<0.01$) for the boys. These coefficients increase to 0.37 ($p<0.05$) and 0.50 ($p<0.01$) respectively when the same cohort's Form 3 science marks are used. The 1988-entry cohort sat the MRT in Form 3 and correlations with their Form 3 science marks are 0.06 (*NS*) for the girls and 0.41 ($p<0.01$) for the boys. For those in this cohort who returned after Form 3, the correlation coefficients for MRT with Form 5 physical science marks are 0.35 (*NS*) and 0.66 ($p<0.01$) respectively, with corresponding values of 0.22 (*NS*) and 0.53 ($p<0.01$) for MRT with biology. These figures suggest that mechanical reasoning ability is indeed a better predictor of science performance for boys than it is for girls, and that it is an ability more relevant to physical science than to biology.

A partially contradictory pattern emerges, however, for the 1986-entry cohort, who sat the MRT in Form 5. For the girls, the correlation coefficients are 0.76 ($p<0.01$) for MRT and physical science, and 0.53 ($p<0.05$) for MRT and biology; these compare with corresponding coefficients of 0.36 ($p<0.05$) and 0.26 (*NS*) for the boys. A combination of very small sample sizes (16 girls and 34 boys), the 'ceiling effect' on the MRT score, and the rather exceptional ethnic balance in the girls in this cohort - referred to earlier - suggest that these figures should be treated as being somewhat unreliable and exceptional, rather than as a convincing contradiction to the pattern observed with the other data.

5.5 Mechanical reasoning and spatial reasoning

It seems reasonable to anticipate a significant positive correlation between mechanical reasoning and more general spatial reasoning. Cronbach reports that the MCT correlates about 0.6 with measures of spatial reasoning (Cronbach, 1990: 180). Form 3 students in Solomon Islands used to sit a Space Relations Test as part of a battery of Scholastic Aptitude Tests until these were abandoned after an investigation revealed that very little use was being made of results from them, and that they added little to what was already known about students from other sources considered more reliable (Livingstone, 1991). The Space Relations Test required students to fit shapes into spaces in squares, hence involving the mental rotation, translation and fitting together of shapes, i.e. the imaginary manipulation of two-dimensional 'objects'. For the Form 3 students who sat both this Space Relations Test and the devised Mechanical Reasoning Test in 1990, a positive correlation was in fact found with a value very much in line with that given by Cronbach ($r = 0.54$, $p<0.01$).

The tendency for scientists, notably physical science specialists, and students who choose science courses to show greater than average spatial abilities is widely reported (Roe, 1952; Smith, 1964; Child and Smithers, 1971; Bradley, 1981; Kelly, 1987). This association is frequently interpreted as a causal link, largely through some feeling of logical necessity, that the physical sciences "ought" to demand greater spatial ability. Thus Gray (1981: 43) states that "[I]ntuitively one would expect the requirement for spatial thinking to be greater for physics and least for biology, with chemistry somewhere in between". The nearest he gets to justifying this intuition is to refer to a study by Werdelin which showed that spatial ability forms one part of the structure of mathematical thinking which, in turn, is important in science. This has an interesting link with a point made in the comprehensive review of the psychology of sex differences by Maccoby and Jacklin (1974), a work which has itself - and, to my mind, rather strangely - been used to support the link between science achievement and spatial ability (e.g. Sayers, 1980). They point out (p 91) that a space factor emerges as part of mathematical skill for boys but not for girls, and suggest this means that girls have different mathematical "styles" which do not in themselves imply an inferior performance. The different degrees of correlation between mechanical reasoning and science performance for boys and girls, found in the present study, is interpretable as indicating either a different approach to science questions by the girls, or a difference in performance on science questions that make different cognitive demands. Maccoby and Jacklin (*op cit*: 89-91), for example, refer to the Harvard Project Physics study which showed that male students performed better on questions involving visual-spatial skills whereas females did better on verbal-skill items.

Other writers have been more circumspect in interpreting the association between spatial skills and science performance. Halpern (1986: 48) only feels confident enough to state that "[I]t seems likely that visual-spatial skills are used extensively in engineering, architecture, chemistry and the building trades". Sayers (1980) criticises a professor of psychology who sees boys' superior spatial ability as "obviously" making them better architects or engineers, while Curran feels that the emphasis on differences in spatial skills is something of a red herring:

> "Spatial ability may be linked to science ability but the two are not synonymous. There are many other factors involved ... For example, convergent thinking, logic, independence, self-assertion and conservatism have been variously linked with the scientific mode of thought."
>
> (Curran, 1980: 27)

I. M. Smith (1964: 135-139) appears to treat spatial ability as an inborn trait and sees mechanical reasoning as a sub-set of more general spatial abilities. Petersen (1980) argues for a strong biological component to spatial ability, particularly when accounting for the well-established difference between boys and girls in this ability. She does, however, accept that evidence that spatial skills can be enhanced with practice is suggestive of some socio-cultural influence. Cronbach (1990: 59) quotes the Bennett MCT manual's claim that "[m]echanical comprehension may be regarded as one aspect of intelligence" but himself rejects this claim and suggests that "MCT is a measure of understanding acquired through general exposure to tools and machines" (p 221). In a wide review of studies of spatial abilities, Lohman (1988) describes attempts to train spatial skills and suggests that even the limited success of these is "difficult to explain theoretically when spatial ability is viewed as a trait" (p 220). His own research and his review of other data leads him to support the conclusion that "activities such as woodworking and automechanics may assist in developing spatial skills" (p 231).

The very significant improvement made by the K G VI students on the Mechanical Reasoning Test during their secondary school careers supports the view of mechanical reasoning ability being, at least partially, a product of experience, but exactly what experience is less clear. If "exposure to tools and machines" is the important experience, the boys might be expected to make significant gains over the girls while at K G VI simply from the fact that they all take Manual Arts and the girls do not. The absence of clear evidence for any large gains has already been mentioned: the difference in mechanical reasoning ability seems to be already established when the students arrive at the school and school experience seems to produce roughly equal improvements for both boys and girls. It may be, however, that secondary school is offering experiences to the girls which would improve their mechanical reasoning to a level comparable with that of the boys, if only the boys were not continuing to develop through the extra experience of tool handling in Manual Arts which is not available to the girls.

5.6 The MRT and personal experience

5.6.1 Levers

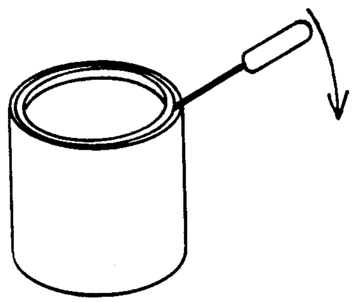
Some light can be thrown on the role of experience from the responses to two of the questions on MRT which were also used in the shortened version that formed part of the wider 1992 test. After this test, between 34% and 44% of all students in each of Forms 1, 3 and 5 were interviewed about their answers to some of the questions. This included two questions on the use of levers, questions 5 and 9 on the MRT (see Figure 5.1). The first of these is about prizing a lid off a tin using a knife, the students being asked to choose which knife, out of three of different lengths, would allow the lid to be prized off using the smallest force. The second question is identical in principle but concerns the use of a spanner to loosen a nut. (Unfortunately, the drawing in this question actually shows a bolt rather than a nut: this was not noticed for more than two years, until these interviews started!). In both questions, application

Figure 5.1 Questions 5 and 9 from the MRT

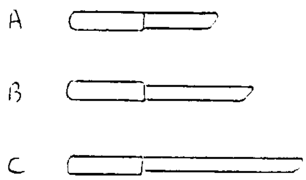
Question 5

The lid on this tin of Milo is stuck really tight.

I want to use a knife to lever it off, as shown in the drawing



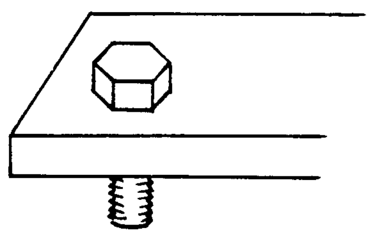
The drawings below show three knives - A, B and C. Which one should I use so that I can lever the lid off with the smallest force?



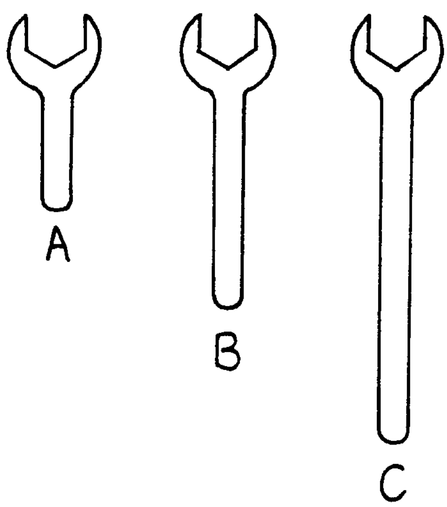
Question 9

The nut in this diagram is stuck really tightly in the metal plate.

I want to unscrew the nut with a spanner.



The drawings below show three spanners - A, B and C. Which one should I use so that I can unscrew the nut using the smallest force?



of the concept of mechanical advantage of a lever leads to the choice of the longest knife, or spanner, as the one which requires the smallest applied force to do the job. This concept may emerge quite easily from the experience of using a spanner (even though it may remain intuitive rather than being capable of formal expression): even if one does not have a variety of lengths of spanner available, one quickly learns that the greatest effect is achieved by applying the force as far from the nut as possible. Levering a lid of a tin is a different experience, however. Firstly, with the possible exception of those on tins of paint, tin lids rarely require a very large force to remove them, so the convenience of the smaller movement of a short lever often outweighs the mechanical advantage of the longer one. Secondly, a longer knife is more likely to bend and break than a shorter one. Very few of us would, in practice, choose a long knife in preference to a short one for this task. The mechanical advantage of the lever takes second place to other practical considerations and this is a poor task through which to learn the concept. Choosing the long knife as the answer to this question shows an appreciation of the principle of the lever rather than just experience of a particular application of the lever. It may demand an acceptance of the principle in the face of conflicting personal experience. Thus, to get this question right - for the right reason - involves going beyond experience to abstract and apply a rule which may be obscured by other influences, in order to understand the principle as universally applicable.

Table 5.4 gives the proportions of boys and girls giving the correct answer to each of the two questions, these figures having been obtained by combining the results of both the 1990 and the 1992 tests.

Table 5.4 Correct response rates to questions on levers, by Form and gender

	Percentage choosing the longest lever *(Sample sizes in brackets)*			
	Knife & tin lid		Spanner and nut	
	Boys	Girls	Boys	Girls
Form 1	19% *(113)*	11% *(81)*	49% *(113)*	34% *(81)*
Form 3	35% *(110)*	11% *(72)*	76% *(110)*	51% *(72)*
Form 5	67% *(76)*	51% *(35)*	96% *(76)*	66% *(35)*

As anticipated, the knife and lid question proved to be more difficult. The girls clearly lag behind the boys on both questions, although the ratio of the percentage of boys getting the spanner question right to the percentage of girls getting it right remains constant at just under 1.5:1, and, in the knife and lid question, there is dramatic improvement between Form 3 and Form 5. An indication of the extent to which the principle of the lever has actually been understood, either from science lessons or by generalising from experience, is given by the proportion of students who choose the longest lever as the answer to **both** questions.

For the boys, this is 14% in Form 1, rising to 32% in Form 3, and reaching 66% in Form 5. The girls take much longer to learn the principle, or, at least, to accept its general applicability: the 2% of Form 1 girls getting both questions correct had only risen to 7% by Form 3, but then jumped to 37% in Form 5. The original MRT contained a third question on the mechanical advantage of a lever, question 13 (see Appendix 3). If we apply the more demanding criterion that students who understand this concept should get all three of these questions correct, then this time lag between boys and girls in the development of the concept appears even more starkly (although the sample size is much smaller since this criterion can only be applied to those who sat the full MRT in 1990). No girls at all in Forms 1 and 3 gave the correct answer for all three questions, but 53% did so in Form 5 (9 girls out of 17). The proportion of boys getting all three correct rose from 6% in Form 1 (3/53) to 28% in Form 3 (17/60) and to 72% in Form 5 (26/36).

Levers, and other simple machines, do not appear on the Solomon Islands science syllabus until Forms 4 and 5. The above data suggest very strongly, therefore, that it is only when levers are dealt with explicitly in science that the girls begin to appreciate the general principle. The boys, on the other hand appear to be developing an awareness of the principle before it is met in science lessons.

Presumably this occurs through their personal experience of devices which provide clear illustrations of it.

Those students who were interviewed about their answers to these two questions were asked if they had ever used a spanner. Less than half of the girls (45%) had done so, but almost all of the boys (97%) had, with more than half of these boys stating they had used a spanner "often" or "quite often", whereas the girls' experience was almost always limited to "once" or "once or twice". Bicycles, outboard motors, connecting up gas cylinders and changing vehicle wheels were the main sources of the boys' experience. The girls' limited opportunities to use a spanner came from a surprisingly wide range of activities, including building a house, repairing a sewing machine, bicycles and connecting gas cylinders. Life in Honiara seems to offer the girls more opportunity to use a spanner, but the number of girls from rural areas and the number who have used a spanner are both too small to make much of this observation.

The importance of following up the written test with individual interviews can hardly be overstated. As most teachers are aware, written tests are rarely, if ever, perfect measuring instruments. No matter how well devised the questions are, students guess, make mistakes or mis-read questions. The impersonality of such tests makes some students answer questions less conscientiously than the setter would hope, knowing that even if the test is reviewed later in class there is unlikely to be any individual follow-up. Individual discussions with a sample of students after the test, however, allows some assessment of the extent of these effects and of the validity of conclusions drawn from the answers. In the context of this research (and, in my opinion, in the context of classroom teaching too) the greatest value of such follow-up arises from the insight which it can give into the students' thinking. An examiner setting a multiple-choice question will devise distractors to satisfy anticipated erroneous reasoning. If a student chooses a particular wrong answer the examiner will perhaps feel that he or she now understands the reasons for this choice: a trap was set, a victim caught and the route taken to the trap is confidently announced. My own experience is, however, that students have many more ways of reasoning through to both right and wrong answers than are dreamt of by most examiners. For many questions, it is only by asking students to explain how they arrived at an answer that can one really know whether a right answer does indicate the grasp of a concept, or what the misconceptions are that produced a wrong answer. Good (1977) makes a similar point when he urges caution in the use of pencil-and-paper tests for the assessment of Piagetian conservation skills: until one talks to the students one cannot be quite sure how they interpret the question and what, therefore, is being tested. A widely-administered written test is probably quite reliable for assessing the extent to which a particular concept is held, although guessing and fallacious reasoning may make this assessment over-optimistic; it is less useful for uncovering misconceptions, unless supplemented by other forms of assessment.

During interviews on the two lever problems, about 6% of answers were changed by students on reconsidering the questions. For some students, the interview was held several weeks after the test and these changes revealed a genuine change of mind, but in others it was clear that the presence of an interviewer led to a more careful consideration of the problem than had been given under the relatively anonymous conditions of the written test. A further 4% of answers were admitted to be guess-work while no explanations could be given for the choice of a further 3%, which could mean these were guessed at or that the students simply felt they could not explain themselves. Overall these figures suggest a reliability of greater than 85% for these questions in the written test.

Among Form 1 students, interviews about the two lever questions revealed widespread lack of knowledge, even at an intuitive level, about the principle of the lever. This was most noticeable with the girls, but still significant amongst the boys. This was clear in the spanner-and-bolt question, where the length of the spanner was often not seen as the key consideration. The size of the spanners' jaws compared with the size of the bolt head was frequently the main factor influencing choice. All the spanners were actually drawn with identically-sized jaws (this being re-checked after this tendency began to appear in interviews) but students saw differences and chose the spanner which they thought would fit the bolt: sometimes one, sometimes another. In other cases, where the longest spanner was chosen, this choice was justified in terms of the space that the longer handle provided for the hand to grip; or the shorter ones were rejected because they did not project far enough beyond the plate holding the bolt and hence would be difficult to grip.

A very small proportion of Form 1 girls (2 out of 17 interviewed), and a higher proportion of Form 1 boys (8 out of 25) made comments which showed some appreciation of the lever principle as it applies to the spanner, but only two boys could be judged as having seen this as a generalisation that could be applied to the knife-and-lid problem too. Actual statements justifying the choice of the longest spanner were almost always incorrect in a strict scientific sense, being expressed in terms of energy rather than forces: "Because you won't need a lot of energy to unscrew if you had the long handle" from a girl, and "Because if you use the short one you will need too much energy to unscrew the bolt" from a boy. Such statements reflect a lack of precision in knowledge of terms but reveal the sort of intuitive understanding of levers referred to earlier.

By Form 3 the length of the spanner was much more widely recognised as the important factor determining the size of the force that must be applied, but the girls were still not showing any evidence of generalising the principle to both situations. Only three out of sixteen girls interviewed had chosen the longest knife for prizing off the tin lid and they did so either for an irrelevant or wrong reason, or were guessing and could give no reason for the choice. The value of personal experience in moving one towards an understanding of levers was, however, succinctly revealed in this statement by a Form 3 girl who had used spanners "quite often":

> "If you take the small one and put all your force on it you get sore hands, and if you use the big one, you'll just put less force on it and you will turn the screw quite easily."
>
> (20/F/90, August 1992)

The problem itself was enough to inspire another girl to seek out the necessary experience for herself:

> "I thought of this one during the holidays because I remembered doing this one. So I asked one of my uncle's spanner and I tried it."
>
> (38/F/90, August, 1992)

She had originally chosen the middle-sized spanner but in the light of her experience changed to the longest one, because she now knew that "You don't need a strong force to take off this one."

In contrast, interviews with Form 3 boys revealed that most choices of the longest knife were influenced by personal experience with spanners, although a clear statement which could be recognised as the principle of the lever was still rare. Most justifications were given in terms of personal experience:

> "Because ... as we turn that spanner with the long handle ... we can feel that it uses less strength."
> (38/M/90, August 1992)

> "I used spanners and I know that the long ones are easier for us because we use ... the force is very easy"
> (29/M/90, August 1992)

An intermediate position was recognised in two cases (out of eighteen interviews): the middle-sized knife was chosen because, although it was known that a longer knife would require a smaller force, it was felt that the tendency of the longest knife to bend made it an unwise choice. This clearly suggests an understanding of levers that was hidden by the choice of answer.

Among the girls, it was only by Form 5 that there was evidence in interviews that the knife-and-lid problem was being seen in the same terms as the spanner-and-bolt one, as an application of the lever, and this evidence still came from a minority. Such an equation in principle of the two situations was, however, quite common among the boys at this level. Knowledge of the lever was still frequently expressed in terms of personal experience - the feeling of using a spanner - or in incorrect physical terms - "it will do less work" - but the principle was seen as a general one.

> JL: Why did you choose the longest spanner?
> SS: So that you have ... er ... less effort for unscrewing the bolt.
> JL: Where would you hold it?
> SS: [Points to the end of the spanner]
> JL: Why there?
> SS: Because the farther the distance from the bolt there, we have less effort to unscrew the ... bolt.
> JL: Why do you think the longest knife is the best one to use here?
> SS: It's for the same reason as ... [Points to the spanner question]
>
> (54/M/88, August 1992)

5.6.2 Wheels - and a surprise

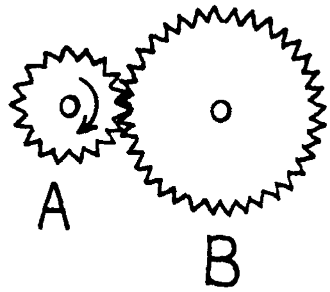
Another major theme in the Mechanical Reasoning Test is provided by questions on the relative motions of variously interconnected wheels. Two of these, numbers 3 and 14, ask about the relative speeds of connected wheels of different sizes (see Figure 5.2). A comparison of the performances of boys and girls in these two questions (Table 5.5) provides an interesting contrast with the lever questions analysed above.

Figure 5.2 Questions 3 and 14 from the MRT

Question 3

The toothed wheel A turns one complete revolution. (This means it turns round once.)

How many revolutions does it make wheel B turn through?



Question 14

AX, BY and CZ are pairs of pulley wheels joined by rubber bands.

A, B and C are all the same size. X is smaller than Y and Y is smaller than Z.

A, B and C are all turning at the same speed.

Which of the other wheels will be turning fastest: X, Y or Z?

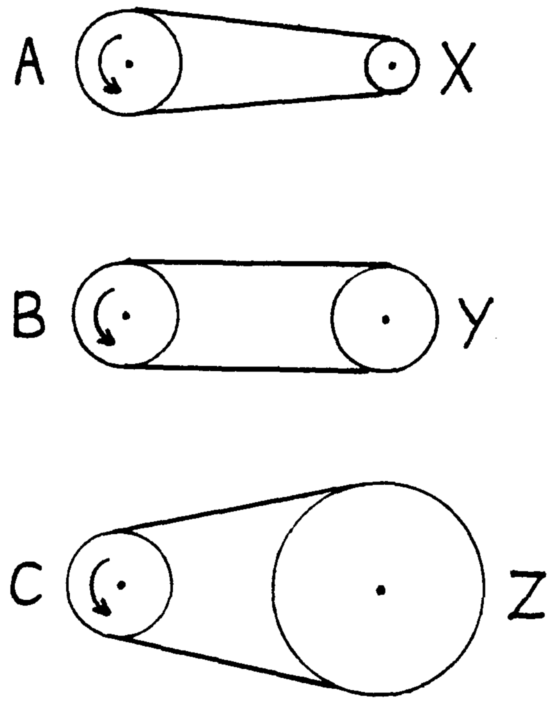


Table 5.5 Performance in questions 3 and 14 of the MRT, by Form and by gender

	Percentage choosing correct answer *(Sample size in brackets)*			
	Question 3		Question 14	
	Boys	Girls	Boys	Girls
Form 1	55% *(53)*	31% *(45)*	70% *(53)*	62% *(45)*
Form 3	58% *(60)*	57% *(28)*	82% *(60)*	93% *(28)*
Form 5	56% *(36)*	71% *(17)*	83% *(36)*	88% *(17)*

In Form 1 the girls' performance is inferior to that of the boys in both questions, but this inferiority quickly disappears. In question 3, the virtually constant success rate of the boys contrasts with the large improvements shown by the girls from Form 1 to Form 3 and again from Form 3 to Form 5. (The girls' performance in Form 1 in is no better than chance for a question with three options for the answer.) Although both show improvements in question 14, the most significant changes occur in the girls' performance. This was the only question in the MRT in which the girls out-performed the boys at both Form 3 and Form 5.

If the girls' results are examined more closely, it emerges that the greatest improvements occur for those from a rural background, as indicated by primary school attendance, as shown in Table 5.6. (Form 5 data are not included here as the number of girls in Form 5 with all-rural primary school experience was too small, at just 3, to make the figures meaningful.)

Table 5.6 Changes in performance in questions 3 and 14 of the MRT for girls of rural and urban backgrounds

	Percentage choosing correct answer			
	Question 3		Question 14	
	Form 1	Form 3	Form 1	Form 3
Rural students	15%	78%	31%	100%
Honiara students	37%	53%	77%	88%

It seems probable that there is something in the girls' experiences in K G VI which is behind this dramatic improvement, something which is absent from the boys' experiences and which was less familiar to rural girls than to urban girls before coming to secondary school. Perhaps the commonest example of a machine in which one wheel can be seen to be driving another is the bicycle and experience of this may be influential, but it is unlikely that it would explain the gender-based differences described. Unfortunately, there was no interview follow-up on these questions, but a possible source of the patterns described above is the sewing machines that the girls all use in their home economics course. Most of these are powered by a foot treadle and include a band drive from a large wheel to a small one. They also include a small wheel which can be used for winding thread onto a bobbin and is driven by direct contact with a larger wheel. Hence these machines include devices very similar to those in the two MRT questions considered. Although the driving of one wheel by another through a band, or chain, is observable on a bicycle, the direct-contact drive, either using cog wheels or relying on friction, is not so commonly seen. This may explain the lack of improvement in the boys' performance on this question in contrast to that shown by the girls. As an attempt to understand the relatively poorer initial performance of rural girls, it would be useful to know whether Honiara girls have more experience with sewing machines before coming to secondary school. No questions were asked directly about this, although the only girls in the general background interview who mentioned using a sewing machine as part of their spare time activities at home were all (three) from Honiara.

5.7 A wider look at experience

The above analysis of some of the MRT questions is intended to illustrate how particular experiences contribute to the development of specific aspects of mechanical reasoning and to illustrate that such reasoning ability is at least partially - and perhaps very largely - due to the accumulation of such experiences. The wider the range and the greater the frequency of experiences of mechanical devices and manipulation of simple machines, the more developed mechanical reasoning skills are likely to be.

It is possible to make a case for there being a general spatial reasoning component to mechanical reasoning, and the correlation between Form 3 SAT Spatial Reasoning and MRT scores given earlier support this. But either spatial reasoning itself is improved through concrete, manipulative experiences with machines (with the term still being used in its scientific sense that implies only simple devices) or there is a significant element in mechanical reasoning which is distinct from the purely spatial component.

Some indication of the nature and extent of student involvement in activities which may have some influence on the development of mechanical reasoning was sought from answers to two questions asked during the general background interviews given to samples of Form 3 and Form 5 students. Students were asked if they had ever done any work which made use of tools, with carpentry, mechanics or any sort of repair work being suggested as examples of what was meant. They were also asked to recount how they spent their spare time when they were younger: what sort of games and other activities they took part in and what sort of things they used to play with. The hypothesis behind this was that boys would reveal greater experience with tools and mechanical devices and that their play would involve more complex manipulation activities than that of the girls, offering a possible explanation for their greater mechanical reasoning ability when they arrive at secondary school.

5.7.1 Experience with tools

The boys were about twice as likely as the girls to have used tools: 30 out of 41 boys interviewed (73%) described having done so, compared with 15 out of 43 girls (35%). (Of of these girls, one had previously been at a Provincial Secondary School and her only experience with tools was through the mechanics course there.) Girls living in Honiara were about three times more likely to have had opportunities to use tools than girls from rural areas, but among the boys no distinction between rural and urban dwellers was found. The girls' experience was of a more limited nature than that of the boys: mostly fairly simple carpentry such as sawing, although two girls had assisted with house building, two others had helped with car repairs and one described repairing her sewing machine. Carpentry was the main experience with tools for about half of the boys too, although this seems to have been more complex joinery than that described by the girls, with house building as a common context for this work. Others mentioned car and bicycle repairing, and even tinkering with radios, but the maintenance of outboard motors was a relatively common source of experience which was available to boys and not to girls. One third of the boys who had used tools had worked on these, all of them non-Honiara dwellers, but not one of the girls had done so. It would seem that this important -

and perhaps the most mechanised - aspect of rural life is an exclusively male domain.

Over 85% of the girls expressed an interest in learning some mechanics and carpentry and supported the idea of girls taking woodwork at school along with the boys. They generally gave their reason for this as a desire to learn how to make useful items such as furniture. Although this was sometimes expressed in terms of achieving greater independence, there was also a common feeling that such work was still essentially man's work:

> "If they get married and ... if their husband don't know how to make those things then they can make them for themselves".
>
> (37/F/89, 14/5/91)

For a few girls, this interest emerged as an expression of frustration at the limitations imposed on them by their socially-defined roles:

> "So that we can learn new skills ... Whereas if we just do girls' jobs all the time, that's not ... we can't learn new things".
>
> (28/F/88, 27/2/92)

Interestingly, two girls drew inspiration from the fact that females had just begun to be trained by the Ministry of Transport, Works and Utilities for skilled manual posts such as electricians and mechanics. Two former girl pupils had been at the school to carry out repair work just a few weeks earlier. This, and the arrival of females to carry out electrical repair work, had caused some comment in the school and seemed to be part of a growing realisation among the girls themselves that they could seriously consider such occupations. In 1989 a sixth-form girl had been accepted for pilot training, and another for mechanical engineering in 1992, although it was not until 1993 that the first Melanesian girl began a university engineering course.

5.7.2 The nature of play

The descriptions of childhood activities given by the students were largely predictable. The boys listed toy cars and trucks, toy boats, toy guns, and soccer as their childhood pastimes, whereas playing with dolls or other 'imitation babies' was by far the most frequently mentioned activity for the girls. In general, only those living in Honiara possessed any ready-made toys, bought from shops, and these included dolls, cars, toy soldiers and, occasionally 'Lego' or other building blocks. For those living in the villages, playthings had mostly to be fashioned from available materials and an important distinction should be made between those made by the girls and those made by the boys. Although a small proportion of girls mentioned making simple model boats, they were more likely simply to use existing objects to represent babies rather than to construct a plaything: stones, bananas, potatoes, tin cans and young coconuts were all mentioned as being used for this purpose. The boys, on the other hand, were more likely to use materials to construct a toy, usually a toy car or truck. These seem to have been much simpler than those personally seen quite often in East Africa, cut quite intricately from tin cans, but they nonetheless required some manipulative skills in the making.

Much of the girls' play can be characterised as imitative, perhaps involving less imagination and certainly less manipulative practice than that of the boys. The girls' games are a direct imitation of, and preparation for the adult roles of housewife and mother:

> "Sometimes I play with dollies. Sometimes I watch my mum doing ... [laughs] ... doing something and then I imitate her".
>
> (06/F/89, 16/4/91)

> "We played at imitating bigger women ... cooking and something like that".
>
> (11/F/89, 11/3/91)

> "We used to get stones as babies and try to imitate our parents by gathering together and saying we are praying to God ...".
>
> (13/F/88, 6/2/92)

One girl stated that she never played at all but just helped her mother in the house. Certainly, both boys and girls agreed that, in the villages in particular, the girls were expected to start helping their mothers with housework - "learning women's work" - at a younger age than the boys began working. Both their early play and the household tasks into which the girls are quickly initiated provide poor opportunities for the development of spatial and mechanical reasoning skills. The boys' experiences may not be very rich in this respect either, but they do seem to be superior to those of the girls.

5.8 Discussion

Gay and Cole (1967) felt that the lack of imaginative play among Kpelle children extracted a cognitive cost and a similar point has been made by others in reference to various aspects of cognition (e.g. Lunzer, 1980; Smith, 1980). Piaget and Inhelder stressed the importance of a child's experiences of the manipulation of concrete objects for the development of spatial concepts and reasoning.

> "In short, the motor activity already employed in perceptual activity, and consequently involved in the construction of perceptual space, is again found as an essential component in the creation of representational images, and consequently in the representation of spatial notions."
> (Piaget and Inhelder, 1956: 42)

Hallpike (1979: 281) points out that interaction with the physical world is not a sufficient condition for the individual's development of "conceptual space" but must be supported by reflection upon actions. Nevertheless, he is clear that opportunities for such interactions are necessary for the development of spatial skills and the quality and extent of these skills will be influenced by the nature of these interactions.

Some of the most interesting work in this field has been inspired by the evidence for cognitive differences between boys and girls. Maccoby and Jacklin (1974) concluded that there are three such differences that have been well established: superior verbal ability of girls throughout childhood and adolescence, and superior mathematical and visual-spatial abilities of boys, particularly from adolescence onwards. Etaugh (1983) reviews studies of early childhood that show the differential treatment by adults of boys and girls which, among other things, reinforces what is considered "sex-appropriate" play. This generally means boys playing with toys that involve greater motor activity and are cognitively more complex, whereas girls are encouraged in interpersonal stimulation and nurturance play with dolls. Conner and Serbin have found positive correlations between visual-spatial ability and preference for these more manipulative "masculine" activities (Connor and Serbin, 1977; Serbin and Connor, 1979), but causal influences can only be inferred from this work. Direct evidence of causal links between play and spatial ability is, however, offered by experiments carried out by Sprafkin *et al* (1983). They found that a programme of increased exposure of girls to male-preferred toys did improve performance by these girls in visual-spatial tests. This goes considerably further than earlier work which had simply demonstrated that specific training in visual-spatial tasks could improve performance (summarised in Sprafkin *et al*, 1983: 172-174).

These studies have invariably been carried out in North America or other developed regions but the brief descriptions of their childhood pastimes given by the K G VI students are enough to establish that the same basic pattern of differences between the play of boys and girls exists in the Solomon Islands as in North America or Europe. The range of toys available is much smaller and the individual toys are less complex, but it still seems to be a valid generalisation that boys' play is concretely manipulative while that of the girls is imitative and nurturative. Whether this leads to greater spatial ability among the boys (which is not consistently detected until adolescence in any case) and this in turn gives them an advantage in science, or whether a different mechanism is in operation is still a moot point. Kelly outlines an alternative which must be interpreted with caution in the Solomon Islands context, in view of a much lower level of technology in toys, but which is still relevant:

> "But I doubt whether sex differences in spatial ability lie at the root of the problem. They are just as likely to be a symptom. Children who play with construction toys and handle tools probably develop both their spatial ability and their scientific aptitude in the process. And conventions

> of child rearing today ensure that such toys and tools are much more frequently made available to boys than to girls."
>
> (Kelly, 1987: 13)

The superior overall performance of Honiara-based boys over rural boys in the mechanical reasoning tasks and the lack of any consistent differences in performance between Honiara girls and rural girls are observations that still require some explanation. The situation with regards to tool use has already been mentioned: no difference between Honiara and rural groups for the boys, but a greater use of tools among Honiara-based girls. Both boys and girls from Honiara were more likely to have played with toys bought from shops and to have owned a bicycle, although these are still not general experiences. Consequently, it would be difficult to frame an explanation of the observed differences in performance which relied primarily on these two aspects of the students' lives.

Although an individual's experiences can be analysed by fragmentation into categories such as "use of tools" or "play", this may miss more general, more diffuse influences of living in an urban environment: influences whose consequential whole are greater than their experiential parts. Musgrove (1982) argues for the existence of a distinct "city effect" in cognitive development, which becomes particularly potent when combined with the influences of good schooling. Hallpike (1979), drawing on

Piaget's (1930) analysis of the role of mechanical experience in the development of "reversibility", suggests that the simple presence of more machines in a city, the more mechanical city environment, is of great importance in promoting certain areas of cognitive development. Other aspects of urban life have also been emphasised. Goldthorpe (1975: 119) sees a "foreign influence" in Third World cities leading to an "outward orientation", while Musgrove (1982) places great emphasis on the differences in social relationships found in city and village. Inkeles and Smith (1974) on the other hand, dismiss the existence of any city effect beyond that of individual institutions such as factories, schools and communication systems; and Ginsburg (1966) discounts any modernising influence of Third World cities because of their domination by rural immigrants. This latter point echoes the distinction made by Redfield and Singer (1954-1955) between a "secondary city", with its generalising culture, and a "primary city", which retains much of the folk-culture of the village.

Simply in view of its relative newness, smallness and lack of development, it would be difficult to argue that Honiara is very far beyond the "primary city" stage. Many of the students who were born in Honiara and who live there most of the time still give their parents' island as their home, and most residents maintain very strong links with their home islands and culture. Some areas of the town are inhabited very largely by immigrants from one particular island or region - White River by Polynesians from Rennel and Bellona; parts of Naha by Malaitans - so that they form cultural enclaves, resisting generalising influences. Despite this, the vast differences between Honiara and rural villages (or even other "urban" areas) in terms of level of material development are very obvious and the observation of an effect such as an increased mechanical awareness among Honiara students would not be surprising.

The degree to which urban influences have an impact on an individual will depend on the individual's level of participation in urban life and exposure to those influences. A trite remark, but important when one considers the relative meanings of urban life for boys and for girls. Rather than offering greater opportunities to the girls, life in Honiara may, for some, be more restrictive in certain respects than life in the villages. Girls may remain at least as much tied to the house, and possibly more so in view of the dangers perceived to be present in the township. For boys on the other hand, life in Honiara may offer release from some of the manual labour and subsistence activities which are their lot in the village, leaving them generally with greater freedom, particularly since they are less likely to suffer the "security" restrictions imposed on the girls. Whatever the town has to offer, the boys are more likely to be in a position to partake of it.

The weakness with this sort of argument is that it has already been shown that, for girls, residence in Honiara rather than in a rural village (as indicated by primary school attendance) does result in significant superiority in overall academic achievement, which is at least suggestive of superior cognitive functioning. Hence it is difficult to argue that if urban experience does affect cognitive development the girls are somehow shielded from this effect. What is perhaps more tenable is that the nature of the urban experience is different for boys and girls, and hence its cognitive consequences are different. From the analyses of achievement already described, for example, it would seem that life in Honiara (or, rather, some aspects of it) does benefit the girls' language abilities (see section 4.3.2, previous chapter). It is possible that whatever aspects of urban life promote the mechanical and spatial abilities that are the concern of this chapter, these are simply not part of the girls' experience of Honiara. Alternatively, it is possible that urban experiences which promote mechanical reasoning are available to both boys and girls, but are simply not taken up by the girls because of a lack of interest and motivation derived from social and cultural pressures. Hence, it may be differential socialisation processes that leave only the boys in a position to benefit from those aspects of urban experience which contribute to spatio-mechanical reasoning, and to concentrate on these cognitive outcomes would be to confuse the symptoms with the cause.

5.9 Beyond cognition

In their comprehensive review, Maccoby and Jacklin (1974: 132) point out that good intellectual performance - particularly on tests of spatial ability - is positively associated with independence or autonomy of the individual. Witkin (1967) had suggested that conformity, reliance upon authority and restriction of the autonomy of the individual are associated with greater field-dependence. This in turn, claims Halpern (1986), has been shown to be largely a function of visual-spatial ability: higher spatial ability implying greater field independence. Thus a link seems to be established between personality characteristics on the one hand and cognitive abilities on the other, which in turn leads to a link between personality and performance in science - a link much emphasised by Head (1979, 1980, 1985). The contribution of personality to the cognitive development of girls is summarised by Maccoby and Jacklin thus:

> "However, the studies on personality correlates of intellectual performance have continued to suggest that intellectual development in girls is fostered by their being assertive and active, and having a sense that they can control, by their own actions, the events that affect their lives."
> (Maccoby and Jacklin, 1974: 133)

It is clear from the descriptions given in chapter 3 of the present thesis that the home background and general socialisation experiences of the girls do not encourage this autonomy which benefits intellectual development. In the villages in particular the girls are encouraged to be subservient to the boys, to be dependent on them for leadership and decision-making, although this situation is eased somewhat in some urban families. Both in and out of Honiara the range of activities in which the girls are allowed to participate is more circumscribed than for the boys and centred very much on the home and family.

Although there is professed equality of opportunity and esteem for boys and girls within the school, it is inevitable that ingrained attitudes will persist and influence the atmosphere and expectations. This is neatly illustrated by a comment written on a Form 1 girl's report by her form master, in 1988: "Though a female, she has shown a lot of capabilities as a leader". The girls have more restrictions on their freedom than the boys: it is the girls who must be checked back into their dormitory, surrounded by barbed wire, at eight-thirty at night while the boys are still relatively free to move around (and to make use of the classrooms for further studying).

During interviews many of the girls did, however, comment on the extra opportunities that school life afforded them compared with home. The Duke of Edinburgh's Award Scheme in the school, for example, always had female participants in a much greater proportion than existed in the school as a whole. These girls commonly remarked that the attraction of the scheme for them lay in the opportunities to learn new skills that they would never otherwise have had and, particularly, in the opportunity to trek and camp out in the bush - at home an activity that only boys could consider. Accompanying these expeditions gave valuable opportunities to observe interactions between the boys and the girls out of school. It was noticeable that whenever they were walking in a mixed group, the girls generally let the boys do the route-finding and general-decision making, although they wanted to be informed and aware of what was happening. Some girls, however, were clearly determined to make full use of these rarely-granted opportunities and be in charge of themselves. (Whenever possible the expeditions were arranged so that walking and route-finding was done in single-sex groups, but this was not always feasible.) At camp-sites it was interesting to note a clear division of labour, carried out automatically and without discussion: the boys constructed the shelters and the girls cooked the food.

The point to be made is that if inequalities in performance between boys and girls are to be redressed - in science or other subjects - there is a need for more than action aimed at specific cognitive areas. One could argue, for example, for increased opportunities for the girls to obtain the manipulative and mechanical experiences that might develop greater spatial abilities - although the degree of success such intervention would have so relatively late in life would be a matter for investigation. But this alone is unlikely to be sufficient without an accompanying alteration in the ethos of the school which recognises the rights of the girls to personal autonomy so that they can exploit their intellectual potential. Since this would mean divorcing the school and its inmates from the influence of society, it would be no easy task!

This line of reasoning inevitably leads us to a consideration of non-cognitive aspects of the students' responses to science. Their views of the relevance of science to both their present situations and their possible futures may be important to their achievement in the subject, and are important areas of concern in their own right too. The next two chapters, therefore, are concerned with the attitudes that the students develop towards school science and the extent to which they feel it may meet the needs of their anticipated future roles.

CHAPTER 6 ASSESSING ATTITUDES AND IMAGES OF SCIENCE

6.1 Attitudes to science: the what? and the why?

Oppenheim summarised existing definitions of an attitude as "a tendency to act or react in a certain manner when confronted with certain stimuli" (1966: 105). The important aspect of this definition is the link that it makes between attitudes and some sort of behaviour, either speech or action. Oppenheim was wise to include the term "tendency" for it has been pointed out that a series of mediating variables may intervene between attitude and behaviour, of which social setting and competence are but two (Shrigley, 1990). But, if it is only responses that can be observed or measured, the latency of attitudes leaves them rather inaccessible, and Larkin (1980) maintains that attitudes should be taken to be identical with social behaviour rather than its precursors: a view which is significant because it leads to ethnomethodological approaches to the investigation of attitudes through the observation and interpretation of behaviour instead of the psychometric techniques which now dominate. Others have reversed the direction of influence in Oppenheim's definition and argued that attitude follows behaviour (Bem, 1970), while yet other analyses place attitude and behaviour in reciprocal relationship (see Shrigley, 1990, for a summary).

There is agreement, however, that attitudes belong to the affective domain; they can be taken to be affective responses to experiences, affective determinants of behaviour or a combination of these. Shrigley, Koballa and Simpson (1988) claim that there is a "cognitive backdrop" to attitudes formed by beliefs, but their attempt to clarify the distinction between belief and attitude is less than convincing[1]. Despite this, it does seem obvious that attitudes must have some cognitive base: one can hardly have an attitude towards something of which one has never heard; but the attitude is clearly not the same as the knowledge. An exact and comprehensive definition of attitude has been the subject of much academic discussion (Shrigley, Koballa & Simpson, *op cit*) and will doubtless receive much more, but it is one of those concepts for which an intuitive understanding is quite adequate for many purposes, and for which detailed analysis may often serve to add more confusion than enlightenment while offering no increase in explanatory or predictive power.

In science education, one of the key concerns with attitude is the link between attitudes to science and achievement in science. Achievement is the behaviour which it is hoped attitudes will help to predict. Some writers clearly feel that the existence of such a predictive link is as much a matter of common sense as empirical investigation: e.g.

Brannon, 1976 (cited in Shrigley, 1990); and Ormerod and Duckworth, 1975: 2:

> "Research findings as well as common sense suggest, therefore, that the attitudes and interests of pupils are likely to play an important part in any satisfactory explanation of the variable levels of performance shown by pupils in their school science subjects."

Note the direction of influence implicit in this statement: attitudes and interests influence levels of performance, rather than performance inspiring interest. Simpson and Wasik (1978), however, comment on the lack of empirical support for this "assumption" of a link between affective and cognitive achievement in science, and feel that their own data do not clarify the situation any further.

The support given by research findings to this position has been a matter of debate. Some researchers have concluded that the predictive link is supported by their own or others' findings (e.g. Bloom, 1976; Marjoribanks, 1976; Schuman & Johnson, 1976; Haladyna & Shaughnessy, 1982; Schibeci & Riley, 1986; Germann, 1988; Simpson & Oliver, 1990), although some see the level of correlation as being too low to merit such confidence (Fraser, 1982), and others have interpreted the evidence as indicating a causal effect in the opposite direction, of achievement on attitude (Peterson & Carlson, 1979). In a review of the relevant data from eight countries, Steinkamp and Maehr conclude:

> "It all seems simple enough: One should like what one does well and do well what one likes. Simple it may be; correct it is not."
> (Steinkamp & Maehr, 1983: 389)

There have been serious criticisms of both the quality of attitude to science studies and their predictive capacity (Gardner, 1975; Munby, 1983; Schibeci, 1984, 1985). These have tended to support the belief that attitude should determine achievement to some extent, and have concentrated heavily on the need to improve conceptualisation and instrumentation[2].

An alternative view of the educational importance of attitudes to science is to see their positive development as a useful end in itself, rather than to place all the emphasis on their links with achievement (Hodson & Freeman, 1983; Millar, 1986; Kelly, 1986).

> "The development of favourable attitudes towards science is increasingly being recognised as an important aspect of science education. Children's attitudes to science may well prove more lasting when they leave school than the bits of scientific knowledge they have acquired. Tomorrow's adults will live in a rapidly changing technological environment, and their attitude to that change will influence their ability to cope with it in emotional as well as material ways."
> (Kelly, 1986: 399)

Such a position is particularly relevant in the teaching of "science for all", where the future non-specialists in a class outnumber the specialists (Reid & Hodson, 1987). It may also be especially important in a developing country where resources outside the school for the informing of opinion on science and technology are meagre, so that the importance of schooling in the development of attitudes is increased.

At this stage it is perhaps important to make the distinction, which has so far been glossed over, between attitudes to science and attitudes to school science[3]. In the above quotation, Alison Kelly appears to be referring to attitudes to science in general, although the rest of her article seems to mix these in with attitudes to school science. The two may well be linked: it seems likely that someone who enjoys science lessons, and finds them stimulating, will develop positive attitudes to science in general, but this is not necessarily so. It is also possible that a student may be turned off science through finding it difficult, yet may still feel that science is important for national development. Hofstein and Welch (1984), for example, found that U.S. high school students' attitudes to science "in the abstract" remained steady or became more favourable as they got older, while at the same time there was an increasing feeling of "but it's not for me".

Certain patterns have emerged from the work on students' attitudes to science, and have been summarised by Ormerod & Duckworth (1975), Gardner (1985) and Schibeci (1984, 1985).

Interests and attitudes are generally very positive among younger students, up to early secondary schooling or the age of about 12 years, but thereafter decline, perhaps more rapidly in science than in other subjects and more particularly in physics and chemistry than in biology, which may actually attract more interest among older students (Gardner, 1985; Head, 1985; Kelly, 1986; Häussler, 1987). Boys tend to score higher than girls on measures of various aspects of attitude to science, although to a lesser extent in biology than in the physical sciences, and girls in single-sex schools are more positive about science than those in co-educational schools. These conclusions are derived mostly from studies carried out in developed countries, but the same sort of patterns seem to be supported by research in some less developed countries, notably in Africa (Ato & Wilkinson, 1983, 1986; Obioma & Ohuche, 1985; Lehrke, Hoffmann & Gardner, 1985; Banu, 1986; Duncan, 1989)[4].

The concern of much of the work on attitudes to science is to unearth the factors that influence them. The effects of age and gender outlined above are widely agreed upon, but Schibeci's 1985 summary points out that the influences on attitudes of structural variables, such as socio-economic status, and educational variables, such as ability and intelligence, are either weak or indirect, and that no unequivocal conclusions can be drawn on the influences of various curriculum projects or instructional strategies. He suggests that there are signs from the limited amount of work carried out that strong links exist between personality variables and attitudes, a point that has been forcefully made by Head (1985), and that school variables such as learning environment may exert an influence on attitudes. In this latter area, a study in Nigeria by Ato and Wilkinson (1986) has shown that the use of science equipment in schools can have beneficial effects on certain attitudes, such as those towards scientific enquiry and the normality of scientists, and that these effects are greater on girls than on boys. They suggest that the handling of equipment increases the girls' confidence in their own abilities. Earlier work by the same authors found that the location of a school was also influential on attitudes, with students in Nigerian urban schools responding more positively towards science than those in rural schools. (Ato & Wilkinson, 1983). Also working in Nigeria, Jegede and Fraser (1989) maintain that socio-cultural factors, particularly aspects of traditional culture, can influence attitudes to science; but they seem to be working within a framework that assumes a negative attitude to science from students in non-Western schools, in contradiction to the evidence from other studies, even within Nigeria (e.g. Obioma & Ohuche, 1985; Banu, 1986).

An important corollary to attitudes to science in general is the image of science and scientists that the individual holds. This image may be both influenced by attitudes and influential on them, but at least part of it can be seen as the cognitive base on which attitudes are built: unless we know the image that someone has of science, we do not know what it is he or she has an attitude towards. If, as teachers, we are concerned with changing attitudes to science, we may find it most productive, at least as an initial step, to change the image that our students have of science and scientists - a lesson long since learned by advertising agencies and politicians.

A concept closely related to attitude is "interest". Gardner (1985) considers the two to be overlapping concepts, but still insists on a need to distinguish them and other concepts such as enjoyment and motivation. Gardner and Tamir (1989) suggest that an "interests analysis" may be more useful for the understanding and predicting of performance than much of the traditional work on attitudes, and a distinct literature on interests may be developing (Lehrke, Hoffmann & Gardner, 1985). In contrast, Rennie and Punch (1991) use the term "science-related affect" as "the complex of students' attitudes towards, interests in, and perceptions about science at school." In other words, while they recognise there may be a distinction between interest and attitude, their concern is with the sum total of all of these concepts that belong to the affective domain. A similar approach is adopted here: the concern is with affective responses to science treated generally rather than with a narrow aspect of such responses which has yet to be shown to be useful[5].

6.2 Attitudes to science: the how?

The investigation of attitudes to science is now totally dominated by psychometric methods[6]. One of the commonest approaches is to devise and administer a Likert-type scale to produce a value, or a series of sub-scale values, for the attitude under scrutiny (Schibeci, 1984). After criticisms of much earlier testing (Gardner, 1975; Munby, 1980; Schibeci, 1984), the process for the production of a Likert scale has been developed and refined. Koballa (1984) described a nine-step process for scale production; this was expanded to fifteen steps by Abdel-Gaid, Trueblood & Shrigley (1986) and a "jury process" for assessing statements was added by Calhoun, Shrigley & Showers (1988). To this complex process must be added the list of fourteen criteria recommended by Edwards (1957) for consideration when writing attitude statements, and a considerable application of statistical techniques, including factor analysis (see, for example, Hassan and Shrigley, 1984, or Misiti, Shrigley & Hanson, 1991, for an indication of the techniques involved).

The complexity of this process of producing a valid and reliable attitude scale was one of the factors influencing against the use of such a scale for this particular research, or at least influencing against placing total reliance on such a scale. The statistical nature of both the analysis and validation demands a reasonably large population which can be expected to show a range of attitudes, and access to sophisticated statistical computer software - neither of which was available. An alternative to the development of a scale would have been to make use of a previously prepared and validated scale from elsewhere, but there are serious reservations about the cross-cultural use of such scales, which have in most cases been developed in the USA or another industrialised society[7]. A borrowed scale would still have to be re-validated and so the practical problems would remain[8].

Despite the enormous amount of development work which has gone into Likert scale production and validation techniques, they are still open to certain criticisms, and suffer from certain limitations. The first of these arises from the difficulties of interpreting a score on such a scale. The score has no value in absolute terms; the best that can be done with it is to make a comparison - but with what? Comparison between two individuals taking the same test is possible but must assume that they both interpret the standard type of Likert categories, such as "very strongly agree" or "disagree slightly", in the same way; there is no logical reason why the intensity of emotions of one individual making one statement should be comparable with those of another making the same statement. In practice comparisons are frequently made between different groups, but at best, an attitude scale can only safely be treated as an ordinal scale and only comparison by rank is defensible. Furthermore, since the score on any scale or sub-scale will be an aggregate from several items, there are different ways in which the same total could be attained by different people, each of these representing different *nuances* in attitudes which might be judged to be the same from a simple numerical comparison. Although some sort of "profiling" for each individual could get around this problem, this increases the complexity of both analysis and comparison enormously (Oppenheim, 1966: 140-142; Page, Nash & Orr, 1979)[9].

It has been argued (Page, Nash & Orr, 1979) that a face-to-face interview attempt to discover attitudes is more likely to encourage the respondent to make "socially acceptable" attitude statements, or to give answers that are thought likely to please the interviewer, than is a more impersonal written attitude scale test. In practice, it is probably easier to complete such a written test in a way that portrays the particular image that one wishes to project than it is to maintain a false position in front of an experienced and sensitive interviewer. Ultimately, the written test (unless it is totally anonymous, and then it becomes impossible to link it with other data) is not impersonal at all, it is merely not being immediately supervised and, as such, offers opportunity to construct a set of "socially acceptable" attitudes, if that is the respondent's desire.

For the purposes of this research, the most serious weakness with psychometric techniques is their positivistic, reductionist approach, placing the emphasis on sub-division and measurement, rather than holistic understanding. While it was considered that it might be useful and enlightening to be able to rank various groups on certain aspects of attitudes to science, it was also felt that this alone would not be enough. The aim was to try to achieve an empathetic understanding of these attitudes, to place them in the wider context of the students' lives, and appreciate the reasons for the development of interests and attitudes. For these purposes, it was decided that a more ethnographically-inspired approach would be more useful.

6.3 Assessing affective responses among K G VI students

With this wide (perhaps even "loose") interpretation of affective response in mind, investigations were carried out using a variety of instruments. The domain is considered in two parts, covered in the last section of this chapter and the following chapter. First there is a need to establish the image of science and scientists that the students hold: the cognitive base to which they respond. Secondly, there is the investigation of the students attitudes to school science, rather than science in general, and both the sources and consequences of these attitudes.

The major source of information on students' conceptions of scientists and the nature of science was the basic background interview given to ninety six students in Forms 3 and 5, referred to already in Chapter 3 and reproduced in Appendix 2. As part of this interview, students were asked, "What sort of work do you think scientists do?"; and where a scientist might be found working, by giving them four options: a laboratory, an office, a factory, and outside. They were then asked to try to imagine a scientist at work and were given a short time to do so before being asked about the person they were imagining: sex, colour, age, dress, whether working alone or with others, and whether likely to be introvert (quiet and shy) or extrovert (talkative and out-going). It was found to be more productive to present the interviewee with specific questions and options rather than just to ask for a description of the scientist that he or she was imagining. Finally they were asked where they thought they might have got their ideas from for this image of a scientist, whether they themselves felt they were the right sort of person to be a scientist, and if they could name any jobs other than "scientist" which demanded scientific knowledge.

This source of information was supplemented by less formal, less structured interviews with Form 5 and Form 6 students on how they viewed science and scientists. Some of these interviews were carried out as a preliminary to devising the form of the more structured interview; others were more in the nature of wide-ranging, directed conversations with students whom I had come to know well. Some were recorded and transcribed, but for others, notes were made soon afterwards, relying on memory.

The basic background interview also examined students' opinions on school science by asking them about their school subject likes and dislikes, which parts of their science course they found difficult, which they enjoyed and which they disliked, how they felt about science practical work, and whether they thought any of the science they had learned had been useful or might be useful in the future. The question of the usefulness of science was extended by asking if they thought a knowledge of some science was useful to those who did not need it in their work. Gender issues were introduced by asking whether they thought science was more interesting or useful to boys than to girls, and whether they thought boys or girls performed better than the other in any areas of school science. All questions were followed up with attempts to elicit reasons for the respondent's choices.

It was anticipated that there might be problems with the reliability of the answers to some of these questions. In particular, students might decide that when their science teacher asks them which subjects they enjoy, it would be politic to include science in their answer! The possibility of this happening was hopefully reduced by the fact that I was not personally teaching the majority of those interviewed and those whom I was teaching were students I had known for several years, with whom it was hoped a good enough *rapport* existed to encourage a truthful answer. (When students did include science as a subject they enjoyed, they were generally challenged in a good-humoured way that they were giving this answer simply to please me, both to look for evidence in their reaction that this might actually be the case and to give them an opportunity to alter their choice.) It was also hoped that asking for a reason for any subject choice would help to determine whether the choice was genuine or not. In practice, there were no instances in which it was felt the answer was untruthful, and some students were quite willing to give science (or physics, generally known to be my own speciality) as a subject they disliked or found difficult[10].

The personal background questionnaire given to almost all in Forms 1 to 5 early in 1990 (see Appendix 1) asked the students, among other things, which three subjects they enjoyed most at school. This gave a wider indication of the popularity of subjects which could be compared with the interview data, but gave no information on reasons for popularity. (With the questionnaire being completed early in the year, it was not really useful to ask the newly arrived Form 1 students about their subjects.) This exercise was repeated with Form 5 students at the end of their course in 1991 to give some indication of the stability of preferences, since most of these students had completed the questionnaire earlier in Form 4, and a few had also taken part in the interviews.

Both the background questionnaire and the end-of-course survey given to Form 5 students also asked for science topic preferences. The latter survey listed the syllabus topics that had been studied in the previous two years, but the former gave rather more general headings, and included aspects of applied science which did not actually appear on the syllabus (more details are given in the discussion of the results). As such, the data from these can be considered complementary, rather than overlapping. The end-of-year Form 5 survey - and the interviews - asked for opinions on the course that the students had actually experienced, whereas the other questionnaire was presenting more of an opportunity for the students to indicate what they would like to be taught (although this is, in turn, likely to be influenced by their experience of school science lessons).

Since it was suspected that career aspirations might be both influenced by and influential on school subject interest, both the questionnaires and interviews asked students about these.

A further measure of interest in science was obtained through a monitoring of school library use by all students during 1992, noting the type of book - and subject matter for non-fiction books - taken by each student, whenever one was borrowed.

Finally, an attempt was made to develop a set of Likert-type attitude scales for five areas: personal enjoyment of school science, personal instrumental value of school science, performance self-concept in school science, national value of science, and science as a truth-system. In response to evidence from interviews and other sources, a later version subdivided the scales relating to school science into separate scales for biology and physical science. Although tolerable levels of internal consistency were achieved for some of the scales, it was decided that, without facilities for more detailed statistical analysis, these could not be improved to a level which would allow them to be used as originally hoped. Useful information was available from some of the items taken individually or in small sets, however, and reference will be made to these where applicable[11]. These had been used with various Form 3, 4 and 5 classes between 1990 and 1992.

The remainder of this chapter will look at the evidence available from these various sources on just how the students perceive the nature of science and its practitioners.

6.4 Images of scientists and science

When asked to imagine a scientist at work, ninety six percent of the interviewed Form 3 and Form 5 students imagined a man, with just three girls imagining a woman. Eighty nine percent described their imaginary scientist as white and eleven percent as black, while four out of five said he was either old or "middle-aged". (The female scientists pictured by three girls were all described as young, with two being black and one white.) Almost half (48%) thought of a scientist dressed in white, while a further thirteen percent mentioned some form of specialised clothing: "like a doctor's", "protective clothing", "clothes to do with experiments", or even "things the scientists usually wear when they get up in the moon or any planets." Most (76%) pictured a scientist working alone, but there was no agreement on a particular general personality type: the proportion stating their scientist would be "quiet and shy" was the same (47%) as that believing he or she would be "talkative, sociable and out-going". In several interviews a strong impression was gained that the student did not really associate scientists with a particular personality type and there is probably a random element in this last figure: a choice made only because one was asked for.

Some basic elements of the stereotypical image of a scientist identified by Mead and Metraux (1957), as being held by American high school students, are present here: an elderly or middle aged man wearing a white coat and working alone. Later studies have confirmed that this remains the dominant image among students in various countries: USA (Beardslee & O'Dowd, 1961), Mexico (Rodriguez, cited in Chambers, 1983), Canada, USA and Australia (Chambers, 1983), an unspecified S.E. Asian country (Md Som, Hill & Wheeler, 1989). For Solomon Island students the white male aspect of this image seems to offer little in the way of a positive role model, especially for the girls, but 40% of the boys and 25% of the girls interviewed did feel that they were "the sort of person who could be a scientist" (although very few of these actually thought such a future likely). A lack of interest was a reason several students gave for their being unsuitable, but by far the commonest reason was that they simply did not feel themselves to be clever enough or capable of learning the vast amounts of knowledge they thought a scientist must possess. This is another element of the stereotypical image which these students shared: that a scientist must be unusually intelligent.

> "When I hear the word scientist I think it ... I think maybe he is male and he is genius."
> (19/F/85, 12/10/89)

> "Because the feeling I have is a scientist ... you have to be a lot clever person."
> (43/M/88, 3/2/92)

> "Whenever I hear the word 'scientist', I mean I ... sometimes I just feel inferior. I mean I, I don't know. I mean they're very intelligent people and they must be very, very clever."
> (09/F/84, 25/10/89)[12]

For some, this extends almost to omniscience:

> "He will know everything that ... what will happen in the future."
> (17/F/89, 1/2/91)

A few students felt deterred from becoming a scientist by the belief that a scientist must concentrate on his work to the exclusion of other interests. This aspect came out quite strongly in the results of an investigative technique that was tried with several students but abandoned for various reasons. This asked students to allocate people, for whom brief character descriptions were given, to certain occupations[13]. The position of "research chemist" was given by a large majority of students to characters described as being "very serious" about their work and not interested in social life. Girls were more likely than boys to mention their belief that a scientist works alone as a personal discouragement, but this was not a common point made by either sex.

When asked where they thought scientists would work, ninety eight percent of the students thought they would work in a laboratory. Only forty four percent thought they might work in a factory and only twenty two percent in an office. This is all very much in agreement with the stereotypical image found elsewhere, but an interesting difference is that ninety percent of these students also believed that scientists could be found working out-of-doors. (One boy maintained that "mainly his work is outside".) Agricultural and environmental research, and some astronomy, were the examples given of such outdoor work. This almost certainly reflects the dominant concerns of both the individuals and society as a whole, but it should also be noted that the scientific research institutions in Solomon Islands most likely to be known to the students (all in, or close to, Honiara) are an agricultural research centre, a malaria research laboratory, and a centre for research into giant clams.

There was no evidence of the "mad scientist" or "evil scientist" image that appears in Western culture, albeit only amongst a minority or only as an alternative image (Chambers, 1983). One boy mentioned scientists working with nuclear weapons, but references to medical research were all benign. One girl (an excellent science student) did feel that science sometimes "makes people go crazy", but this was more in the sense of a mental "overload", with no evil connotations:

> "All those experiments and formulas ... and ideas ... crashing them together and putting them together" (23/F/87, 23/8/91).

The origins of the mad or evil scientist image almost certainly lie in, or have been reinforced by, a literary tradition of Doctors Frankenstein, Jekyll, Moreau and Strangelove, which is now part of Western popular culture, but with which the students of Solomon Islands are unlikely to be familiar.

If we turn to consider the possible sources of the students' images of scientists, we might expect the influence of school science to be much greater for these students than for those in, say, Britain, simply because there are far fewer influences in the wider society, fewer sources of information about science, fewer images of scientists. Perhaps it should be seen as rather surprising that their image of a scientist is so similar to that of adolescents elsewhere, and they were asked what they felt had influenced them in this respect. Their answers cannot of course be taken necessarily to reveal true influences since there is no reason why they should be aware of all these influences, but they do at least reveal where the students think their ideas come from, and they reveal the sources of influence of which they are aware.

Forty five percent thought that books - mostly but not exclusively science books - were a source of their ideas; a further twenty eight percent mentioned videos and films, while sixteen percent identified school science lessons and science teachers as important influences. Although some Honiara-based students have video players at home and there is a small cinema in the town, and although there is quite a well-stocked public library in Honiara that the girls in particular mentioned using, these sources of images mentioned by the students are primarily associated with school experiences for the majority of students. Basalla (1976) identified a "pop science" image almost identical to that of Mead and Metraux which is reproduced through the media of popular culture, but this Western popular culture finds its way to most King George VI students largely through schooling. The term "schooling" is used here to include the official curriculum, both in and out of class, and unofficial curricular influences of the school itself; but also urban experiences which arise from attending a school in Honiara. This situation does mean that the school has considerable power to influence the students' images of science and scientist[14]. This influence appears clearly in ideas that the students hold about the nature of a scientist's work.

In response to the question of what they thought scientists actually do, the commonest answer from the students was that they perform experiments, with "observing" also receiving many mentions. It is tempting to see this as a reflection of the emphasis placed on practical work in science lessons at the school; and the belief of almost all that scientists work in a laboratory is supported by the teaching of all science lessons in a laboratory, even if this is not necessarily the source of the belief. There is some uncertainty and lack of unanimity over the purpose of these experiments, however. Some saw them in the mould in which practical work at school tends to be cast: the proving of some idea:

> JL: Why do you think scientists do experiments?
> SS: To find that ... to prove that ... to prove something which they ... they did or thought of.
> (56/M/89, 4/3/91)

Just two or three students, in Form 5, had developed this towards the notion of hypothesis testing. This was the clearest such statement:

> "He has to ... for example, if he puts forward a theory, he has to do some research and find out ... whether this ... er ... some experiments to find out whether this is right or ...
> (33/M/87, 25/7/91)

Others saw the purpose as discovery:

> SS: He spends time in his lab ... doing experiments.
> JL: Why do you think a scientist does experiments?
> SS: To find new things
> (65/M/89, 28/5/91)

Only occasionally did this act of discovery take on a clearly concrete nature in the sense of being an act of invention, and new medicines was almost the only product that was ever specified. Space, the Earth and the environment also received mentions as areas of attention for scientists, but by far the most frequently mentioned specific activity was "chemical experiments", "working with chemicals", or "mixing chemicals":

> "You can't see a scientist who is not ... who did not deal with chemicals. I think all scientists deals with chemicals."
> (06/F/89, 16/4/91)

From a science teacher's point of view, however, it was disturbing to find students who did not really see any purpose for these experiments that scientists are believed to perform, beyond, perhaps, some sort of purely internal self-justification:

> SS: They think about experiments ... mixing chemicals.
> JL: Why do they do experiments?
> SS: To find out more about the things they do the experiments on.
> (33/M/88, 5/5/92)

> JL: What sort of work do you think scientists do?
> SS: Probably its mostly something to do with chemistry.
> JL: What sort of things?
> SS: Probably working with chemicals.
> JL: Doing what with them?
> SS: Er ... mixing them together.
> JL: For what purpose?
> SS: I've no idea.
> (18/F/88, 8/5/92)

Although the majority of descriptions of a scientist's work contained no reference to applications or usefulness of science, it would be wrong to suppose that the students take science to be a purely theoretical pursuit. Perhaps someone with the label "scientist" is concerned only with pure science, in their eyes, but they clearly do see scientific knowledge itself to be extremely useful. Conversations with older students, in particular, showed that it was the potential applications of science that had attracted them to it, and which made it valuable in their eyes, rather than the desire simply to know more about the world:

> "I think what these subjects are ... are aimed at doing is to ... to try and make a better world. Because there's no point in learning them if you don't want to ... if you don't want any modern advancement."
> (34/M/86, 15/10/91)

This sentiment was echoed by a Form 3 boy who stated that he would like to find a job that made use of the science he had learned, "Because if I don't have anything dealing with science, I am wasting my time learning science." (29/M/89, 10/5/91)

This view of science as useful knowledge was revealed when students were asked if they could name any jobs which make use of a lot of scientific knowledge. Only seven out of ninety six students interviewed could not suggest any, and the remainder came up with over thirty different suggestions[15], among which doctors and other medical occupations occurred most frequently, followed by engineers and mechanics.

An acceptance of the practical usefulness of science is displayed yet again in the responses to the aborted attitude scale. One of the sub-scales dealt with the role of science in national development, and included statements such as: "Scientific knowledge will be one of the most important contributions to development of Solomon Islands", and "Scientific discoveries will give us the best way of controlling disease in Solomon Islands". To the first of these statements, 93% of the students reacted positively, choosing either "I agree" (36%), or "I agree strongly" (57%), while only 2% actually disagreed with the statement.

The second statement received 83% support, and only 7% outright rejection.

6.5 Summary

The students clearly share elements of a common "international stereotype" image of a scientist, with which one would probably not expect them to identify. Nonetheless, their attitude towards such a scientist, while respectful almost to the point of awe in some cases, is generally positive. There is not always a clear idea of the purposes of the scientist's work, although notions of the nature of this work may be influenced by experiences of school science. Media images appear to be important but there is more scope for influence by school than might occur in industrialised countries. A major attraction of science is the perceived usefulness of the knowledge which it generates, perhaps more as applied by technologists than as investigated by scientists. This leads to high esteem for at least the national, if not the personal, value of such knowledge.

This high esteem in which science appears to be held does not necessarily translate into popularity of science as a school subject, particularly if one bears in mind the comments that suggest the study of science is the domain of the genius, and the lack of obvious identity with the stereotyped scientist. A perceived general or national usefulness of science is likely to be of less importance for determining attitudes to school science than a notion that it is, or will be, personally useful. Again, school science may be judged less from considerations of the nature of scientific knowledge in general and more from the day-to-day experiences of science lessons. Just what opinions the students do have of school science and why these appear are the concerns of the next chapter.

CHAPTER 7 SCHOOL SCIENCE: ATTITUDES AND INTERESTS, ORIGINS AND IMPLICATIONS

7.1 The popularity of school science

Even allowing for the bias that might arise from having a science teacher as the interviewer, the responses from interviews make it clear that science - or at least certain parts of it - is a popular subject in the school. When asked the question, "Which subjects do you enjoy most?", Form 3 and Form 5 students, boys and girls, cited either science in general or one of biology or physical science, more frequently than any other subject. This position was broadly, if not identically, supported by responses to the written questionnaires given to students in Forms 2 to 5. These indicated that science was the most popular subject at all levels, with the exception of Form 3, where mathematics took the honours. (Mathematics was second to science for all other Forms.) It is not really worth providing actual figures here since these are likely to be susceptible to all sorts of temporary influences that render them unstable: the popularity of some subjects, for example, was found to alter quite dramatically with a change in teacher. The point being made is simply that there is a generally positive attitude to science in the school.

When asked to give reasons why they enjoyed the subjects they had stated, several students mentioned their perceived usefulness, in some respect. As far as science was concerned, any usefulness was not commonly seen in vocational terms: only six students out of the sixty six who expressed a liking for school science, or part of it, give relevance to their intended future career as a reason for their interest or enjoyment. A usefulness in everyday life was sometimes given as a reason for liking some topics in the course, but personal relevance is a better term to use to describe the source of attraction of much of the science to these students, particularly, but not exclusively, in biology:

> "Because in biology we learn ... I mean, about things in our body ... our own things ... and how our body works. And all these things are interesting."
>
> (26/F/88, 30/4/92))

An immediacy and reality were seen as general properties of science that enhanced its interest:

> "Science, I like science because ... it's very interesting. I want to know about things just around me and things that are moving, and non-living things, like that."
>
> (15/M/89, 3/5/91)

> "Things that we learn in biology I can see ... it's real. I can see them sometimes and I know where they are at. ... And physics ... some things that we learn are true ... They are in real life."
>
> (33/F/87, 10/6/91)

Some students clearly revealed a sense of excitement, almost empowerment, from gaining new knowledge about their surroundings and phenomena in their everyday lives:

> "Especially when I am small I just thought, 'Oh, these things are coming from this and this'. But when ... say for example acids and things like that ... how tides move. Especially those things, say, for example, the rainbow. I may have thought about it as the Bible said, 'God created this and that'. And when I came to form one, we learn about the ... evaporate and how the water rises and caused by the wind blowing, caused the rain. Therefore I know and understand."
> (04/M/89, 15/4/91)

> "Science ... I want to study it more so that I know more about ... biology and ... more about science, developing science, so that I ... understand it more. I mean ... dunno ... I like it because it's active and it studies more about what's around you."
> (52/M/89, 21/2/91)

This active, practical nature of science mentioned in the last quotation is an important reason for its popularity. Almost one third of those interviewed volunteered this as a major source of their enjoyment of the subject, and when asked directly whether they enjoyed science practical, only one student (a girl) expressed a dislike for it - although four other girls showed somewhat qualified enthusiasm. Practical work was also a key factor in the popularity of agriculture, home economics and woodwork, and both there and in science one of the explanations given for liking practical work was that it provided a change from the routine of listening, reading and note-making of so many other lessons: "I have to move and do the work and ... time just passes by" (09/M/87, 12/8/91); or even, "I mean, you can play around in the class" (35/F/89, 24/5/91). More important than this simple variety factor, however, was the feeling that "hands-on" experience was a much more effective route to remembering and understanding:

> "I enjoy doing much of practical when we do the experiment and finding out of things the teacher didn't tell us ... Because in theory the teacher tell us and it went out in the other ear, but in practical I usually do it by myself, so I remember it."
>
> (31/F/89, 22/4/91)

> "Because you do them by your own ... When you do them by your own ... the ideas come from your own mind so they can't escape. You can remember them."
>
> (12/M/88, 31/1/92)

> "Because, for example, when we write a lot we don't know what we are talking about, but when we do practical work we can understand some of the things we do in science."
>
> (48/F/89, 15/2/91)

For some students, practical work is one of the key characteristics that sets science apart from other subjects:

> "I think that's what I was trying to say today about the arts subjects. When they talk about things it is ... er ... seems to be talking about it. Even though we do not understand what they are talking about, we just talk about it. But in science, when we talk about things, they show this is what we are talking about. And we do it ourselves ... and we get familiar with it and then ... er ... in the end we know what we are doing."
>
> (43/M/87, 4/8/91)

This sense of dealing with a concrete reality, implicit in this last quotation, is stated explicitly by many students as the important feature of practical work that attracts them. For some this takes the form that practical work turns theoretical concepts into tangible reality, and for others it acts as a "proof" of theory. Among some of this latter group there is the interesting implication that at least part of what is learned at school is seen merely an academic exercise which has no meaning in the real world: the truth of an idea is determined by its realisation in the physical world, not by the authority of a teacher or textbook, nor by logic or mathematics:

> "Well it's practical. We use it. We test it. If we learn about it and we don't test it, I don't ... it's not really ... <u>real</u>, true to me."
> (52/M/89, 21/2/91)

> "I just enjoy it. I think actually because, in real life, you ... we ... we don't deal with things in books, just reading things, like that, we have to do <u>practical</u> work. So I enjoy doing practical."
> (28/F/88, 27/2/92)

> "I like practical work because we are trying to do what is in theory and then prove in practical that it is right."
> (39/M/87, 12/9/91)

> "I like practical work because sometimes the things they write in books are not true, and then if we do the practical ourselves, we know if they are true or not. ... Sometimes we follow the book and if they say that this happens ... even if we follow the steps carefully, the theory in the book is not true. And the teacher will explain and say 'Oh, this is wrong'. So ... it's better to do it ourselves."
> (27/F/88, 30/4/92)

Although these last comments might be taken to be a demonstration of healthy scientific scepticism, it is probably more correct to interpret them as a reliance on concrete experience as the touchstone of truth. One girl, for example, described practical science as finding "facts" and "solutions to problems" (29/F/88, 13/4/92). In the school context at least, "facts" are probably more commonly associated with information gleaned from reference books; and "solutions to problems" is the sort of phrase one sees at the back of mathematics or science books above a list of answers to pen-and-paper problems. For this girl, however, "facts" and "problems" are also to be found and solved in concrete experience. This view of knowledge is very reminiscent of that found among the Kpelle by Cole, Gay, Glick and Sharp (1971), who showed that the Kpelle "reject knowledge forms that do not come out of their lived experience of the world. The Kpelle cannot accept a syllogistic conclusion if they have not observed the relationship between events" (Masemann, 1990). The K G VI students' comments are eloquent expressions of the importance of including as much practical experience as possible in the science course.

Comments such as "I want to do things by myself", or "We find out about things ourselves" were common in students' accounts of why they liked practical work, but these do not necessarily imply that the students wish to work individually. In practice, practical exercises were usually carried out in small groups and these students have had little experience at working individually with apparatus. It is the independent learning aspect, rather than individual learning, which is found appealing - a feeling of independence from immediate control by the teacher of the learning experience. An emphasis on the individual is more a characteristic of the traditional classroom, stop-talking-to-your-neighbour approach, than the group-organised laboratory lesson, and several students saw group consultation as one of the attractions of practical work:

> "One way I like it is that because if we do it in a group we share ideas about it and then we come to the conclusion about it. But another thing is that if I do it by myself, I might find it quite difficult."
> (12/F/89, 18/2/91)

> "Yes, I enjoy it. ... Because I share my ideas with others and others share their ideas also.
> (47/F/89, 28/2/91)

Discussion and sharing of ideas takes place not only within a group sharing one set of equipment, but also between groups, for the purpose of checking one's results:

> "Well sometimes because if my answer is wrong with the other group, I might think that it is wrong"
> (12/F/89, 18/2/91).

Many students were clearly happy to have the opportunity to discuss and receive confirmation of their own observations from their peers, to arrive at an interpretation by consensus. It is tempting to see this behaviour as an example of the unwillingness to be singled out from the group, of the desire to conform that was mentioned in chapter 3: a lack of self-confidence that Crocombe (1989: 34-37) attributes to traditional child-rearing practices. It may also be interpreted more positively in terms of the emphasis laid on consensus rather than conflict in decision-making that some Melanesians have personally put forward to me as being a characteristic of a "Melanesian way", or even a "Pacific way".

Few of the interviewed students expressed an actual dislike for science. Four girls singled out physics, or physics and chemistry, while another two disliked all the science. The reason given was always the same, namely that the subject was "too hard". In half of the cases this difficulty was linked directly with a dislike for mathematics and the need to carry out calculations in science[1]. Only one boy expressed a general dislike for all science and he could give no reason beyond a dislike.

More common than a aversion to science in general, was a dislike for certain topics, or, conversely, a distinct partiality for some parts of the course over others. These preferences, and the patterns in them, are the subject of the next section.

7.2 Patterns of interest

Answers to the general question about interest in science reveal differences in the preferences shown by boys and by girls. Although science ranks highly with both, in the junior forms it appears to be more popular with the boys[2]. In the senior forms, this difference may be reduced, or disappear, but this is at least partially due to the tendency for these older students to distinguish between biology and the physical sciences - since they are now taught separately. The popularity of science among the girls is now biased towards biology, while the boys show a weaker tendency to favour physical science - a phenomenon that has been widely noted (Smail, White & Kelly, 1982; Shannon, Sleet & Stern, 1982; Sansanwal, 1983; Dawson, 1983; Smail & Kelly, 1984)[3].

An analysis of topic preferences, however, reveals that the situation is not quite as straightforward as this. When Form 3 girls were asked which of the topics from their science course of the previous year they had enjoyed most, biology topics appeared as the four most popular: human body systems, food and nutrition, seeds and plants, and diseases and micro-organisms, in that order. But when the boys were asked the same question, they gave priority to the same four topics. Among the Form 5 interviewees, the girls once again showed much greater predilection for biology topics -

particularly human biology - than for chemistry or physics. The boys at this level were now giving preference to physics topics, most notably electricity, but with human biology a very close second. What seems to be happening here is the situation noted by Ormerod and Duckworth (1975): human biology is of interest to both boys and girls, but boys also have a wider interest in other areas of science.

The reasons given by the students for preferring these topics were, perhaps not surprisingly, similar to those given for enjoying science in general. Personal relevance and usefulness are particularly important in accounting for the popularity of human biology:

> "Body systems ... Because it tells me about my own body."
> (17/M/88, 14/4/92)

> "Food and nutrition ... Because it gives me ideas of how to make a balanced diet."
> (28/F/89, 13/5/91)

> "Body systems ... I want to be a nurse and I want to learn about things in our bodies."
> (36/F/89, 17/5/91)

The satisfaction of curiosity about themselves and their environment also gave biology topics a great appeal to the students, quite apart from any possible practical usefulness. When asked directly which topics they felt had been useful or might be useful in the future, however, the same human biology references appeared, although with the addition of electricity too.

The other important sources of enjoyment of certain topics were the ease with which the students found they could understand them, and the way in which they were presented. This latter usually appeared as the enjoyment of practical activities, but the perceived competence and attitude of the teacher were also considered to be important. The difficulty of certain topics - almost always in the physical sciences - was the main reason given for disliking them. For some topics, this difficulty was blamed on poor presentation and explanation[4] by the teacher, but certain areas seem to present particular problems. The more theoretical aspects of chemistry, such as atoms, formulae and equations, were found difficult, and some of the girls picked out the quantitative aspects of physics as causing them problems. This occurred even among girls that enjoyed mathematics. It seems that the nature of quantitative problems in physics, involving a "translation" from physical reality to a mathematical representation, is quite different from the largely symbolic problems encountered in mathematics[5].

These exercises on topic preferences all asked the students to evaluate courses they had already been taught. As such, their answers are an indication not only of interest in the subject matter, but also of their experiences of science lessons. It was felt that a list of topics presented to Form 1 students, early in their first year at the school, would tap interest rather than experience, since they would have received very little, if any, instruction on any of the subjects. Topics presented for their judgement were not necessarily those that would actually appear on their science course. In fact, it would have been folly to include terms such as "chemical reactions", or even just "physics" and "chemistry", since these would be unknown to the majority. It was found rather difficult to select areas of chemistry which could be described concisely and simply and, as a result, the list of eleven topics used was rather biased towards physics and biology. It was decided to present a similar list to Forms 2 to 5 also, although it was accepted that some of their choices would be influenced by experience of school science. Perhaps unwisely, since it reduced comparability, some changes were made to the lists used with older students, so as to make use of their familiarity with scientific terms. The trends in the interest shown in the selected topics by the boys and the girls, from Form 1 to Form 5 are shown by the data in Table 7.1. Each student was asked to select the three topics that appealed to him or her most.

Looking at the Form 1 choices first, the girls clearly prefer the biological topics over those from the physical sciences, with the notable exception of astronomy. Although

Table 7.1 Science topic preferences expressed by students, by Form and by gender. (Figures give the percentage choosing each topic.)

Topic*	Gender and Form									
	Boys					Girls				
	1	2	3	4	5	1	2	3	4	5
Stars	58	30	16	21	3	34	34	15	15	12
Engines	45	45	57	56	64	20	13	19	19	6
Electricity	43	45	45	47	50	15	6	7	12	6
'Scopes	28	21	21	3	6	10	11	7	12	0
Plants	28	36	14	3	3	47	51	22	4	24
H. Body	34	40	45	44	39	64	55	78	85	59
Disease	25	34	48	44	33	69	45	67	65	76
Materials	8	6	2	15	19	5	4	7	4	6
Reactions	--	21	31	18	19	--	19	22	19	35
Animals	15	15	16	--	--	25	40	33	--	--
Sea Life	11	6	7	--	--	10	19	22	--	--
Atoms	--	--	--	24	3	--	--	--	12	24
Environment	--	--	--	6	28	--	--	--	31	24

* The topics are listed here under abbreviated headings. They were as follows on the questionnaire:

Stars: The stars, the Moon and the planets.
Engines: How a car or outboard motor engine works.
Electricity: Electricity and machines that use electricity.
'Scopes: How to make a telescope and microscope.
Plants: Plants, seeds, flowers, and how they grow.
H. Body: Your body and how it works.
Disease: Diseases, what causes them and how to prevent them.
Materials: How to make materials like concrete and plastic.
Reactions: Chemical reactions.
Animals: Animals and birds and how they live.
Sea Life: Living things in the sea.
Atoms: Atoms and molecules.
Environment: The natural environment and ecology.

the boys are more interested in the "applied physics" topics than the girls are, they also show a significant interest in biology; their scientific interests do seem to be rather broader than those of the girls, even at this early stage. Biological interest from both boys and girls is centred mainly around human biology, diseases and plants: those areas of direct concern to an agricultural population in a country with serious endemic diseases and very limited medical resources. The relative lack of interest in animals perhaps reflects the absence of livestock rearing: pigs, flying foxes, birds and fish may be hunted, but their care and development are largely irrelevant.

These broad patterns of interest persist throughout the school. The girls' interests remain dominated by biology, while physics and some human biology attract the attention of the boys. The girls' interest in astronomy rapidly declines, but a moderate liking for chemistry develops. Some of the developments are likely to be explicable in terms of school science experience[6]. For example, the Form 2 course includes an extensive study of seeds and plant growth, and it is noticeable that interest in this topic declines after Form 2. This may be due to the students' feeling that they have now learned enough, or it may be that their experiences of the course have blunted their enthusiasm for this topic. The reverse effect may explain the difference in the responses to the environment and ecology topic between Form

4 and Form 5. The first real work on this topic is encountered in Form 4, and the apparent increase in popularity may be a real one influenced by experience, particularly since practical field-work is an important component of the approach to this subject[7].

It does seem likely, however, that there are certain areas in which interest is maintained largely irrespective of experiences in school science: human biology for the girls, and machines for the boys are the obvious examples. The implication is that the origins of such enthusiasm lie outside school experience. The topic preference choices were examined for significant differences between boys and girls, and between rural and urban students (using primary school attendance as an indicator of urban experience). To increase group populations and to reduce the impact of cohort effects, the data from all Forms 1, 2 and 3 students were combined. Table 7.2 gives these combined data.

The data clearly endorse gender as a major source of differences in interests, with these differences being in favour of the boys for physical science and girls for biology. Although not all urban/rural differences are statistically significant, these differences are almost invariably in favour of rural students for biology topics and urban students for topics from the physical sciences.

Table 7.2 Statistically significant differences in science topic preference for combined Forms 1 to 3, by gender and by rural/urban background. (Figures show the percentage choosing each topic.)

Topic	N:	Boys *(160)*	Girls *(113)*	Group Urban Boys *(58)*	Rural Boys *(90)*	Urban Girls *(72)*	Rural Girls *(39)*#
Stars		(35	30)	(41	33)	(32	28)
Plants		(26	43)**	(19	29)	(43	44)
Engines		(51	16)***	(66	42)***	(25	0)**
Reactions		(25	20)	(34	17)*	(25	11)
H. Body		(41	65)***	(33	46)	(58	74)*
Electricity		(45	9)***	(50	40)	(10	8)
Animals		(15	34)***	(5	20)*	(41	29)
'Scopes		(23	9)**	(22	22)	(8	8)
Sea Life		(8	17)*	(5	11)	(17	18)
Disease		(36	59)***	(29	43)*	(60	62)

Notes:

Significance of differences between bracketed pairs:
unmarked pairs - NS
pairs marked * - $p<0.1$
pairs marked ** - $p<0.01$
pairs marked *** - $p<0.001$

(Significance determined by *t*-test on mean scores with standard deviations, for each pair.)

The urban and rural populations do not add up to the total population as those students with two years or less experience of a Honiara primary school are not included in either category, although they appear in the total.

The "car and outboard motor" topic clearly reveals these two influences at work: one derived from gender, and the other from urban experience. Not one girl with entirely rural primary school experience placed this topic among the three she would most like to learn about, whereas twenty five percent of the Honiara-schooled girls did so - with that proportion being almost exactly maintained from Form 1 to Form 3. The considerable urban experience gained from being a boarder at King George VI School does not alter the rural girls' lack of interest, whereas that of the rural boys grows: from 31% choosing this topic in Form 1, to 44% in Form 2 and 50% in Form 3[8].

It has already been suggested that the chief influences on these preferences, and attitudes to science in general, arise from notions of personal relevance, interpreted in a wide sense. The perception of relevance may derive from past influences and experiences, from more immediate present concerns, and from aspirations and perceptions of possible futures. With a view to understanding what the students hoped or expected the future might hold for them, and how this might influence their reactions to science, they were asked about their career hopes and plans; their responses are considered in the next section.

7.3 Students' occupational aspirations

As a preliminary cautionary note, it must be pointed out that the professed job aspirations of the K G VI students are not at all stable. Eighty five students who had previously stated their vocational interests were re-examined between eighteen months and two years later (some orally, some in a written questionnaire), and only forty percent returned the same answer. On the other hand, despite fluctuations in an individual's aspirations, no significant change in overall pattern was detected between Forms 1 and 3, and so it is felt that a summary obtained by combining responses from all students in this range does obtain useful information about the range of jobs in which the students are interested. The data presented in Table 7.3 were obtained from the 1990 and 1992 cohorts in Form 1, the 1989 and 1991 cohorts in Form 2 and the 1988 cohort in Form 3. It was decided not to include Form 4 and Form 5 data since the selection process necessarily produces a population which is not entirely comparable with that of Forms 1 to 3. If these data for the older students did show any developments, they would be difficult to detect because of the small populations of certain groups, notably girls from rural or farming backgrounds. The only trend which was in fact hinted at in the older students' choices was a decrease in interest in teaching among girls, but no statistical significance could be attached to this.

Table 7.3 Occupational interests expressed by students in Forms 1 to 3, by gender, by rural/urban experience* and by father's occupation**.

	Percentage naming each occupation							
	Girls				Boys			
	Hon	Rur	ModS	SubF	Hon	Rur	ModS	SubF
(N:	*117*	*61*	*142*	*27*	*112*	*139*	*179*	*75)*
Occupation								
None	26	34	25	41	29	27	28	33
Doctor	18	4	15	0	9	13	11	12
Nurse	13	18	13	15	0	0	0	0
Teacher	6	25	12	26	2	8	3	8
Eng/Mechanic#	1	3	1	4	24	26	26	23
Science##	2	0	2	0	2	1	1	1
Carpenter	0	2	1	0	1	4	1	5
Pilot	3	0	3	0	13	4	8	4
HS Wh.Collar+	14	5	14	4	13	5	11	3
Clerical	9	5	6	11	0	2	1	1
Agriculture	0	2	1	0	1	4	2	3
Others++	8	3	7	0	7	7	7	8

Notes

* Rural/urban experience is judged, as elsewhere, by primary school attendance. Hon: 3 or more years in Honiara schools
Rur: all primary schooling rural.

** Father's occupation classed simply as either modern sector (ModS) or subsistence farming (SubF).

This occupation category includes engineer, mechanic, technician and electrician. Although it may be felt that "engineer" should be distinguished from "mechanic", interviews revealed that students frequently used the former when they meant the latter.

Scientist, marine biologist, physicist, meteorologist.

\+ High Status White Collar: the commonest examples were lawyer and accountant but includes a few others, such as architect and surveyor.

++ Includes sailor, ship's captain, police, storekeeper, and others difficult to classify.

The data are organised to display the influences on aspirations that derive from gender, urban experience, and father's occupation[9]. The greater interest shown by the boys in technical and engineering occupations could be predicted, and it should be noted that this interest shows no differentiation by urban experience or father's occupation (within the very crude distinctions made here at least). The level of interest in becoming a doctor is similar for both boys and girls but this aspiration is not shared by the rural girls from subsistence farming backgrounds. For these girls, an interest in medicine appears as an interest in nursing, which is clearly seen by all as an all-female profession. The white collar aspirations of rural, farming background students are more modest than those of their urban, modern-sector colleagues, with this effect being most pronounced among the girls. Teaching is seen as the route into white collar occupations for rural girls whereas their urban sisters aspire to more prestigious occupations such as law and accountancy. The rural, farming girls offered a much narrower range of interests and a much higher level of indecision than the other girls or the boys. This effect is likely to be due to a combination of a lack of awareness of options available together with lower ambitions[10].

The urban/rural and modern/subsistence sector factors are important qualifications on that of gender, particularly for the girls. This point has either been ignored or was not found to be significant in some other analyses of occupational aspirations in less developed countries. For example, both Duncan (1989), in Botswana, and Foreman (1984), in Trinidad and Tobago, comment on the lower aspirations of girls compared with boys, but do not record any differences derived from other factors. An exception to this is a study from Nigeria which revealed lower educational aspirations for rural girls compared with urban girls and echoed the K G VI finding that rural girls were much more intent on becoming nurses than their urban sisters. An interesting explanation is offered for this:

> "Nurses working in rural areas are often accorded the status of doctors, since they are the people assigned to head the various health centres ... Indeed, to the rural female student, nursing is the height of female achievement in her social environment, since the nurses are always being sought for by all within the community, and the location of their homes is widely known"
> (Akande, 1987: 79)

Duncan (1989) uses her data to support findings from elsewhere (e.g. Lueptow, 1981; Jacobowitz, 1983; Johnson, 1987) "that boys are far more likely than girls to aspire to jobs with a scientific or technical component" (Duncan, 1989: 133). The King George VI figures suggest that this is an over-simplification: certain groups of girls do aspire to jobs that they feel demand a certain type of scientific knowledge. Specifically, the urban girls, and those from modern sector backgrounds, show a significant level of interest in becoming doctors, which they see as requiring a knowledge of biology. It was pointed out in chapter 4, that when asked to name occupations which they felt demanded a lot of scientific knowledge (apart from "scientist"), the students altogether produced quite a long and varied list, but for the girls this was dominated by medicine: two thirds of the girls interviewed suggested doctors needed to know science, although nurses were very rarely mentioned. Engineering and other technical occupations received significant mention, but among the boys these were the most often mentioned, with doctors a close second.

Neither boys nor girls show any interest in "pure science" occupations, but the greater interest shown by the boys in applied science is restricted to jobs seen to need the physical sciences. Biology would appear to be seen as occupationally equally relevant to both boys and girls. But to state this is to exclude an important aspect of the girls' perceptions of their future.

In addition to any aspirations they may have towards wage-earning occupations, most, if not all, of the girls anticipate that they will get married and bring up a family. They have an anticipated vocational future of housewife and mother in addition to the interests listed in Table 7.3, and this can be expected to influence their attitudes towards their school experiences. This is seen clearly in the accounts given by the significant proportion of girls who gave home economics as one of their favourite subjects as to why they enjoyed it[11]:

> "Because ... I can ... er ... I can learn some way to sew clothes or to cook ... like ... to do in the future when I get married ... so that I may learn how to sew or cook the food for the families."
> (26/F/89, 11/2/91)

> "Because home economics deals with things that when girls marry they can help"
> (11/F/89, 11/3/91)

> "Home economics ... because it's... it's interesting ... It's life."
> (29/F/88, 13/4/92)

It is of course true that if most of the girls expect to get married, then probably so do most of the boys, but the implications of this are different for each of them. The following excerpt is from an interview with a Form 5 girl who stated she wanted to get a job and did not want to get married:

> JL: Why not?
> SS: Because I want ... I don't want anyone to disturb me.
> JL: You think that marriage is a disturbance?
> SS: Yes.
> JL: Is it also a disturbance for the boys?
> SS: No.
> JL: Why not?
> SS: Because ... er ... they don't care about the family, they depend on the woman.
> (13/F/88, 6/2/92)

Interesting support for this view of the girls' future came from the only student interviewed who had claimed that school science was more useful to girls than to boys; an opinion that seemed to have been influenced by the heavy emphasis on biology in the science course of Form 2 and the first part of Form 3:

> SS: Girls ... girls are ... interested in biology in schools. For the future I think they are the ones that do most of the things.
> JL: What sort of things?
> SS: For example, when they have children, like that, they know how to give them which type of right food and also how to take care of them, protect them from diseases.
> (33/M/89, 14/2/91)

The gender-based divisions which appear in these occupational aspirations are likely to reflect occupational stereotypes, derived from perceptions of the existing labour situation[12]. What is of concern next is whether these stereotypes, when linked with perceptions of education appropriate for each occupation, result in a gender-typing of school subjects, notably science. Interest in science has been shown to be gender-dependant, but is there a broader gender-typing of science in general?

7.4 Gender-typing in science

Some two-thirds of the students interviewed felt that science in general is equally interesting and useful to boys and girls, but thirty one out of ninety five thought that boys find it more useful, more interesting, or both. Girls expressed such an opinion slightly more frequently than boys (36% to 29%), but the difference is not significant.

More than half of these students gave reasons of the form "Because boys usually get jobs that are usually dealing about science" (56/M/88, 17/2/92), quoting mechanic, doctor, engineer and scientist as examples of such jobs. One Form 3 boy made the point in a different way:

> "Because I think girls' job when they leave school, I think is housewife, or a typist, or secretary, or some managing, but it's not needing much about science."
>
> (35/M/89, 3/5/91)

A second type of reason insists that boys are simply more interested in science, although this may be combined with a statement about jobs too, as an explanation for this interest:

> "Boys want to fiddle around with things in science and girls don't."
>
> (17/F/88, 20/2/92)

Some students - more frequently girls - maintained that boys are just "better" at science, or some parts of science, than girls are:

> "I can see in my class that usually the boys are very good in class than the girls"
> (22/F/88, 30/3/92)

Another group went further to state that boys are generally more active, or even more intelligent than girls, or that they apply themselves more to their work:

> "Because I think boys are ... have lots of intelligence and they are the ones who have good ideas. I mean, like doing studies to know more about science. They are the people who get to know ... eager to know things."
> (13/F/88, 6/2/92)

> "Boys concentrate on their work. Girls get distracted by boyfriends."
> (17/F/89, 1/2/91)

There was a disturbing tendency for some of the girls to make self-depreciatory remarks:

> "[The boys] are quicker at thinking about things."
> (20/F/88, 28/2/92)

> "Girls are like lazy women so they have to do it slowly."
> (11/F/89, 11/3/91)

> "Most boys have more knowledge than girls."
> (50/F/89, 8/5/91)

This belief in a somewhat generalised inferiority of girls was similarly expressed by some of the boys, although it must be noted that such explicit expressions were unusual[13].

Although the majority of students do not gender-type science in general, the responses are very different when they are asked if boys or girls perform better at any parts of science. Sixty percent of both boys and girls thought that boys are better at some parts, while sixty eight percent of boys and fifty eight percent of girls thought girls are better at some parts.

Physics, certain topics in physics, or physical science were the areas in which boys were declared to do better than girls in half of the statements of this type, with girls as likely as boys to make such responses. Chemistry topics were rarely cited, and only boys suggested they were better than girls at any biological topics. The other significant area of perceived superiority for boys was practical work: fifteen percent suggested this, with boys claiming superiority more often than the girls conceded it.
Only about three quarters of the interviewed students could suggest a reason for the boys' superior performance and the commonest of these was simply that the boys are more interested in whatever topic had been mentioned:

> "Physics is about how things work, and that is more interesting to boys."
>
> (17/F/88, 20/2/92)

Sometimes this interest was seen to be linked with possible career options, and about a further fifteen percent of the reasons were explicit statements about particular topics being relevant to jobs that only boys would get:

> "Boys become mechanics."
> (24/M/88, 9/4/92)
>
> "Girls don't want to work with machines and tools."
> (25/F/89, 6/5/91)
>
> "Because I saw in the hospitals there are only men who are doctors."
> (25/M/89, 1/2/91)

In which direction this influence operates, whether interest and performance derive from a perception of job opportunities or *vice versa*, is difficult to say, and the students themselves were not all clear, but statements such as the last one quoted above were common and do suggest that a perception of a possible future influences interests. The reality is likely to be a mutual support based on socially defined notions of occupational roles and interests. Some girls at least seemed to be aware of the social forces reaching into their responses to science through definitions of gender-appropriate futures.

> SS: I think boys are ... I think they are better at dealing with ... elements.
> JL: Do you think that is just the way they are, or do you think it's because of the way they are brought up?
> SS: I think ... it depends on a person ... Because girls, when they are young, they grow up and they go to school or college up to the age of twenty. ... Twenties to thirties ... they get

> interrupted with boys and they get married at the early age, and ... the girl hasn't made use of her studies, and ...
>
> (13/F/88, 6/2/92)

> SS: If the girls try their best like the boys then they can do as well as the boys.
> JL: You think sometimes the girls don't try their best?
> SS: Here in Solomon Islands that's right. [Laughs]
> JL: Why is that?
> SS: It is because ... relatives ... and custom, they stop girls from going to school sometimes when they reach nine years old or something, then they say, "You stop schooling and let the boys go to school."
>
> (37/F/89, 14/5/91)

Superior manual dexterity was a common reason given by both sexes for the boys' supposed better performance in practical work, although a few boys were able to relate this to the greater opportunity that boys had in general for skilled manipulative work:

> "I'd say ... boys get to use their ... their hands more often than girls"
>
> (67/M/88, 6/4/92)

Other reasons given for this perceived superiority in practical work were that the boys had the necessary strength and that girls get "over-excited" during "experiments that are explosive".

Three quarters of those of both sexes who thought the girls better at some part of science gave biology as the relevant area, or a biological topic, most commonly food and nutrition. The commonest reason given for this superior performance is that many of the biological topics are also covered in home economics: this accounted for about one quarter of the explanations given. Thus, even when the girls' superiority is conceded, it is explained away through the curriculum giving them an unfair advantage:

> "Because some of the things we do in biology, they do in home ec. ... so they just learn those things ... two times."
>
> (62/M/88, 24/2/92)

Both sexes claimed that the girls were neater, more careful workers who paid more attention to the teacher than the boys did. Some girls considered this made them better at practical work than the boys, but for the boys these characteristics, together with a tendency to read more, were considered more likely to make the girls better at theoretical rather than practical work. Biology was identified as a subject demanding more reading, more note-making and fewer calculations than the physical sciences, and hence making it more suitable for girls. Implicit self-depreciation appeared again in explanations from two girls that biology is an easier subject than the rest of science.

Almost another quarter of the reasons given for the girls' superiority in biology related the subject to the girls' future occupations. For the girls this was more likely to mean looking after a family:

> "Food and nutrition ... Because they are everyday life and about food, and they do shopping and cooking."
>
> (19/F/88, 12/5/92)

While some boys made the same point, they were more likely to mention medical applications of biology as being relevant to the girls' possible careers. They emphasised the more patient, caring nature that girls were believed (or expected?) to possess, making them more suitable as nurses or, less often, doctors. Human biology is clearly associated with a caring, nurturative future that is more appropriate to females than to males. The responses of one boy can be quoted here to sum up the common perceptions of gender roles that influence both aspirations and attitudes:

> JL: Do you think girls are better at any parts of science than boys?
> SS: I think so. ... On the medical side, I think girls are more better than boys. For example, looking after patients in hospital, or caring for sick people.
> JL: You think girls make better doctors?
> SS: Yes.
> JL: Why is that?
> SS: Because most boys ... they are not loving and they don't care for other people.
> JL: Do you think this is something natural or something that is learned as they grow up?
> SS: I think it's natural.
> JL: Do you think boys <u>should</u> be harder and less caring than girls?
> SS: I think it's a good thing.
> JL: Why?
> SS: So that ... er ... boys ... when they get older, they are the ones ... they are the ones to boss their families, so they should be harder so they can control the family well.
>
> (58/M/89, 29/1/91)

7.5 Attitudes and achievement

The largely qualitative approach adopted for the analysis of the students' attitudes to school science doesnot really allow scope for investigating links between these attitudes and achievement in science. Certainly, the divisions which were found to be important in the analysis of performance - gender and rural/urban - have also been found to be useful in the consideration of attitudes, and there are suggestions of possible links. For example, there are echoes of the girls' better relative performance in biology in their greater preference for biological topics and in their perception of the personal relevance of these topics.

To look for a more explicit link between attitudes and performance, however, we must turn to the attempted development of attitude scales. The difficulties that were encountered with these scales, and the limited success in their production, have already been mentioned, and must be born in mind when use is made of them. Information obtained from these scales is better treated as suggestive rather than conclusive.

The final version of the attitude test comprised eight scales: Personal Value, Personal Enjoyment and Self-concept, in biology and physical sciences separately, National Value of Science, and Science as a Truth System. The items used to assess these are reproduced in Appendix 4. Making comparisons between scales is fraught with problems, as discussed in the previous chapter (section 6.2), but in this case, a certain amount of comparison is legitimate, since the two sets of three scales referring to biology and physical sciences used identically structured statements, with either "biology" or "physical science" as the subject. Table 7.4 compares the rank order of each of the eight scales in the scores of girls and boys in Form 4 and Form 5, who sat the test in 1992.

Table 7.4 Rank order of attitude scale scores, by gender, Forms 4 and 5 (combined), 1992

	Boys (N: 73	Girls 49)
Biol Personal Value	5th	3rd
Biol Personal Enjoyment	3rd	1st
Biol Self-concept	7th	6th
Phys Sc Personal Value	4th	5th
Phys Sc Personal Enjoyment	2nd	4th
Phys Sc Self-concept	8th	8th
Science National Value	1st	2nd
Science as Truth System	6th	7th

Several points are worthy of note in these rankings, some of these supporting earlier observations about these students. Science is perceived by all to have an important role in national development, but at the same time, is not accepted unequivocally as the prime source of knowledge about the world. This latter point will not be expanded on using data from this test as the relevant sub-scale - Science as a Truth System - was undoubtedly the weakest in terms of internal consistency, but it will be returned to from a different angle in chapter 10.

Within each of the sets of scales for biology and physical science, enjoyment is ranked higher than personal value, and self-concept takes the lowest rank. While accepting that such "vertical comparisons" are difficult to defend, they do suggest that the students enjoy lessons in these topics and find them of some relevance to their own lives, but also find them rather difficult. This fits well with what has already been said about their attitudes to school science. "Horizontal comparisons", across Table 7.4, are more legitimate, and these support the finding that girls prefer biology, while the boys prefer physical science. A further breakdown of the students by rural/urban background produces the same patterns, with the exception of rural boys, who rank biology higher than physical science on all three scales.

Correlations between attitude scales scores and scores in science examinations are presented separately for Form 4 and Form 5, in Tables 7.5 and 7.6, since it was felt that combining scores from totally unrelated science examinations was not justifiable. This produces rather small sample sizes, so that only quite large correlation coefficients show statistical significance.

Key to Tables 7.5 and 7.6:

Attitude scale abbreviations

- BPV: Biology, Personal Value
- BPE: Biology, Personal Enjoyment
- BSC: Biology, Self-concept
- PSPV: Physical Science, personal Value
- PSPE: Physical Science, Personal Enjoyment
- PSSC: Physical Science, Self-concept
- SNV: Science, National Value
- STS: Science as a Truth System

Significance levels

- Unmarked: p>0.10
- *: p<0.10
- **: p<0.05
- ***: p<0.01

Table 7.5 Correlations between attitude scale scores and examination scores in biology and physical science for Form 4, 1992, by gender

Attitude Scale	Correlation coefficients, r Boys(N=31) Biology	 Boys(N=31) Phys Sc	 Girls(N=27) Biology	 Girls(N=27) Phys Sc
BPV	0.07	0.06	0.22	0.05
BPE	0.25	0.09	0.45**	0.31
BSC	0.34*	0.02	0.47**	0.26
PSPV	-0.23	-0.30	0.19	0.14
PSPE	0.23	0.29	0.08	0.07
PSSC	0.14	0.21	0.34*	0.25
SNV	0.01	-0.04	0.22	-0.03
STS	0.01	-0.03	0.30	0.19

Table 7.6 Correlations between attitude scale scores and examination scores in biology and physical science for Form 5, 1992, by gender

Attitude Scale	Correlation coefficients, r Boys(N=42) Biology	 Boys(N=42) Phys Sc	 Girls(N=22) Biology	 Girls(N=22) Phys Sc
BPV	0.10	0.02	0.25	0.26
BPE	0.13	-0.07	0.45**	0.33
BSC	0.50***	0.38**	0.16	0.08
PSPV	0.11	0.23	0.06	0.17
PSPE	0.20	0.23	0.22	0.48**
PSSC	0.44***	0.54***	0.23	0.33
SNV	0.09	-0.04	-0.01	-0.17
STS	-0.01	-0.08	-0.19	-0.10

It is difficult to see any detailed patterns in these data, but it seems that attitudes to science in general (the SNV and STS scales) are unrelated to science achievement. As far as the SNV scale is concerned, this probably arises because of the generally very positive attitude to science among all students. The extent to which school science is seen to be of personal value, in terms of a future career or relevance to everyday matters, also seems to be unconnected with performance. Enjoyment of the subject and opinion of one's one ability in the subject, however, do seem to be fairly consistently and positively related to achievement. The correlation between self-concept and achievement may simply indicate that the students are aware of how well, or how poorly, they are performing. Similarly, enjoyment of the subject is just as likely to be a consequence of success as it is to be a cause. As ever, no inference about causes can be made from such correlations. What does seem to be suggested, however, is that simply having a high opinion of the relevance - whether personal or national - of science does not of itself encourage high achievement[14]. The encouragement of positive attitudes towards science, therefore, must be justified in terms of their own value, rather than in terms of improving performance.

Ultimately, we must go beyond an examination of factors which may or may not be correlated with performance, and which may or may not influence performance - the concern which has occupied the last three chapters. Ultimately there is a need to understand mechanisms, and this requires an examination of the learning process itself. To be aware of forces and circumstances which may have an effect on achievement is valuable in that we can encourage the occurrence of those circumstances or try to bring those forces into play. But to operate at this level is to operate as a mechanic, not a scientist. The latter becomes possible only when we understand the operation of the forces that we wish to apply. It would be pretentious to suppose that this thesis even attempts to reach that stage, but the next two chapters are intended as a step in what might be a hopeful direction. They are an investigation of the understanding of certain scientific concepts that the students develop during their exposure to secondary science. To achieve this, the investigation is framed by constructivist analyses, although it is hoped that these are approached critically.

CHAPTER 8 THE DEVELOPMENT OF UNDERSTANDING OF SELECTED SCIENCE CONCEPTS

8.1 Introduction

Three different topics have been chosen to illustrate the development of the students' conceptual understandings in science: burning, what constitutes "an animal", and the nature of vision. It was important that any concepts chosen for investigation should be within the everyday experience of all students. These particular concepts will be used because it is felt that they each have significantly distinct characteristics. Burning is a phenomenon that is external to the observer and hence public. Vision, by contrast, is an internal, private event. Any particular act of burning may be examined and discussed by several observers (and, in fact, many common experiences of fires will occur in circumstances in which people are gathered together), but each individual's act of seeing is an experience for that individual alone. The development of definitions of an animal was chosen for study because this is essentially the development of the understanding of language, and this, it was felt, was the epitome of a socially influenced process.

The students' understanding of each of these ideas is examined to see how it changes through exposure to school science, and scientific uses of these concepts, as the students progress through the school. The students' conceptions, and their development, are examined for differences among them that may be related to the sort of categorisations that have been used earlier in this account, but more emphasis is placed on comparing them with those reported from other countries and cultures. A considerable literature now exists on children's conceptions of a wide variety of phenomena in many countries (Carmichael *et al*, 1990), making such comparisons possible, but a significant factor in making this decision is that the information on the K G VI students' ideas comes from interviews, so that the numbers involved are rather too small for subdivision.

Two approaches to the analysis of students' understanding of scientific concepts have dominated the field: that following Piaget, and that based on more recent constructivist approaches. A review of these two approaches will be presented before the K G VI results are given. (In this particular study, the work on burning actually developed from a series of investigations along Piagetian lines, while that on animals and on vision was inspired by constructivist writings.)

8.2 Science education and Piaget

Science educators, perhaps more than those in any other subject, have taken Piaget's account of cognitive development to have crucial implications for their subject. The Piagetian stage model has been used as a guide for the ordering of material in curriculum projects such as *Science 5-13* and the Australian Science Education Project (Driver, 1983: 77); and for Shayer and Adey (1981), the development of a "Science of Science Teaching" was predicated almost entirely on the implications of Piaget's theory.

In looking at possible reasons for this interest, Adey (1982) suggests that science education may be seen as "the vehicle for cognitive development", with secondary schools seeing science "as the major route ... by which the individual's powers of evaluating evidence, and reaching sound rational conclusions may be developed." To this could be added that the apparent concerns of Piagetian studies - substance, weight, area, and abstract reasoning - are precisely the everyday business of science teachers. Given the importance of these basic concepts to an understanding of science, Piaget has perhaps too willingly been interpreted as providing a guide to children's concept acquisition. In reality, Piaget's concerns were elsewhere:

> "It is important to stress that almost all Piaget's investigations stem from some philosophical issue about the structure of knowledge and not, as is commonly believed, from a psychological concern about children themselves as individuals."
> (Bliss, 1993: 25)

Adey was right to emphasise the processes of reasoning in science as being those with the clearest links to Piaget's work, but whereas Piaget was interested in the development of reasoning *per se*, the science teacher aims to develop reasoning in particular domains:

> "But although Piaget and others have described the development of reasoning in such a comprehensive manner, the model does not tell us, for instance, what conceptions the pupils have of electricity, heat, light, matter, etc. before they begin science lessons. This is because Piaget and others have been interested in the development of reason in general. Our interest lies in a specific subject area."
> (Andersson, quoted in Bliss, 1993: 32-33)

Another element of Piaget's theory, that of stages of cognitive development, has attracted attention to such an extent that the theory has often been simplified to a description of such stages. The stage element has dominated cross-cultural work on Piaget's ideas, which has largely been carried out in the spirit of testing the order and ages of attainment of the stages in a wider, more varied population; the need for such tests having been acknowledged by Piaget (1966) himself. Lists of such studies are available in Dasen (1972) or Modgil (1974). In Melanesia, these studies have been concentrated in Papua New Guinea, with Prince (1968a, 1968b, 1969) carrying out the earliest and most extensive. (See Price, 1978, and Lancy, 1983, for a review of Piagetian studies in Papua New Guinea.)

A sufficiently large body of work soon became available for Dasen (1972) to conclude that the general pattern of development suggested by Piaget could be considered to be universal (but with developmental lags and plateaux in less industrialised societies). Some years later, Furby (1980) came to a similar conclusion. On the other hand, it seems that research was throwing up several contradictions and challenges, as Ashton (1975), when reviewing essentially the same work as Dasen and others, felt that "the research to date challenges the notion of invariance in the sequence of stage acquisition and the idea of a basic cognitive structure corresponding to each of Piaget's stages" (p478).

One of these challenges, presented by cross-cultural studies in particular, was that a variety of environmental influences were shown to be of much greater importance for cognitive development than had previously been suggested by Piaget: schooling (Greenfield, 1966), an urban environment (Poole, 1968), contact with "Western" values (Dasen, 1972, 1974), and a variety of specific social, cultural or concrete experiences (Price-Williams, Gordon & Ramirez, 1969; Furby, 1971; Okonji, 1971; Greenfield, 1974). Piaget (1972) was obliged to accept that the influence of environmental factors on cognitive development was greater than he had originally suggested, and that the stage of formal operations, in particular, might not be achieved in some societies[1].

Partly in response to the contradictions being presented by the results of research in non-Western cultures compared with those from Western countries, a body of criticism of the methods and interpretations of such research began to develop (Greenfield, 1966; Price-Williams, 1969; Cole & Bruner, 1971; Goodnow, 1973; Brown & Desforges, 1979). Some writers, such as Cole & Scribner (1974) and Ashton (1975), recognised the difficulties and responded by suggesting more culturally sensitive investigative procedures, based on greater general cross-cultural understandings.

Despite these attempts to refine methods and analyses, the emphasis that had been placed on the stage model meant that it became increasingly difficult to apply Piaget's theory in the situations important to science educators (and, no doubt, those in other subjects too) (Bliss, 1993). The stage element of the theory had come in for criticism early on, by Flavell (1963), and his points were re-made and amplified by Brown and Desforges (1979). Of particular difficulty was the phenomenon of horizontal *décalage*: the time lag that children show between attaining competence on tasks that ought to require the same cognitive abilities. Kuhn (1977), Smedslund (1977) and Odom (1978) all picked this out as presenting a serious problem, and Piaget (1971) himself admitted that he had no adequate explanation for the phenomenon. He introduced the notion of "task resistance" in response, but Brown and Desforges (1979) dismissed this as merely a "safety clause", introduced to give artificial protection.

A point to notice about talk of "task resistance" is that it brings in a domain-specific element which strikes at the very heart of the Piagetian approach (Modgil & Modgil, 1980). The particularities, rather than just the generalities, of objects in the real world must now be considered. In his later work on causality, Piaget began to find that he had to take greater cognizance of this real, external world than he had done earlier, conceding that "the causal explanations depend more on the objects than on the subject" (Piaget, 1977). As Bliss (1993: 34) puts it:

> "Piaget may have been getting a glimpse of some of the difficulties involved in making science intelligible to young people."

It is perhaps the promise of meeting this concern, of making science intelligible to our students, that has led to "constructivism" being afforded a dominant place in science education at the present time: dominant to the extent that it has been declared that "now we are all constructivists" (quoted in Matthews, 1993).

8.3 Constructivism and science education

The central tenet of constructivism is that each child constructs his or her own understandings and models of reality on the basis of personal experiences of the environment. On those terms, Piaget was undoubtedly a constructivist (Sutherland, 1992: 81; Bliss, 1993: 27-30), but those who label themselves constructivists today recognise his position as such, and his influence, to varying degrees. Glasersfeld (1989) seems to recognise at least some debt, and Ernest (1993) claims that it is "primarily the influence of Jean Piaget" which has established the dominance of constructivism (although he is referring to the situation in mathematics education, rather than science). Rosalind Driver, one of the key figures in establishing constructivism in science education, while recognising Piaget's constructivism in a limited sense (Driver, 1982), and the seminal nature of his studies of children's ideas (Driver, 1985), prefers to emphasise other roots, notably Ausubel and Kelly (Driver, 1983; Driver & Oldham, 1986). It appears to be Piaget's structuralism and his stage model that Driver is particularly keen to distance herself from (Driver & Easley, 1978).

Given this fundamental proposition of the constructivists, their concern with uncovering the nature of children's ideas about the world is easy to understand. Any knowledge developed in response to school science will be constructed under the influence of existing ideas. Certainly until quite recently, the concern of the constructivist school has been primarily the collection of children's conceptions on a wide variety of topics, together with studies of the way in which these change, or fail to change, in response to science teaching. Lewin (1992) suggests that there is still a need to examine the conceptions of students from a diversity of cultures, whereas Black and Lucas (1993) see the development of theories and models as the main priority, so that the collection of data can be "informed by explicit assumptions and by sharply directed purposes" (p232).

Solomon (1993) has suggested that a considerable diversity exists in the existing perspectives and aims of researchers. Those who have explicitly adopted Kelly's Personal Construct Theory (1955), with his underlying notion of "man-as-scientist", prefer to use the term "alternative conceptions" for children's ideas, and to try to insist on the coherent nature of these conceptions, forming "alternative frameworks". For these workers, children's ideas are to be respected as "children's science" (Driver, 1983; Osborne & Freyberg, 1985), and their self-consistent nature makes them very resistant to attempts to modify them (Viennot, 1979; Champagne, Klopfer & Anderson, 1980; Gunstone & White, 1981). Driver and Easley (1978) refer to such an approach as "ideographic", contrasting it with a "nomothetic" approach, in which students' responses are assessed in terms of their congruence with accepted scientific ideas. They are critical of the nomothetic use made of students' ideas in the Piagetian tradition.

For those adopting Kelly's ideas, there is an important divergence from Piagetian constructivism. This arises from Kelly's insistence on the conscious control by the child of the construction of knowledge, contrasting with Piaget's maintenance that conscious control can only play a minor role in the process (Bliss, 1993). Coupled with Kelly's emphasis on the individually-specific nature of knowledge construction, in contrast to Piaget's interest in the characteristics of construction common to all, it is easy to see how the notion of "pupil as scientist" is supported. A further difference arises from the fact that Kelly developed his ideas from work done with adults and older students, so that to apply them to younger children is to assume a similarity in the mental processes of children and adults (Sutherland, 1992: 81). Piaget's theory, on the other hand, is essentially aimed at showing how the cognitive processes in adults develop from the qualitatively different processes that form children's thinking.

In something of an "opposite corner" are those who refer to the "misconceptions" of children. For them there can be no consideration of children's ideas as quasi-scientific; their aim is a pragmatic one of understanding students' difficulties and errors so that they may be better corrected. The situation-specific nature of children's ideas, and their lack of consistency, to the point of contradiction, may be seen as reasons for regarding them more as *ad hoc* explanations of individual phenomena, rather than as genuine frameworks for interpreting the world (Champagne, Klopfer & Gunstone, 1982). Solomon (1993) suggests that this approach may be atheoretical, but that its methods often show great inventiveness, and its findings will certainly have to be addressed by any cognitive theory that develops.

A third research programme identified by Solomon is one which investigates cultural effects on children's ideas about science. This may be concerned with establishing the relationship between cultural learning and school learning in a particular cultural context (Solomon, 1983), or with demonstrating the cognitive impact of particular aspects of a culture (e.g. Mohapatra, 1991; Jegede & Okebukola, 1991). Such approaches emphasise the importance of socially derived knowledge, in contrast with the construction of knowledge by the individual that underlies the first of Solomon's frameworks, outlined above. The very power of such socially located sources of knowledge provides an alternative explanation for the persistence of such knowledge in the face of attempts to change it.

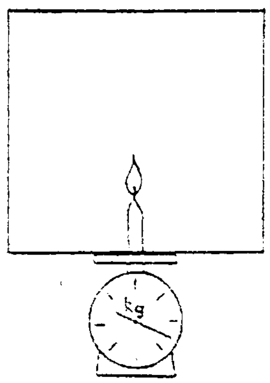
One of the most obvious inheritances of the constructivists from Piaget is the use of the "clinical interview" as a major investigative technique. The topics, examples and lines of investigation of the Geneva school can be seen to have influenced many of the investigations of students' conceptions which have characterised constructivist activity. That this is so is clear from the acknowledgements given by many investigators to the seminal work of Piaget on various topics and concepts, sometimes describing their own or other influential work as replications of Piaget: Driver, 1985; Gunstone & Watts, 1985; Méheut, Saltiel & Tiberghien, 1985; Séré, 1985; Hewson, 1986; Rice & Feher, 1987; Osborne, Black & Smith, 1993. For convenience, and to extend the range of situations to which children's responses can be investigated, the practical situation involving the use of real apparatus in the Genevan studies has, in some investigations, been replaced by drawings and descriptions: the "interview-about-instances" (Osborne & Gilbert, 1980) and "interview-about-events" (Osborne, 1980) techniques are examples of this approach that have been commonly used (see Osborne & Freyberg, 1985: 5-12). This was the sort of approach adopted in investigations of the concepts held by K G VI students. The results of these investigations are reported in the remainder of this chapter and the following one.

8.4 Students' understanding of burning

Several investigations into children's ideas about burning have been reported (Schollum & Happs, 1982; Driver *et al*, 1984; Knox, in Driver, 1985; Méheut *et al*, 1985; Andersson, 1986), but it was felt that the examples which they used (e.g. a car engine, combustion of steel wool, a burning cigarette in a space craft) were inappropriate for use with the King George VI students. The situation which was actually used as the basis for a discussion about burning originally formed a written question on a test of Piagetian-type conservation tasks, given to all Form 1, 3 and 5 students in 1992. This question concerned a burning candle inside a closed container on a balance, and is reproduced in Figure 8.1. Brief interviews about the question were given to 41 students from Form 1, 35 from Form 3, and 27 from Form 5. Each interview began by asking about conservation of weight as the candle burns, but was then developed into more general questions about the burning of the candle.

In her review of studies of the ideas of English 11- and 12-year-olds (i.e. secondary Form 1) about burning, Driver (1985: 156-158) reports that, in general, they were unable to suggest a mechanism of burning, but what she calls a *prototypic view* of burning was common. Among other things, this view recognises oxygen, or air, as needed for burning (although its function may not be clear); it describes

Figure 8.1 The situation used as the basis for questions on burning



A large glass box with a candle inside it is placed on a balance which measures mass.

The candle is lit and then a lid is put on top of the box so that there are no openings anywhere.

The candle burns for a few minutes and then goes out.

When the candle is burning and the lid is on, what happens to the reading on the balance?

A It slowly decreases

B It stays the same

C It slowly increases

burning as a process which produces new substances, and it predicts that things will become lighter when they are burnt. The work by Méheut and colleagues (1985) with French children of the same age found this prototypic view too, but only with the burning of certain materials such as wood and cardboard, where a residue, clearly different from the original material was left behind. They also found a common alternative description of the burning of alcohol or wax in terms of a change of state, such as melting or evaporation, rather than a change of substance: as a physical rather than a chemical change. Schollum and Happs (1982), interviewing New Zealand students, aged from 10 to 18 years, about the burning of gas, found Driver's prototypic view to be held by very few students of any age. Only a minority insisted that air was necessary for combustion, or that new substances are produced in the process.

On the question of conservation of weight during burning, Driver (1985: 166) points out the tendency for English children to focus on component aspects of a situation, rather than the complete system, and for their thinking to be dominated by perceptual features. As a consequence they may see combustion in a closed system as resulting in a loss of weight because oxygen is used up, or because smoke is lighter than a solid. She also points out the similarity in the prevalence of these ideas between 12- and 15-year-olds and between those who do and do not study chemistry, thus suggesting such ideas are quite resistant to attempts to alter them through school science. Among the King George VI students, answers to the original written version of the question revealed that only about twenty per cent of students at all levels believed that the weight of the closed container would remain constant. This sort of proportion was supported by the interview data.

Among the King George VI students, almost none at Form 1 described the burning candle in terms of Driver's prototypic view. Only two boys predicted a decrease in weight because air or oxygen would be used up. These were the only Form 1 students who volunteered a role for air in the burning of the candle. Both were from Honiara primary schools, and both stated that they had learned in primary school about air being used in combustion. One other boy decided the production of smoke by the candle would lead to an increase in weight. At the time of the interviews, the Form 1 students had not done any work on combustion in science lessons at K G VI, and had not yet seen the well-known burning-candle-in-a-gas-jar demonstration. For the majority at this level, air was not seen to play any part in the burning of the candle, but this statement needs some clarification.

When asked directly whether the candle needed air in order to burn, almost half said that it did, with varying degrees of conviction. When asked whether the candle made use of the air in any way while burning, however, there was considerable confusion. Most stated that it did not, but the confusion seemed to arise over the interpretation of the question itself. Similar puzzlement was observed when the question was rephrased to ask if the candle would burn if there were no air in the box. Some understanding on the part of the interviewer of the cause of this confusion eventually came when one boy asked what would be put in the box instead of the air. It seems that, for very many of these younger students, a question about the role of air in burning was difficult to understand because of their conception of the nature of air. That air "existed" was accepted, but the nature of this existence was less certain. Since air is always there, unless some other material occupies the space, it is difficult to understand what is meant by there being no air present in an otherwise "empty" container.

The commonest analysis of the situation by Form 1 students was in terms of the melting of the wax of the candle, generally accompanied by a declaration that the weight would decrease, because the candle becomes smaller. This is a concentration on a single aspect of the system, and dominance of attention to perceptual features, as described by Driver, and in line with the findings of Méheut's team. It is interesting that some students maintained the opinion that the weight would decrease even when they were led to the conclusion that the molten wax would re-solidify and form as much solid as had originally existed. Just a small number of students used this idea of the burning as being just melting followed by re-solidifying to argue for their being no change in weight: "Because when the candle melts, it doesn't get away" (10/M/92).

Another idea, expressed by more than twenty per cent of interviewed Form 1 students, was that the heat produced by the candle was responsible for a change in weight. Although some could not explain this clearly, answers implied a notion of heat as a substance with mass - a "caloric" model of heat:

> "Because the heat is ... in the glass and then it makes it heavier."
>
> (03/F/92)

One Form 1 student (with an echo in Form 3) had obviously seen condensation on the walls of a container with a flame in it and interpreted this as a materialisation of heat:

> "It heats the ... container ... The heat becomes liquid and drops onto this thing, and it becomes more heavier."
>
> (13/M/92)

The notion that the production of heat could cause a change in weight persisted among a minority of Form 3 students and Form 5 girls, although the mechanism sometimes became more refined:

> JL: Why do you think the reading on the balance will decrease?
>
> SS: Because ... er ... hot air rises, so I thought it will ... and air in that will, like, lift it a little bit.
>
> (20/F/90)

By Form 3, attention among the boys had moved away from the melting of the wax, and descriptions now resembled Driver's prototypic view of burning. These boys were now referring to air or oxygen being used up and, if this was as far as their analysis went, predicting a decrease in weight. Some also described the production of smoke, fumes, carbon dioxide, or some other product, and this led them to conclude that the weight will increase. None of them, however, were at all clear about the role of oxygen. They knew it was necessary, some thought it actually disappeared, and others claimed it was converted into other things; but there was no clear statement of oxygen taking part in a combination with something else:

SS: Because air has weight and while this candle is burning it exhaust the oxygen inside this box.
JL: What is the candle doing with the oxygen?
SS: It's using it in order to burn.
JL: How does it use it when it's burning?
SS: Because oxygen supports burning.
JL: What actually happens to the oxygen?
SS: The flame consumes the oxygen.
(34/M/90)

SS: We know that oxygen is a light gas. Therefore ... if the oxygen gas is gone out because it is used by this ... er ... candle here, therefore ... er ... the ... the balance will ... the reading will ... will increase.
JL: Because the oxygen is a light gas?
SS: Yes.
JL: Where has it gone? What has happened to it?
SS: It is used by this candle.
JL: What does the candle do with it when it uses up this oxygen?
SS: It support the burning.
JL: Does the oxygen turn into something else or does it just disappear?
SS: I think it must turn into something, but I don't know what.
(21/M/90)

SS: There's oxygen here and oxygen has a mass and ... this flame is eating up the oxygen ... and we'll have a vacuum which ... Well, not a vacuum, we'd still have oxygen there, but not very much.
JL: Where does the oxygen go? What happens to it?
SS: In order for the flame to light it needs oxygen. ... The flame, I think, mixes with oxygen ... Just like sugar mixes with the water.
JL: Is it using the oxygen?
SS: Using it, yes.
JL: What does it do with it?
SS: Not so sure.
(26/M/90)

The vocabulary of these boys was almost certainly reflecting that used in teaching: oxygen supports burning, oxygen is used up or consumed during burning. Their model of combustion is a product of their school science course, and it is one in which matter disappears.
What is remarkable about the Form 3 responses is that those of the girls did not reveal a change from the Form 1 position at all. The majority of the girls' accounts still focused on the melting of the wax and shortening of the candle, or on the effect of the heat of the candle. One girl argued for a decrease in the weight because the lid "stops the air from going inside" and two others thought the weight would increase because the candle was producing something, described as "fumes" or "gases", but out of sixteen female interviewees, these formed a small minority.

By Form 5, a model of burning in which oxygen is used up and something else produced was clearly dominant among the boys, with eleven out of thirteen interviewed giving such an account, of varying degrees of sophistication, but with the majority identifying carbon dioxide as the product. The mechanisms by which carbon dioxide is produced, and the consequences for the weight of the system, still tended to be vague, with references appearing to the oxygen (or the candle) changing into carbon dioxide. A few, however, did have the notion of a process of the combining of existing materials which may result in the weight remaining constant, although not all thought the process through this far:

SS: It would stay the same because ... er ... the oxygen in here will be used up by this candle flame.
JL: What happens to it when it is used up?
SS: It changes into ... er ... carbon dioxide.
JL: What else do we need to make carbon dioxide?
SS: Carbon.
JL: Where has the carbon come from?
SS: From the ... candle.
(34/M/88)

SS: I think the reading of the balance will increase.
JL: Why?
SS: Because the air ... the box will gain some mass.
JL: From where?
SS: From the candle and the air ... carbon dioxide which the candle produce.
JL: Because the candle is producing carbon dioxide the mass will increase?
SS: Yes.
JL: Where does this carbon dioxide come from?
SS: From the candle burning.
JL: What does the candle make the carbon dioxide from?
SS: From air ... from oxygen and ... er ... carbon in the candle.
(56/M/88)

JL: Why will the weight decrease?
SS: It's because the oxygen inside ... the air ... the particles and atoms ... they have mass, and when you burn the candle ... it will use up the oxygen. The burning candle will use up the oxygen, so in that case, the weight will decrease.
JL: When the oxygen has been used up, what has been done with it? What does the candle do with the oxygen?
SS: When it uses up oxygen it means that ... er ... it takes the 'O-two' and gives out carbon dioxide.
JL: So it is using the oxygen to make carbon dioxide?
SS: Yes.
JL: Where does the carbon in the carbon dioxide come from?
SS: The carbon, I think it's ... it's in the ... it's from the burning candle.
(25/M/88)

This last student was the only one to make any reference to atoms or molecules, but notice that this still did not lead him to conservation of mass. It does seem, however, that he had a reasonably correct idea of the process that was going on and that the contradictions in his description might have been eliminated by getting him to think it through more carefully. Judging from their accounts, this was probably true of a substantial number of the Form 5 boys.

This is still not the case with a majority of girls at Form 5, however. Only five girls out of thirteen interviewed described the burning of the candle either in terms of oxygen being used up or something else being produced, or both. Others still concentrated on the melting or the effect of heat, or were simply unable (or unwilling) to give any explanation at all for their choice of answer. On the face of it, the majority appear to have no model of combustion at all. In their end-of-term science test, however, taken just a few weeks earlier than this interview, these same Form 5 girls were faced with a question about the products of combustion of a hydrocarbon in a plentiful supply of air. Nine out of the thirteen girls that were interviewed had answered this question correctly, giving water and carbon dioxide as the products; and another two had given carbon dioxide only. In response to the right stimulus they could discuss the products of combustion, it seems, but that was all that the knowledge was: a response to the appropriate stimulus. For these girls, the world of school science contains hydrocarbons, combustion, carbon dioxide, and so on; but an item such as a candle belongs to their everyday "life-world", which is quite distinct from that of school science. A question about candles is answered by drawing on knowledge from the appropriate domain: that of everyday experience, not that of school science.

For the boys, however, it seems that the two domains of school science and the everyday world are not always so distinct. Science reaches into their life-world, and explanations from science may be applied in that world - at times, at least, if not always. Perhaps scientific knowledge and explanations are more likely to be used when there are no powerful explanatory theories available elsewhere: theories that may derive from personal interpretations of experience, or that may be socially negotiated.

And it does seem from the responses of the students that there are no powerful models of burning available in the world outside the science class. Driver's prototypical model - a foreshadowing of the scientific one in key respects - is not held by the younger students before they meet combustion in school science. It seems possible that the sources of this model for British children lie in the elements of scientific culture that permeate experiences in an industrialised country: the media and the technology of everyday experience, certainly, but also the presence of parents and others who are themselves educated and knowledgeable in these areas of basic science. These sources of ideas are largely missing for the Solomon Island children, and it seems that burning is a phenomenon for which there are no socially-produced accounts available.

A very important qualification must be imposed on these statements, however. The investigation dealt with one example of burning only - a candle. It is possible that if a different situation - such as the burning of wood in a fire - had been chosen, accounts of the process might have been forthcoming. This is recognised as a serious limitation and it arises because of the original purpose for which the burning candle situation had been devised: that of investigating notions of weight conservation in a chemical change.

8.5 Conceptions of "an animal"

There appear to have been relatively few investigations of children's understanding of the term "animal", but the three that have been located are interesting because they have been carried out in three different countries. Bell (1981) studied the conceptions of "animal" held by New Zealand students between 10 and 15 years of age. She summarised the majority conception of an animal as a four-legged, large, terrestrial creature, such as a cow, cat, lion or elephant. The accepted biologists' conception of an animal was used by a mere ten per cent of the interviewed students. Spiders, worms and butterflies were rarely classed as animals. Human beings ("a boy") were categorised as animals by only slightly over half of the students. In general, categorisation was based on visual clues and family resemblance, not on the possession of defining features.

These findings were largely supported by a study in the USA of elementary school, high school and college students (Trowbridge & Mintzes, 1985). Large, four-legged, terrestrial vertebrates formed the majority of examples given to the request to give examples of animals. This study also found considerable stability of concepts across age groups.

In a study of African children in South Africa, Tema (1989), followed Gilbert and Watts (1983) in distinguishing between the conceptual frameworks from which the children operated when making their categorisations, and the actual criteria they used for classification. What was interesting in the former was the common use, among the younger students in particular, of an anthropocentric framework. This takes the human being as a point of reference for classification: human beings are not classed as animals, and living creatures are classed as animals through their differences from human beings, such as an inability to talk. Tema sees similarities between her subjects' responses and those recorded by Bell, in that they also concentrated on superficial features for categorisation, but it is clear that this anthropocentric framework led to an important difference: "They all seemed to recognize insects, worms and reptiles as animals" (p205). Tema argues for the influence of African traditional thought in this anthropocentrism, and found that it tended to give way to accepted biological classification as the students progressed through school. She found no significant differences between rural and urban students in their classification of animals and non-animals.

Information on the K G VI students' ideas of what is or is not an animal was obtained firstly from an item in the Science Skills Test given to all students in Forms 1, 3 and 5, in 1991 and 1992. This presented the following list of creatures and asked the students to decide whether each one was "Animal" or "Not an animal": dolphin, eagle, caterpillar, shark, human being, ant, pig, starfish, bat, snake and worm. All of the creatures in the list are classified by biologists as animals. In 1992 this was followed up by interviews with students in all three forms, asking them first to confirm that they were familiar with each of the animals listed, and then to explain the grounds for their decisions. The Form 1 students had come across the scientific categorisation of the living world into animals and plants before they sat the written question.

Combining data from the 1991 and 1992 written tests, the proportions of boys and girls in each Form choosing all of the animals in the list as animals are given in Table 8.1.

Table 8.1 Proportions of students, from 1991 and 1992 combined, classifying all examples in the written list as animals, by gender and Form

	Form 1	Form 3	Form 5
Girls	17%	13%	14%
(N:	*77*	*85*	*49)*
Boys	30%	22%	23%
(N:	*123*	*104*	*88)*

There are three points of note in these figures. The first is that they show a much higher proportion of students accepting all creatures in the list as animals than was noted by Bell with her subjects, even though it includes animals very similar to those that were rejected by the New Zealand students, such as worm, ant and caterpillar. Secondly, the proportion of boys accepting all members of the list as animals is always higher than the proportion of girls doing so; and finally, this proportion decreases for both boys and girls after Form 1.

It seems that these Solomon Island students are more willing to accept the scientific classification of animals than the New Zealanders (and the American students of the Trowbridge and Mintzes study), but the boys more so than the girls. The extent of this acceptance declines with passage through school, however, contrasting with the stability or increase reported in other studies. The K G VI students who do accept the biological classification generally perform better than average in science examinations, although the difference only becomes statistically significant for Form 3 and Form 5 students. This suggests that the students who perform better in science are more likely to maintain an acceptance of the biological classification. No pattern in terms of other student characteristics, such as rural/urban background, could be determined.

The older students are also more likely to be able to give criteria for classifying the whole list as animals. Form 1 students choosing the whole list invariably supported their choice with a general statement of the form that all living things are either animals or plants, but were generally unable to give criteria for distinguishing these. Two of the thirteen Form 1 students in this group made explicit references to what they had learned in science classes:

> "Because when we studied the science, the science teacher told us all ... all of these are ... Scientists separate them into groups. So when I see these names, I thought about the teacher ... the teacher's ..."
>
> (50/M/92)

Three out of the five interviewed Form 3 students who had classed all the examples as animals, and all four of the interviewed Form 5 students who had done so, were able to suggest at least one defining criterion for an animal. The ability to move was the commonest criterion suggested, although "they breath" and "eating food" or "finding their own food" were also given. There is a hint here that the retention of the lesson learned in Form 1 about the biological classification of living organisms is dependent on the knowledge and acceptance of the criteria for this classification.

The ability to give criteria for making choices was much more common among the students who had not selected the whole list as animals, especially at Form 1, although a few were unable to explain their decisions. The range of criteria was very wide, and these criteria were remarkably similar for all ages of students. The commonest criteria for the inclusion of one of the examples on the list as an animal were: warm-blooded, vertebrate, living on land, and being viviparous. The commonest criteria for exclusion were: flying, living in water, and being too small. Several references to the presence or absence of legs, the number of legs, or the method of locomotion were also noted.

It would be presumptuous to assume that there are consistent systems of criteria available to the students which are in some way competing with the biologically accepted criteria. When asked, the majority of students could not provide general criteria that could be applied to all the animals in the list. More usually, they were prepared to give their reasons for the inclusion or exclusion of individual members of the list, and these reasons were not consistently applied. Thus, for example, living in water might be given as a reason for excluding the shark, but this might be ignored when considering the dolphin, for which some alternative criteria, such as being warm-blooded, would be sought to include it among the animals. The impression is, therefore, that the students possess an understanding of what constitutes an animal, but the criteria for this are not explicit. In Bell's terms they possess a "common meaning" for the word "animal", which becomes established through social interaction. As one student put it:

> "Like you say ... 'Look at that animal' ... You know, how they say it ... What people say. They don't say, 'Look at that animal' for a worm. They say, 'Look at that worm' ... But when they see a bat they say, 'Oh, look at that animal'."
> (26/M/90)

An analysis of the responses in the written test suggests that the K G VI students have a somewhat wider common meaning than the New Zealand and American students. The proportions of students accepting each of the animals in the list as an animal is given in Table 8.2. Notice that although caterpillar, ant, starfish and worm are the least

Table 8.2 Percentages of students accepting given animals as animals, 1991 and 1992 results combined, by gender and by Form

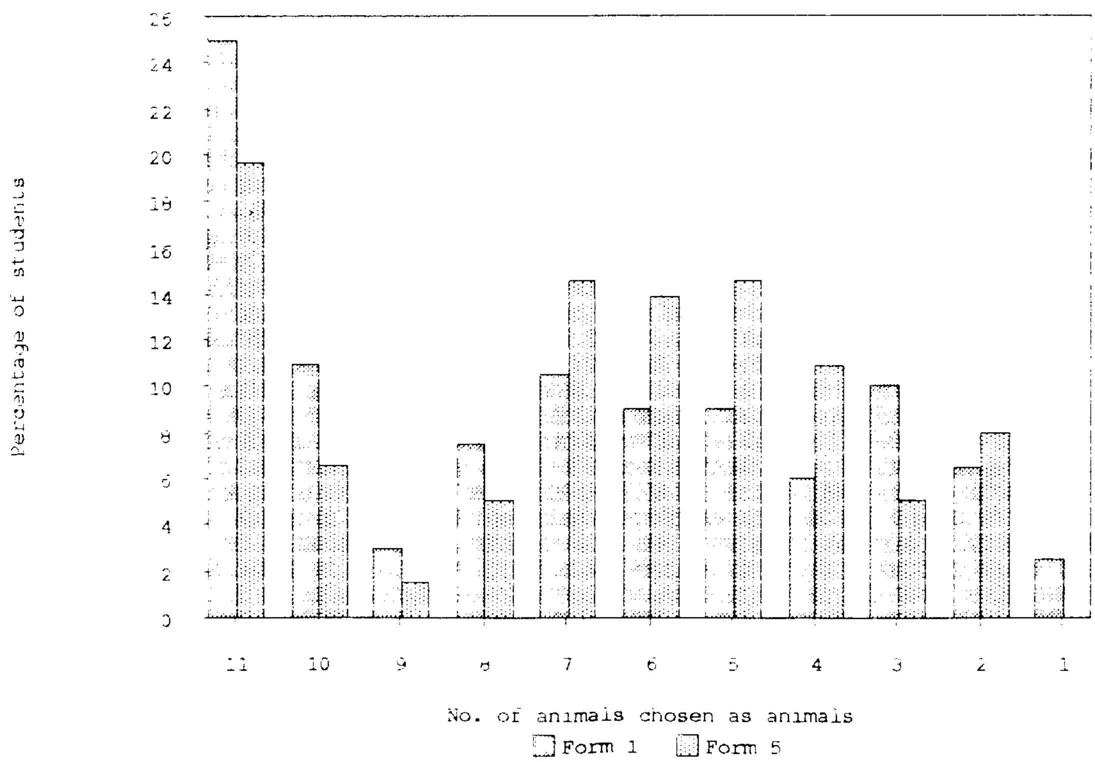
	Male			Female		
	Form 1	Form 3	Form 5	Form 1	Form 3	Form 5
	(N: 125	*104*	*88*	*76*	*85*	*49)*
dolphin	74	85	78	58	75	74
eagle	76	64	67	58	62	69
caterpillar	54	33	38	37	26	31
shark	59	63	58	47	66	67
human being	85	89	97	71	84	88
ant	58	39	31	43	27	31
pig	98	100	100	97	100	100
starfish	45	41	33	29	31	29
bat	86	81	92	67	75	82
snake	81	71	63	58	65	57
worm	56	35	26	37	33	29

accepted, they are still taken to be animals by over a quarter of students at all levels. Dolphin, eagle, shark, bat and snake are very widely accepted as animals, and these certainly do not fit the "four-legged, terrestrial mammal" common meaning identified by Bell and by Trowbridge and Mintzes. There is a greater similarity here with the apparently wider understanding of the term "animal" that Tema reported for African students, and it is tempting to suggest that a connecting factor is that English - and hence the word "animal" - is the first language of neither the African nor the Solomon Island students. As a consequence, their exposure to the general equation of "animal" with "terrestrial mammal" that is common in non-scientific

English usage, both spoken and written, is likely to be less than it would be in both New Zealand and the USA.

This trend towards a common understanding is revealed in the convergence of the proportions of boys and girls choosing each of the given examples. For example, the significant differences between the proportions of boys and girls recognising a dolphin or an eagle as an animal in Form 1 have disappeared by Form 5. Further indication of this process is given in Figure 8.2, which shows the proportions of students at Form 1 and Form 5 choosing different numbers of animals in the list as animals.

Figure 8.2 The number of animals in the given list chosen as animals; a comparison of Forms 1 and 5



By Form 5, there is clearly an increase in the proportion choosing between five and seven animals from the list. The animals most likely to be chosen, in decreasing order of popularity are: pig, human being, bat, dolphin, eagle, shark, snake. There is a tendency to equate "animal" with "mammal", but it is the scientific understanding of "mammal" - including the bat and dolphin - which is influential, rather than an understanding as a fur-covered, terrestrial animal, which was identified by Bell. The influence of school on the use of English seems to be more significant in the Solomon Islands.

An important environmental factor may also be at work in producing this rather wider interpretation of "animal" in the Solomon Islands. That is, quite simply, that there are very few large mammals to be found in the country. Livestock, apart from pigs, are not common, and the largest wild mammals are fruit bats and opossums - and dolphins, if one includes the ocean. Reptiles, such as snakes, turtles and lizards, form a significant proportion of the wild animals, and it is worth noting that both lizards, turtles and fruit bats may all be part of the human diet. This may also influence their consideration as animals.

One aspect of Tema's findings with African children which has not yet been compared with the Solomon Island data is the use of an anthropomorphic framework which does not recognise human beings as animals. An examination of Table 8.2, above, will quickly reveal that this is not a common position among the K G VI students. Even at Form 1, a large majority accept human beings as animals. Tema reported that some of her subjects classified all non-human living things (apart from plants) as animals. She gives no quantitative data on the extent of this pattern, but the discussion suggests that it was a significant occurrence. Among K G VI students, less than two percent made such a choice, although rather more rejected human beings as animals along with other creatures in the list. Many of those interviewed who did not classify human beings as animals felt unable to give a reason for this - particularly the younger ones - but those who could gave the developed brain, intelligence, or "sense" of human beings as their reason, with one student also referring to the ability to talk.

In an inverted version of Tema's anthropocentrism, some of the K G VI students did treat human beings as a point of reference, but took them to be animals and made comparisons with them to justify their classification of other animals. One third-form boy, for example, defended his choice of a bat as an animal like this (in a mixture of Pidjin and English which causes difficulties with spelling):

> "Bat, becos ... hem garem blad, ya? Hem save shok long elektristi olsem. So that's why me say I think hem garem sem blad nao mek hem closup long human being ... If hem fly onto electricity gives hem shok ... wea hem dai."
>
> (54/M/90)

A Form 3 girl chose a pig as an animal "because a pig can walk ... can walk like us" (30/F/90), while a boy declared that a shark could not be an animal because "it is different to us" (23/M/90).

Why should Solomon Island students be more willing than Africans to accept human beings as animals? More willing than New Zealanders too, it seems. It may simply be due to the absence of any "block" in their belief systems against such an idea, such as those that exist in both African traditional thought and in Christianity, according to Tema. This would leave them more open to the acceptance of the biological classification when they meet it in school science. On the other hand, there may be an aspect of traditional belief which actively facilitates acceptance of the idea. It is difficult to generalise about Melanesian traditional beliefs in this respect, if only because little obviously relevant material on the matter can be traced. While Keesing (1982: 71) points out the existence of a contrast between the human and the non-human in Kwaio cosmological structures, Whiteman (1984b: 92) emphasises the essentially integrated nature of the Melanesian universe. Perhaps the belief that *mana* - a concept much discussed, but roughly understandable as life-force or sacred power - can exist in living and non-living objects, human and non-human creatures, makes it easier to link human beings and other animals. In some Melanesian societies, spirits are believed to occupy not only human beings, but other animals too, notably snakes and sharks (Hogbin, 1964; Stephen, 1987c; White, 1992; also some K G VI students, in describing traditional practices and shrines, have described snakes as sometimes being the embodiment of spirits). Perhaps this point about snakes and sharks accounts for their relatively common acceptance as animals by the K G VI students, in the data given above (Table 8.2). It could even be argued that any society which has practised cannibalism, as many Solomon Island societies did, is likely to distinguish less sharply between human beings and other animals which are eaten! (Certainly, one student did use the fact that they are eaten as a criterion for classifying some of the given examples as animals.)

But the credibility of any of these speculations depends initially on demonstrating that these modern, educated youths are in fact influenced by traditional beliefs to a significant extent. They may be more under the influence of Christian teaching, for example, than tradition, and this, if Tema is right, would tend to discourage the classification of human beings as animals. Certainly there was considerable suspicion about the "descent" of humanity from animals, as expressed in evolutionary theory, that was encouraged by influential fundamentalist Christian groups. The question of the relationship between these three potential influences on the students' interpretations of the world will be examined in Chapter 10, after the students' conceptions of one further phenomenon, vision, has been discussed in the next chapter.

CHAPTER 9 STUDENTS' UNDERSTANDING OF VISION

9.1 Introduction

The constructivists' basic theme is that understanding of the physical world develops through a process of modification of existing conceptions rather than their total replacement with new ones. The choice of vision as a suitable phenomenon for the exploration of the extent to which the conceptual development of K G VI students in response to science lessons is described by this model arises primarily from the fact that vision is an experience universally shared by the students to an equal degree. It was felt that the understanding of some other phenomena, such as aspects of mechanics, or electricity, for example, might be influenced by the variety of personal experience and exposure to technology. Thus, the development of the concept of force might be influenced by experience with mechanical devices; but contact with optical devices, which might influence ideas on vision was likely to have been very limited indeed among these students. It was assumed, therefore, as a reasonable approximation, that all of the students meet the topic of vision in school science with similar backgrounds of consequential experience[1].

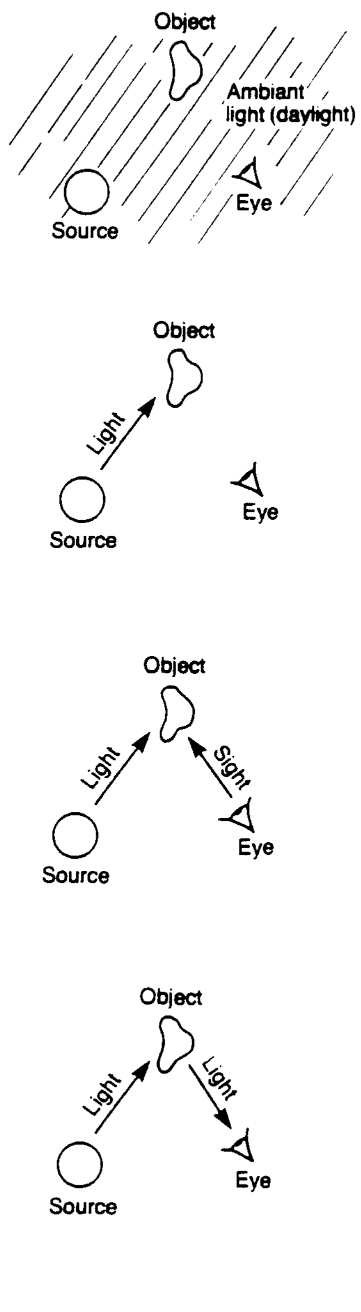
As Watts (1985) has pointed out, the study of children's ideas about light and vision has received rather less attention than several other areas, notably mechanics, but there is still a significant body of data in this field which would allow inter-cultural comparisons. Do the K G VI students enter science classes with the same sort of interpretations of vision as students elsewhere? And do those interpretations develop in a similar way?

The vast majority of studies on children's conceptions of vision appear to have been carried out in industrialised countries. Certainly this is true of the most accessible accounts, although Ramadas and Driver (1989) refer to work done by Ramadas with Indian children. These studies, based in environments very different from that of Solomon Islands, will first be reviewed briefly to establish the dominant conceptions of vision among children in such countries.

9.2 Research elsewhere

Piaget (1974) found that very young children made no link between the eye and object in their explanations of vision, but later they commonly referred to the passage of something from eye to object[2]. Guesne's study (1978, 1985) of French children broadly supported these ideas and led her to suggest a progression in children's conceptions of the mechanism of vision (Figure 9.1). The first stage in this progression is a model of vision which she found predominated among her subjects: light is needed for vision

Figure 9.1 Guesne's summary of the "progression in conceptions of vision encountered among 13 to 14-years-olds, towards that of a physicist." (Guesne, 1985: 28)



but light is taken to be an all-pervasive medium - we are in a "bath of light" - and no eye-object link is suggested. The next step is to accept the movement of light from source to object, but still with no eye-object link. This link, as one from the eye to the object, appears next, but for the few children which she found to be using this model, this link remains an abstract one rather than describing an emission of any real entity from the eye: they may, for example, refer to "sight" from the eye to the object. The final stage is the "physicist's model", and it is only at this point that children take the eye to be a passive receptor rather than an active agent of vision. Very few of her subjects used such a model.

Guesne observed that the model of vision used by children may be situation-dependent. Thus, for a luminous object a child may use a "light to the eye" model, but a model in which the eye is an active agent, or a source of something, may be used to explain vision of non-luminous objects. This situation-dependency was also found by Andersson and Kärrqvist (1983) in their study of Swedish children, aged 12 to 15 years, whose responses they grouped into seven models of the process of vision:

1. Nothing happens between eye and object.
2. The process is described in terms of an active response by the eye, or "active visual system", but with no link between eye and object.

3. We see because light shines on the object.
4. Some kind of "visual ray" (impulse, look, sight) goes from eye to object.
5. Something goes backwards and forwards between eye and object.
6. An image, or something similar, goes from object to eye.
7. Light from the object enters the eye.

Their findings differed from those of Guesne in that what they call "visual ray" explanations were much more common across the whole age range than she had found, although this use was very situation-dependent. Between 35% and 55% of the children used such explanations in at least one of three situations presented to them, although virtually none used them in all three. The use of the physicist's model of vision, with light from object to eye, increased from 1% at 12 years to 30% at 15 years, by which age it was the commonest model.

Models 1 and 3 in the above list are closest to Guesne's "dominant conception", and these were used by a significant proportion (30%) of the youngest members of the Swedish sample, but by very few of those above 12 years old. The Swedish and French results may be seen as rather more in agreement, therefore, when one looks at the younger children.

The use of the term "visual ray" by Andersson and Kärrqvist (1983) is open to criticism. It carries with it an implication that the children conceive of some sort of real physical entity emanating from their eyes. Although some of the children's comments which they quote clearly do have this meaning, there is the suggestion that terms such as "sight" and "look", when used by the children, have been interpreted by the researchers in concrete terms. There really needs to be some interrogation of the children's understanding of these terms before they are included with statements that clearly refer to "rays" or "light" from the eye to the object.

Ramadas and Driver (1989) felt that their analysis of the explanations of vision given by 15-year-olds in the United Kingdom fitted closely with that of the Swedish sample. They produced a more complex schema (using a systemic network) than that of Guesne for classifying these explanations but, unlike her, did not propose a developmental sequence for them. Echoing Driver and Erickson (1983), they suggested a commonality of human sensory experience as the origin of the similarity of children's conceptions of physical phenomena such as vision. This may be supported by the available linguistic metaphors for describing experiences ("throw glances" and "cast looks" are two examples relevant to this work on vision suggested by Andersson and Kärrqvist, 1983, who make the same point). They question Guesne's conclusion that most children at this early secondary school age acknowledge the necessity of light for vision, pointing out that most children in industrialised countries have never been in a situation of total darkness, so will not have experienced a total inability to see anything at all.

As well as the French, Swedish and British data mentioned, studies in Italy (La Rosa *et al*, 1984), Australia (Stead & Osborne, 1980) and Germany (Jung, 1981) reveal similar patterns in children's explanations of optical phenomena, adding weight to the idea that these are universal responses rather than being culture-specific (although the bulk of such studies have taken place in industrialised, mainly European countries). Osborne, Black and Smith (1993), in reviewing the results from a variety of studies conclude that their similarity reflects "a cultural and linguistic independency".

Despite these similarities, and despite their own emphasis on the primacy of common sensory experience, Ramadas and Driver (*op cit*) do seem to suggest that material and cultural environment play a part in concept formation. Thus, after their review of historical theories of vision, they state that they might expect present-day children's ideas to differ from those found in historical writings, since "the experiences available to today's children are different as a result of living in a technological world" (p 13). Their historical review reveals a diversity in the suggested theories of vision, both within and between various historical cultures. While the same idea does sometimes appear in different cultures and epochs, there are others which are rather more culture- or era-specific. Certainly it seems that parallels can be drawn between historical explanations and those expressed by modern children, but it is not clear how much support this lends to universalistic theories when such a variety of interpretations does exist.

9.3 Collecting data for K G VI students

Initial attempts to explore Form 1 students' ideas about vision by asking for written explanations and diagrams were not very successful. Twelve students, early in their first year at the school, were presented with a drawing of a girl looking at a box on a table and instructed: "Explain why the girl can see this box when she looks at it." They were also told they could draw on the diagram if that would help their explanations. The initial response was a certain amount of confusion among many of the students about just what was required, and further verbal elaboration had to be given. Written answers tended to be very brief and apparently not very revealing:

> "The box is there and she looks at it."
> "That box is in front where she is looking."
> "Her eyes are looking to the box"

The suggestion that something could be added to the diagram was generally ignored. Two students drew arrows pointing at the eyes, but these were just label lines with comments such as "Her eyes are looking." One student drew an arrowed line projecting part of the way from the girl's eyes towards the box and labelled it: "She is looking here." One other drew lines, without arrows, forming a cone towards the box with the eye at its apex, but with no explanatory comment. Eight students added nothing to the diagram.

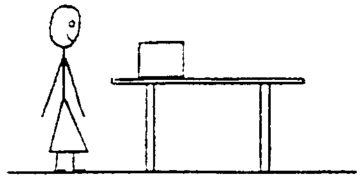
The impression gained from this first trial group was that vision was quite non-problematic to them, or that they had no explicit model of a mechanism: the eyes see and an object in front of the eyes will be seen, that is all. Whether the poor response to the drawing part of the task was a result of this lack of a mechanism or whether it simply reflected difficulties in translating any ideas they may have held into a drawing, it was impossible to say. Overall, it was felt that to rely on written answers from these younger students in particular would require too much doubtful interpretation, and would not be very effective in probing understanding. It was decided, therefore, to rely on one-to-one interviewing to obtain information, although this would give access to a much smaller group of students than had originally been desired.

The interview was based on the same situation that had been presented in the written trial: the interviewee was shown a drawing of a girl looking at a box on a table and asked how it was that the girl could see the box. From this start, the questions asked then depended on the individual responses. A second drawing was then shown, similar to the first, but with a lamp switched on close to the box. The student was then asked why it was that the girl could see the box more clearly when the lamp was on. Finally, two sets of drawings were presented, with various configurations of lines between eye and object - or eye, lamp and object - and the student was asked which one he or she felt best represented what was happening when the girl was looking at the box. The reasons for the choices, and what the lines were thought to represent, were then interrogated.

This latter aspect of the interview was included because it was hoped to get some indication of the ideas about vision held by a much larger sample than could be covered by the interviews. To achieve this, the same diagrams were included in the Science Skills Test given to all students in Forms 1, 3 and 5 in the middle of the 1992. (The diagrams as they appeared in the written test are shown in Figure 9.2.) The responses from the interviews with twenty one Form 1 students were then used to inform an analysis of the choices made by Form 1 as a whole. It is recognised that the confidence that can be placed in this analysis is rather

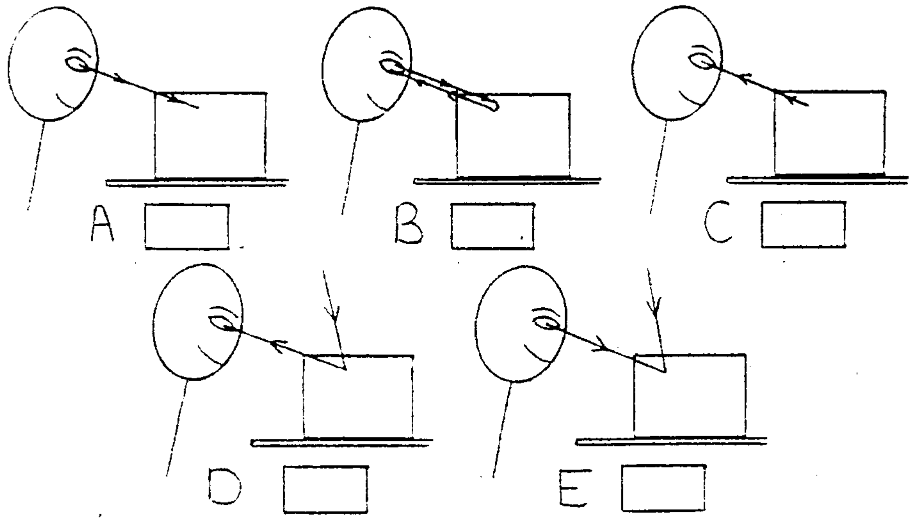
Figure 9.2 The two situations and optional responses for the investigation of vision, as presented in the written Science Skills Test

Question 34



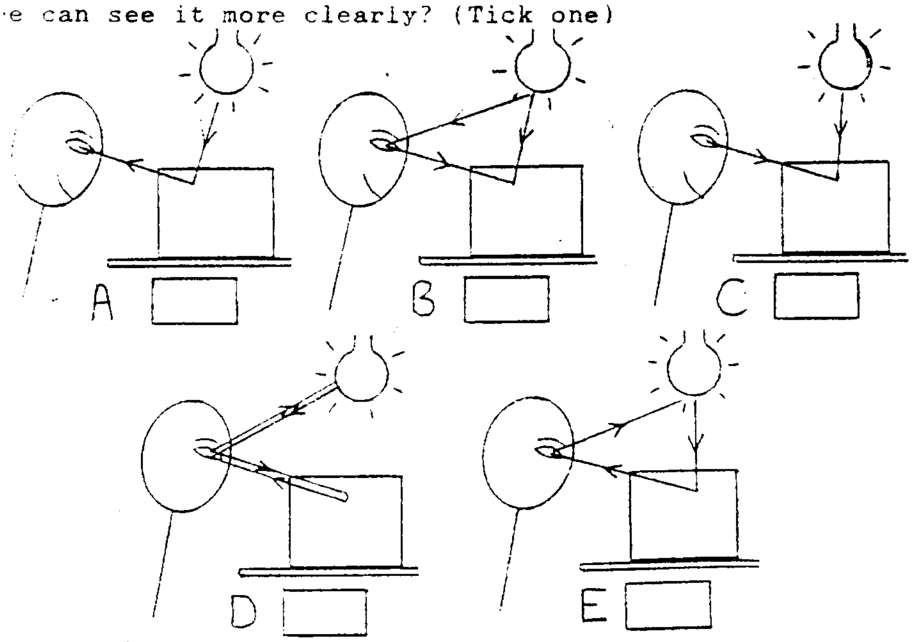
The girl in this drawing is looking at a box on a table.

Which one of the following diagrams best shows what is happening when she sees the box? (Tick one)



Question 35

She switches on a lamp near the box and finds she can now see it more clearly. Which of these diagrams best shows why she can see it more clearly? (Tick one)



limited but, nonetheless, it does give some indication of the extent to which the views revealed in the interviews are held in general.

Practical constraints dictated that Form 3 and Form 5 students could only be interviewed after they had already tried this written version. Thirty four Form 3 students and twenty six Form 5 students were interviewed about the choices they had made among these diagrams. These interviews were, in turn, used to help interpret responses to the written test by the whole cohort at each level.

In order to follow the development of ideas a little further than Form 5, Form 6 science students were asked to draw diagrams for themselves of two situations similar to those described in the Science Skills Test, but there was no interview follow-up to this exercise.

Finally, further information relevant to this issue of light and vision was obtained from Form 5 and Form 6 students through a small exercise administered to a whole class at once. A match was struck at the front of the class and all students were asked to confirm that they could see it. They were then asked to write down how far they thought the light from the match was travelling. The intention was to see whether they felt the light from the match must travel as far as they were seated in order for them to see it[3].

9.4 Results

9.4.1 Form 1

The interviews with Form 1 students largely confirmed the suspicions arising from the earlier preliminary written exercise. The majority of the students did not see vision as problematic, as something that needed to be explained. They generally had difficulty going beyond a restatement of the fact that the girl in the diagram can see the box when she looks towards it:

> "The girl is looking down here and ... she sees that the ... the box ... it is there. So she sees it ... with her ... Her eyes are looking at it and she can see the box is ... on the table."
> (57/M/92)

When asked if there was anything happening between the box and the eye, several students were puzzled by the question. They did not seem to be able to imagine what I might have in mind, what sort of thing could be happening. When asked if there was anything going from the eye to the box or from the box to the eye, however, some students said that there was. This was described as "sight" or "her eyesight", or in one case "attention", but then was almost always described as not a "real thing". It should be noted, however, that these suggestions were often given in a very tentative manner, with a querying note in the voice, as if the asking of the question had suggested that there ought to be something and they were looking for the possible "correct answer".

None of the interviewed students volunteered a role for light in vision in response to the first diagram of the girl and the box. When the presence of light was made explicit in the second diagram - with a lamp above the box - the opportunity was taken to discuss whether light was essential for vision. There was now almost total agreement that the lamp in the second drawing helped vision by shining onto the box and making it brighter, but they did not suggest that anything happened to the light after it had reached the box:

> SS: The light shone on to the box and she can see the box clearly.
> JL: Why does light shining on the box help her to see it more clearly?
> SS: Because the light will make the box appear brighter.
> JL: What happens to this light after it reaches the box? ... [no response] ... Anything?
> SS: Er ... The box ... It shine on the box and she will see the box.
> (11/M/92)

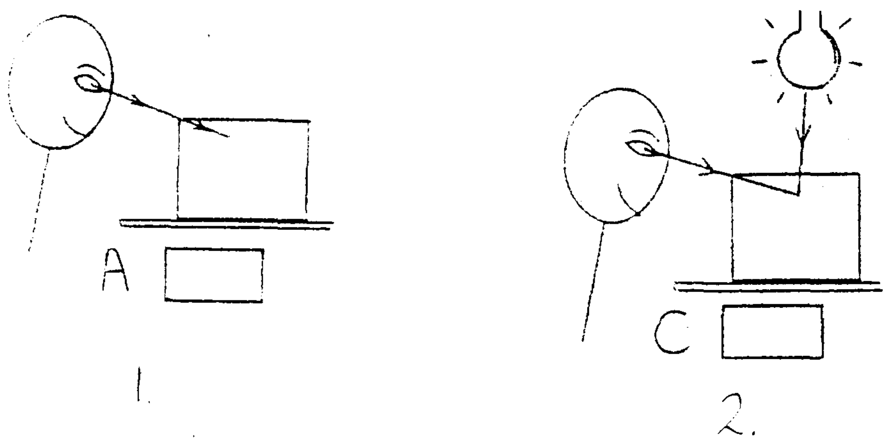
When asked whether the girl would be able to see the box if she were in a closed room with no windows and the light was switched off, there was some disagreement. Some said "No", with varying degrees of certainty in their voices, while others felt she would still see it, though "not clearly". Two students pointed out that she would not see it at all when the light was first switched off, but then she would start to see it "a little bit ... a bit dark". Many of the students were clearly responding to the question directly in terms of memories of their own experiences, rather than from a general theory of vision derived from these experiences. Total darkness is an unusual experience for anyone, whether from an industrialised country or not, and we are all used to being able to see dimly in situations which we would (incorrectly) describe as being totally devoid of light.

The question of whether it is possible to see when there is no light at all was finally asked explicitly, and was answered fairly categorically in the negative by the majority of these Form 1 students. A few were doubtful, and two said they did not know[4].

Together with these majority views, there were also some attempts to describe alternative ideas about what is involved in seeing an object, but these were generally very poorly articulated and difficult to understand. When the students were shown the diagrams with lines and arrows added, however, it seemed to help some of them to crystalise their ideas a little. For some the drawings provided a framework about which they could build their explanations. There was a concern that the presentation of these drawings would actually force the expression of interpretations which were not really believed, but careful interrogation of the students after they had made their choices suggested that this was not so. Two of the twenty one students made choices but could give no explanation for these; the rest were able to give fairly coherent accounts of what they thought the drawing represented.

The most popular choices among Form 1 interviewees were clearly A for the first situation and C for the second (Figure 9.3).

Figure 9.3 The most commonly chosen diagrams in each of the two vision situations, in Form 1



Almost all of the twelve who chose 1A made it clear that the eye-to-object line represents a direction only, not the movement of any physical entity:

> JL: Why did you choose A?
> SS: Becos taim iu luk go iu luk stret daon.
> JL: Is there any real something coming from the eye to the box?
> SS: No.
> JL: So, what is this line?
> SS: Showim hao iu luk go nomoa.
>
> (50/M/92)

Even when this line was described as the girl's "sight", it was stated that this was not a real thing that was moving between eye and object. Just two students felt that there was something passing from eye to object: one could not explain what this might be, while the other very tentatively suggested it was "light".

The choice of 2C (also by twelve students) was consistent with the explanations given for 1A, but with the role of light made explicit: the light illuminates the box, making it clearer, and the girl looks at the box without any real entity leaving her eyes.

For the first situation, only one student picked "the physicist's model" (D) and gave "the physicist's explanation", in terms of light reflected to the girl's eye. None did this for the second, although one student picked diagram 2A and talked of the light reflecting the corner of the box to her eye. This shows a similarity with other interpretations that seemed to refer to the idea of an image of the box, or part of the box, travelling to the girl's eye, although the word "image" appeared to be unknown: the box was said to move up to her eye, but then it was admitted that it did not move as such. For example, a boy who chose diagram 1B made these comments:

JL: What do these lines and arrows show?
SS: They show how the direction that this girl look from here, then this corner will go directly to her eye.
JL: Do you mean the real corner of the box comes up to her eye?
SS: No, it's ... ...
JL: Does any real something come from the box to her eye?
SS: No.

(03/M/92)

Other minority conceptions included the idea that it was necessary for the eye to receive light as well as the object in part 2, while two students gave explanations in terms of a sort of consciousness:

JL: Why did you choose B? [first part]
SS: Because she sees the box and she knows that this is a box.
JL: Is there any real something coming from her eye to the box?
SS: Yes.
JL: What is it?
SS: Memory.

(17/F/92)

The results of the written test are summarised for each Form in Table 9.1. The proportions choosing each option in the interviews and in the written version were broadly similar in Forms 3 and 5, particularly as far as order of popularity is concerned. The relatively high proportion of Form 1 students choosing drawing 1B was not, however, reflected in the interviews, where choices 1A and 2C predominated heavily. It seems likely that the written responses are influenced by a lot of fairly random choice, especially in view of the interview evidence that a model involving an

Table 9.1 Proportions of students choosing each diagram in the written version of the two situations on vision, by Form.

		Form 1	Form 3	Form 5
		(N: 99	*101*	*70)*
Situation	Diagram	%	%	%
1	A	47	34	16
	B	24	19	16
	C	8	8	7
	D	11	31	53
	E	9	9	9
2	A	13	34	39
	B	13	21	29
	C	49	28	16
	D	12	4	4
	E	12	14	13

eye-object link is not common at this stage. When the choice has to be justified to someone else, as in an interview, a lot more thought is probably put into it. At the same time, however, it is interesting that 1B seems to benefit from this process of less careful choice. It suggests that the eye-object-eye model touches on a subconscious perception of the process involved in seeing an object which is only occasionally articulated.

9.4.2 Form 3

By Form 3, the students have had some lessons on optics and the terminology of optics commonly appears in their explanations: rays, reflections, light travelling in straight lines. Nearly all now make some reference to light in discussing vision, even in situation 1 where the source is not explicit. The models of vision within which they use these terms are for the most part, however, still far from the scientific one.

The proportion choosing the correct diagrams (1D, 2A) has now risen to more than 30%, compared with a little over 10% in Form 1. Interviews indicate that most of those choosing these options are reading the diagrams as showing light incident on the box being reflected to the observer's eye. There are also, however, explanations which suggest that there is a transfer of something like an image of the box to her eye that is facilitated by the light shining onto the box: "When the light reach this object ... er ... the light reflects this object to your eyes" (21/M/90). As one boy put it: "You see the box, not the light" (39/M/90).

A large proportion are still choosing diagrams which show an arrow from the eye to the box (1A, 1E; 2B, 2C): between 40% and 50% in the written version, but over 50% in the interviews. There is now much less agreement over the meaning of this line and the arrows on it. Four positions are adopted by roughly equal numbers:

(1) Nothing travels from the eye to the box; the line indicates only the direction in which the girl is looking.

(2) The line represents her eyesight, sight or vision, generally not considered to be concrete.

(3) Light travels from her eye to the box.

(4) Something is travelling from eye to box but its identity, or at least its name, is uncertain.

The notion of light travelling from the eyes appears in explanations for other choices too. This is particularly so for drawing 1B, where light may be described as being emitted by the eye then reflected back to the eye from the object:

JL: Why did you choose B?
SS: Because light travels in a straight line and if it's ... there's a substance in front and if it can't, the light doesn't go through it, it reflects, comes back straight.
JL: So we've got light coming from the eye to the box and back to the eye?
SS: Yes.

(31/M/90)

Other models that appeared in Form 1 are retained by small numbers of Form 3 students too. The role of light in situation 2 as merely an illuminator which makes the box brighter is suggested, for example. There is a slightly greater incidence of explanations suggestive of an "active visual system" (Andersson & Kärrqvist, 1983) than earlier, but these remain a small minority. For example:

JL: Why did you pick this one [1B] ?
SS: Because ... ...
JL: What do the lines show?
SS: It reflects.
JL: What does?
SS: When she saw the box.
JL: What is being reflected?
SS: The eye.
JL: Is there anything actually coming from her eyes to the box?
SS: The lenses.

(09/F/90)

This student is clearly using bits of information gleaned from optics classes - reflection, eyes having lenses - to elaborate an understanding of vision that derives primarily from her psychological experience of the observer as an active agent in the process.

A small proportion also referred to the role of light as being to stimulate the eye:

"Because the light from the bulb come to his eyes, then his eyes can look down there"

(02/F/90)

This was associated with choice 2B, but not all those making this choice appeared to think this way.

9.4.3 Form 5 (and beyond)

In Form 5, the majority are now choosing the "correct" options to at least one of the questions (1D or 2A), showing reflection of light from the object to the eye - although not a large majority. The vast majority of interviewees making these choices are also giving a scientifically acceptable description of what is happening.

Three out of the fourteen interviewees who made choice 2A, however, gave an account of the diagram in terms of images, as in this example:

> JL: So, do these lines show light shining on to the object and being reflected? [Following up such a description from situation 1.]
> SS: No ... Not really ... The light is shone on this object to make it clear and this object reflects its ... er ... image into the person's eye.
> (54/M/88)

Such accounts are a combination of two ideas already encountered: that the role of the lamp is simply to make the object brighter, and that an image of the object transfers itself from the object to the eye. Both of these ideas variously appear in explanations of other choices too, the latter idea often combined with talk of reflection:

> JL: Why did you choose this one? [1B]
> SS: Because the arrows in this diagram shows the girl looking at the box and the box is being reflected into the girl's eye.
> JL: The box?

SS: The image.
JL: So, there's an image of the box reflected into the girl's eye?
SS: Yes.
JL: This line from her eye to the box - is there any real something coming from her eye to the box, or not?
SS: No ... it's just the ... I think it's nothing.
JL: Is there something coming from the box to her eye?
SS: Its image.

(62/M/88)

Rice and Feher (1987) have suggested that "images" and "reflection" tend to get put together in explanations as a result of work on mirrors. Reflection is generally examined in school optics only in the context of mirrors, and mirrors are known to return an image to the observer.

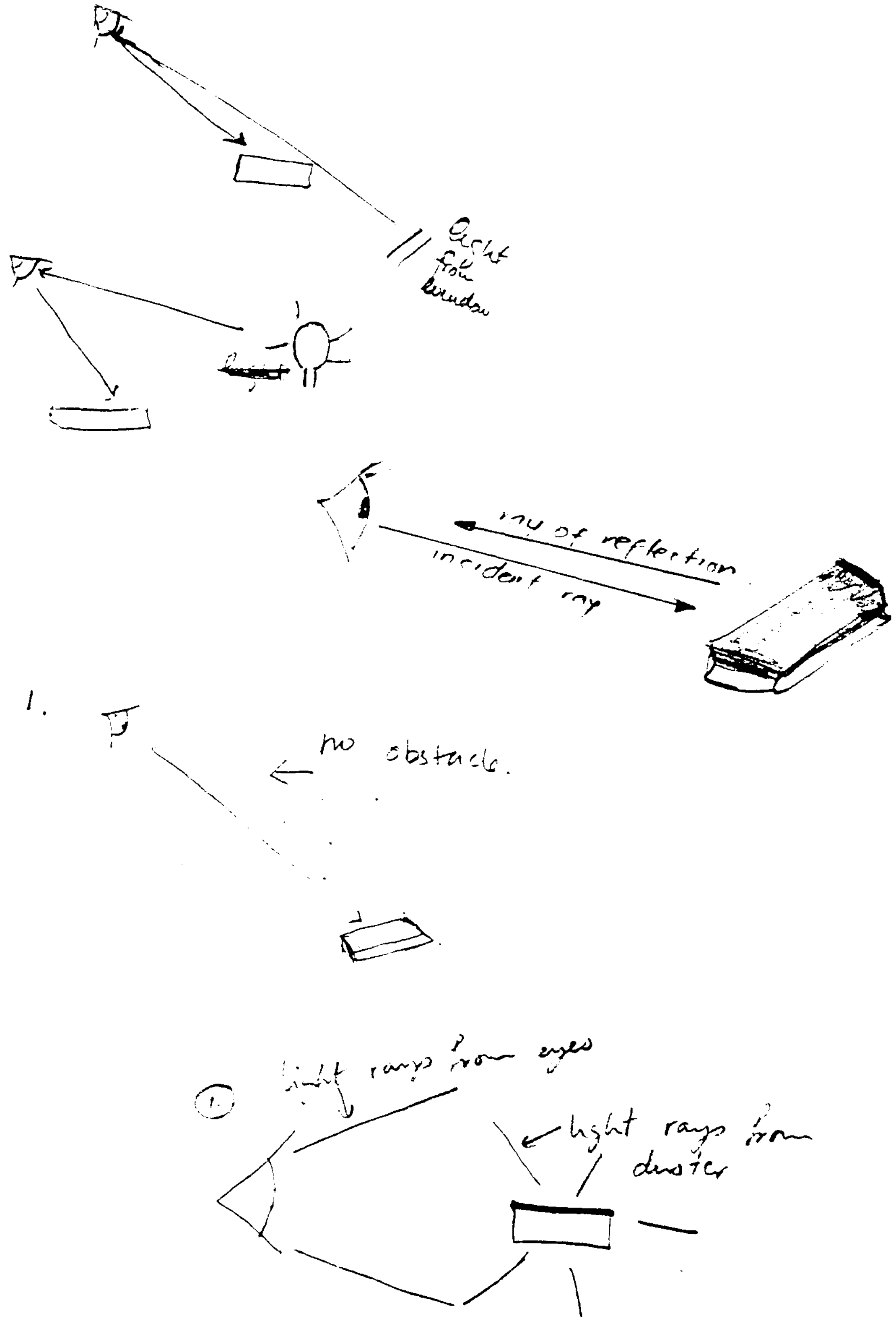
One can further speculate here that such a notion of the mechanism of vision is reinforced by common practice in teaching about the eye. Diagrams of the eye are often drawn showing an image on the retina joined to the original object by two lines from the extremities, crossing at the eye lens. It would be quite easy to read such a diagram as an outline of an image-transfer process.

A very significant proportion are still choosing diagrams with arrows pointing from eye to object. In fact, the proportion selecting either 2B or 2C does not decrease very much from Form 1 to Form 5: 62% in Form 1, 49% in Form 3 and 45% in Form 5. As with the Form 3 students, there is a diversity of opinion on the meaning of these arrows: light, sight, nothing material, something of unknown identity. One interviewee declared that the line showed the girl's sight, and maintained that this is a "real thing", although "we can't see it" - the most explicit identification of sight as a concrete entity that was encountered.

This diversity of responses continued into Form 6 when science students drew their own diagrams rather than making a choice. Only twenty six out of forty five Form 6 science students produced "physicist's conception" diagrams; a selection of typical "alternative conceptions" diagrams is given in Figure 9.4. It is clear that a range of alternative explanations of vision, similar to those already described, persists despite both science teaching and a selection based on performance in science. (Similar situations, in which "successful" students retained earlier misconceptions, but in mechanics rather than vision, have been reported by Champagne, Klopfer & Anderson, 1980, and Gunstone & White, 1981.)

Further evidence that perhaps the majority, even at Form 5, do not always think of vision as involving the reception of light from an object is given by responses to the question about how far the light from a visible burning match travels. Thirty three out of sixty four Form 5 students stated that the light travelled a much shorter distance than their own distance from the match: commonly, a value of a

Figure 9.4 Diagrams produced by Form 6 students that show "alternative conceptions" of the mechanism of vision for a person looking at a board duster.



few centimetres was given. The remainder did not necessarily give a distance greater than their own distance from the match: some gave borderline answers that could only be reliably interpreted if one knew what the respondent estimated his or her distance from the match to be; and some gave a speed for the light rather than a distance. Only about one third gave an unequivocal answer that indicated they were seated within the distance they thought the light from the match was travelling. This increased to about one half with Form 6 students, and from these students there were several answers explicitly linking the distance travelled by the light with sight: "About as far as it can be seen" (04/M/86). These findings agree at least qualitatively with those of Guesne (1985), although her subjects were rather younger than those in this study. It is somewhat surprising that this exercise with a luminous object seems to produce a lower proportion of those apparently accepting vision as a process of reception, rather than action, than the exercise in which diagrams are presented, and in which the object is non-luminous. Perhaps diagrams with arrows going towards the eye are being recognised from optics lessons as the "correct responses" without the message of these diagrams being fully internalised.

9.4.4 Who is getting it right?

If we take the criterion for judging acceptance of the physicists' model of vision to be the correct choice of diagram for both of the vision situations, then about 15% of Form 3 and 30% of Form 5 students are using the model. It is interesting that this proportion of 30% for the older students agrees almost exactly with the figure for Swedish and British 15-year-olds (Andersson & Kärrqvist, 1983; Ramadas & Driver, 1989). If we examine more closely who these students are, few clear characteristics appear. At Form 3, girls are under-represented compared with their proportion of the Form 3 population, but this imbalance has disappeared by Form 5. These figures suggest that the girls adopt the accepted model less readily than boys, but the numbers are too small to draw any definite conclusions. There are no consistent, significant patterns related to urban/rural background or to father's occupation.

The one consistent and significant relationship which does emerge is between acceptance of the model and performance in science: students who choose diagrams showing the physicists' model of vision are more likely to perform well in science than those who do not[5]. This is revealed by looking at the mean scores in the internal science examination taken at about the same time as this investigation into vision was carried out. For those making the correct choice in both vision situations this mean score is significantly higher than it is for those who did not make both choices correctly: 1.3 standard deviations higher at Form 3 ($p<0.001$), and 0.8 standard deviations higher at Form 5 ($p<0.005$). Alternatively, if the choices are scored as 0 for neither correct, 1 for either one correct and 2 for both correct, these scores correlate positively with science exam scores: $r = 0.49$ ($p<0.001$) at Form 3, and $r = 0.42$ ($p<0.001$) at Form 5. For a situation where one variable has only three possible values, and these are not equally distributed, these coefficients are quite substantial[6].

9.5 A summary of conceptions of vision

The various "models" of vision described by the other researchers do seem to include most of the explanations offered by K G VI students. For example, the "dominant conception" which Guesne (1978, 1985) found was held by her subjects applies fairly well, in its general outline, to the majority of Form 1 students. Most accept the presence of light as being necessary for vision but suggest no links between eye and object. Whether these ideas can be taken to constitute a model or an explanation of vision on the part of the students, however, is debatable. The point that came across strongly in interviews is that vision is not, in their opinion, in need of an explanation, as it is quite non-problematic. Even any idea of the role of light in the process is barely at the level of consciousness; it is simply accepted because light is always there. Only by raising its role as an issue, or by presenting a situation in which a source of light is made explicit, does it become a point to be considered as part of an otherwise accepted experience. The presence of an explicit source may then generate an awareness of latent understandings that otherwise border on the subconscious.

The main point of disagreement with Guesne is the developmental nature that she assigns to her four alternative conceptions of vision in labelling them a "progression" (see Figure 9.1). The first stage, with a "bath of light" and no eye-object link, is that to which the majority of Form 1 students might be assigned in view of their answers to initial, open-ended questions. On being presented with the diagrams, however, they favoured a model not included in Guesne's scheme: an eye-to-object link and the role of light still not made explicit. This is suggestive of the "visual ray" model of Andersson and Kärrqvist (1983), supported by Ramadas and Driver (1989). In relation to the present study, however, serious reservations must be made about their interpretation of this as if the "rays" were considered by the children to be something concrete. Among the younger K G VI students, this eye-to-object link was clearly not seen in this way, but remained largely as a non-material "sight".

The second and third of Guesne's stages include a source-to-object light link. The K G VI data suggest that this is less a link that appears with development of ideas about vision, and more one that is situation-dependent. Even prior to being shown the drawings, students described light shining onto the object as being important for vision, as long as an intense, local source was made explicit. Thus, all of the first three of Guesne's conceptions could actually be expressed by the same student, depending on the situation presented and the means used to interrogate it. This is reminiscent of the unstable, even contradictory nature of children's explanations that has been reported elsewhere (Champagne, Klopfer & Gunstone, 1982; Solomon, 1983).

What is also missing from Guesne's schema is that group of conceptions that include an object-to-eye link that is not light. The K G VI responses show that this link may appear as a "return link" from one originating in the eye, or as a response to the arrival of light on the object, although it appears only very rarely in isolation. These are frequently the "transfer of an image" type of models, reminiscent of the Ancient Greek *eidola* concept (See Ramadas and Driver, 1989).

There is a common element in the explanations of vision that the vast majority of the Form 1 students produce, even if there is variety in their details. This common feature is that these explanations have all been put forward to account for the psychological experience of vision in which the observer is the active agent, not a passive recipient. As an observer, one is not only in conscious control of the direction of one's sight, one must often focus one's attention on a particular part of the field of view, and sometimes make a considerable effort to see something clearly. The control, the attention, the effort all originate with the observer. There is no sense whatsoever of anything entering the eye, but more of some sort of attention or awareness flowing outwards:

> "Apparently, the aspects of vision to do with perception and the effort made to see something are much more real to students than the physical and physiological effect of light going into the eyes."
>
> (Ramadas & Driver, 1989: 55)

Perhaps the only exception to this is when a bright light is shone directly into the eyes. In this situation, one sees "nothing", so it is perhaps difficult to comprehend how the reception of light can be part of the normal process of sight. If there is to be any reception, it must be of some sort of representation of the object, not of "blinding" light. Hence it seems that the variety of models of vision suggested by the students can be seen as attempts to account for the personal psychological experience of vision: all those models that propose an outflow from the eye, with or without a return, or an active process of the eye, or even those that suggest the transmission of an image to the eye. Perhaps this sense of what it is that has to be explained by an account of vision is most neatly encapsulated by the Form 1 boy explaining why he chose the diagram with a line from the eyes to the box:

> "Because she saw the box. The box doesn't see her."
> (05/M/92)

It is not surprising when linguistic usage supports these models. The relevant language has evolved as an attempt to communicate and share the experience of vision for the individual. The language both arises from the experience and then supports its implied interpretations of that experience; this is to be expected from the nature and purposes of language (Osborne, Black and Smith, 1993).

An interesting point about the use of a "visual ray" model by the K G VI students is that more concrete versions tend to appear later, in Form 3, after an introduction to optics in Form 2 science classes. For many students it seems that this introduction to optics supplies them with a set of words and concepts which may now be used to elaborate an explanation of vision which is still in the "active observer" mould. The essential personal experience of vision has not changed, and the words and experiences from science classes have not convinced these students that their reading of this experience is an incorrect interpretation of reality. What they have done is to provide the materials with which to construct a more explicit model than before. While many still retain a fairly abstract interpretation of the eye-to-object link, others have taken on board the idea of the passage of light between object and eye to label the emission from the eye as light. Others continue to refer to it as "sight" while perhaps seeing ray diagrams from optics lessons as justifying a more concrete interpretation of its nature.

For a large proportion of students, the personal psychological experience of vision is clearly too strong to be shaken by school science teaching, so they retain a model that involves an active or emitting eye; from the data given above, this proportion may be as high as almost 50% right through to Form 5. Presumably this interpretation is retained on leaving school and school science, which occurs after Form 5 for the majority. Their theory of the nature of vision develops as they progress through school, but its basis in personal psychological experience remains largely unchanged.

9.6 Some conclusions on students' conceptual development

The three concepts chosen for consideration in this chapter and the previous one provide interesting comparisons of the processes of conceptual development in the K G VI students - comparisons that suggest that a search for a single theory of the origins of children's conceptions may be misguided. (It must be kept in mind, however, that this development process is being inferred from cross-sectional data rather than being observed directly in a longitudinal study.)

The boys' understanding of the process of burning seemed to progress towards an acceptance of the scientific explanation in terms of combination with oxygen and formation of new substances as they moved through the school. (The girls did not seem to show this progression, but this difference will be overlooked for the moment.) This understanding progressed to the extent that almost all of the boys interviewed in Form 5 were using this scientific model in their explanation. The explanations of vision also showed a development towards the scientist's version with progress through the school, although this process was only complete for a minority of students by Form 5. The biologist's interpretation of "animal", however, seemed to have been accepted most readily - if still only by a minority - at Form 1, and then to have suffered a subsequent decline in the level of acceptance in Forms 3 and 5.

As a further point of comparison between the students' conceptions of vision and of "animal", it should be noted that a considerable range of interpretations of the first concept persisted throughout Form 1 to Form 5, and beyond, whereas there was a tendency towards a broad consensus about what constitutes an animal among those not using the scientific interpretation. Finally, it should be noted that for both of these two concepts it was those who achieved highly in science who tended to make use of the accepted scientific ideas.

A possible explanation for at least part of these observed differences is based on the existence of different sources of alternative conceptions for the different concepts investigated. Thus, the ready acceptance of the scientific account of burning could be explained by the absence of both socially and personally produced alternative accounts. The interview responses of the younger students showed that their attention initially centred on the melting of the wax of the candle rather than the flame. Once their attention was focussed to the flame, however, the students appeared to have no alternative accounts available, nor did they appear to be constructing such accounts themselves. Their explanations were largely attempts to understand the scientific account that they had met in school science. These ideas from school science lessons provided the material from which they attempted to build their own explanations. This in turn took time to be achieved as it required an appreciation of other concepts, such as air and chemical change. Notice that this understanding is likely to require effort and motivation. This may be important in an explanation of why the use of the scientific account was less widespread among the girls. It is not that there is a rival, alternative theory available; their answers are largely descriptive of their own perceptions only. The relative delay in their adopting the scientific view is more a result of a lack of motivation to consider it and take into their "life-world" knowledge - which is only weakly related to school science knowledge.

For the phenomenon of vision and the understanding of the term "animal", however, rival versions are available. In the case of vision these arise largely from personal attempts to account for sensory and psychological experiences, although these may, in turn, receive some reinforcement from language. This personal constructional origin may explain the variety of accounts which appear, although there are, presumably shared experiences which limit their form.

The alternative conceptions of "animal", however, are social in origin, deriving from common usage of the term. This is not a personal experience to be accounted for, but an item of language for which the meaning must be socially agreed, if communication is to be possible. Hence the tendency towards a relatively common interpretation of the word. The concept of animal will not necessarily be exactly agreed upon by all because exact meanings are rare in the everyday use of language, unlike the exactness of scientific usage.

Sources of alternative conceptions, therefore, may be personal or social, and their resistance to attempts at changing them through teaching will vary according to their availability; and to factors external to the conceptions themselves, such as attitudes and motivation. The sources of alternative conceptions will not necessarily be the same in all cultures. Osborne and Wittrock suggested that commonly held conceptions of physical phenomena are formed under three influences:

> "*Gut science*, based on intuition and spontaneous reaction; *lay science*, based on the everyday use of language and media images and *school science*, based on the symbolic and idealised world of the science classroom."
>
> (Osborne & Wittrock, 1985: 64)

"Lay science", in particular, will be extremely culturally dependent, but it is doubtful that one can actually make clear-cut distinctions between the three. The interpretation of "intuition and spontaneous reaction" that forms gut science must be dependent to some extant on culturally available images and metaphors and, of course, on language. Much of lay science may be formed through negotiation between gut science and formal science, for which important sources will be school science and the media - in more developed countries at least (Solomon, 1993; Lucas, 1993). In the Solomon Island context, these media messages are likely to be much less important.

As an example of media influences on one of the areas investigated here, both Guesne (1985) and Andersson and Kärrqvist (1983) have suggested comic strips as a possible source of alternative conceptions of vision. They cite Superman's X-ray and infra-red vision as an example of the "visual-ray" model that some of their subjects held. It is very unlikely that this would be an influence on Solomon Island students, and yet they did offer such visual-ray explanations quite frequently. It may be more accurate to see these models as responses to personal experiences of vision which have, in the case of Superman, then found their way into the media. The media may therefore be better thought of as providing reinforcement for these "gut science" accounts, rather than as independent sources. (Perhaps, however, familiarity with comic-strip representations of vision may be responsible for the apparently more concrete versions of the visual ray model that Andersson and Kärrqvist found among Swedish students, compared with the more abstract K G VI models.[7])

For all of the students, the scientific definitions and explanations of these concepts were available. That it was generally those who do well in school science that accepted more willingly does suggest that attitudinal or motivational influences are important. Perhaps the degree to which the students accept the scientific versions is a reflection of the extent to which they accept scientific interpretations of the world in general. School science is not the only system of organised knowledge available to them. Three such "systems" might be potentially important sources of worldview for these Solomon Island students: school knowledge (in this case, school science), traditional belief systems (or *kastom*), and Christian religious teachings. The next chapter provides some evidence and discussion of the relative importance of each of these three for the formation of the students' views about the world.

CHAPTER 10 MAGIC, SCIENCE AND RELIGION, AND K G VI STUDENTS

Although the professed concern in this chapter is the relative positions of science, Christianity and traditional beliefs in the K G VI students' overall worldview, the title uses the word "magic" rather than "traditional beliefs" or "custom". In part this is quite simply to allow the use of a title imitating that of Malinowski's famous work (Malinowski, 1948), which was influential in the early stages of this part of the research. It also indicates, however, that the investigation of the students' knowledge and acceptance of traditional beliefs was deliberately restricted, partly just to keep it manageable. "Magic" was chosen as an aspect of *kastom* which can be seen as similar to science, in that both are concerned with the manipulation of natural phenomena, while at the same time being commonly considered to be quite opposed to science in its essence and interpretation of the workings of the natural world.

10.1 Science and magic as incompatible systems?

It might seem reasonable to assume an incompatibility between a belief in magic and the development of scientific knowledge and attitudes. Such an incompatibility is certainly implied in Modernisation Theory accounts of development: the rejection of superstition and magic and their replacement by science and technology being characteristics of the development of "modern man" (Inkeles and Smith, 1974: 28 & 32). It is also a theme in Max Weber's descriptions of the overall process of modernisation, which he seems to see as inevitable:

> "The fate of our times is characterized by rationalization and intellectualization and, above all, by the 'disenchantment of the world'."
> (Weber, in Gerth & Mills, 1946: 155)

In both of these cases, the basis for this incompatibility stems from a labelling of science as rational while magic (and in the case of Inkeles and Smith, religion too) is seen as essentially irrational. This distinction on the basis of rationality has been challenged on various grounds by Lévi-Strauss (1966), Horton (1967) and Barnes (1974), among others, who object that a dismissal of magic as irrational is not tenable. Magic may be quite rational in the type of reasoning it involves but differs from science in the nature of the premises from which this reasoning begins, or the idiom in which its mechanisms are expressed (Horton, 1967). Important differences exist in the nature of evidence demanded, both for the support of premises and for the products of the reasoning from those premises, and in the openness of practitioners to criticism and alternatives. The debate over the rationality of magic is treated in a little more detail in Appendix 5, but for the purposes of this chapter it is claimed that the basic assumptions about the workings of the universe adopted by science and by magic are fundamentally incompatible.

Since human beings are notoriously capable of being unreasonable, the mutual inconsistency of two sets of beliefs seems to be no reason at all for one person not to hold both sets. Certainly, on the larger scale, the dominance of science and technology in the everyday life of western societies has not meant the elimination of superstition, of cults of magic and witchcraft, of belief in astrology. Perhaps, however, this merely indicates some sort of polarisation of society, a division between those who accept the processes of science and those who reject them, rather than a form of schizophrenia at the individual level. At the level of the individual, is it possible to accept both magic and science? Do an increase in knowledge of science and the development of scientific attitudes go hand in hand with the rejection of magic and superstition? Is such a rejection in fact a pre-requisite to the successful learning of the content and methods of science? Does the continued acceptance of the magic inhibit the learning of science?

Malinowski must have assumed that magic and science may co-exist since he argued that societies function with both. His argument was that each has its own sphere of application and significance, although both are directed towards specific practical aims and the mastery of nature. Thus, referring to the scientific knowledge of (basically Melanesian) agricultural societies, he writes:

> "...every primitive community is in possession of a considerable store of knowledge, based on experience and fashioned by reason. ... The success in their agriculture depends ... upon their extensive knowledge of the classes of the soil, of the various cultivated plants, of the mutual adaption of these two factors, and, last not least, upon their knowledge of the importance of accurate and hard work."
> (Malinowski, 1948: 26 & 27)

But there is a limit to such knowledge; there are natural disasters and unpredictable occurrences when this knowledge fails:

> "Thus there is a clear-cut division: there is first the well known set of conditions, the course of natural growth, as well as the ordinary pests and dangers to be warded off by fencing and weeding. On the other hand there is the domain of the unaccountable and adverse influences, as well as the great unearned income of fortunate coincidence. The first conditions are coped with by knowledge and work, the second by magic."
> (*op cit*, p29)

Essentially then, magic is invoked for those events that are inexplicable within the framework of existing "scientific" knowledge, when experience fails. This suggests that an increase in scientific knowledge, and control through technology, must gradually reduce the territory left to magic. Thus the growth of knowledge progressively marginalises magic by decreasing its domain, not by overthrowing it.

At this point, serious reservations must be expressed over Malinowski's labelling of a mixture of technology and accumulated factual knowledge as "science". Lévi-Strauss takes the same approach, taking an extensive taxonomy and applied knowledge as necessarily scientific, in his determination to defend "primitive" thought from charges of inferiority. Such a view of the relationship between science and magic places the emphasis on knowledge. What it misses are the methodologies, the attitudes, the philosophies that are responsible for the development of that knowledge. In short, it misses the essential difference in worldviews between science and magic (and between science and at least some forms of religion). Redfield characterised this difference when he suggested that "precivilised" societies see the world as pervaded with sacredness and the personal - a position echoed by Horton (1967) - so that man is seen as <u>in</u> nature; whereas science distinguishes between man and nature:

> "Man comes out from the unity of the universe within which he is orientated now as something separated from nature and comes to confront nature as something with physical qualities only, upon which he may work his will. As this happens, the universe loses its moral character and becomes to him indifferent, a system uncaring of man."
>
> (Redfield, 1953: 114)

From this point of view, therefore, a scientific worldview does not marginalise magic by consigning it to regions as yet beyond explanation. It simply denies the possibility of magic. It is the boast of Western science that ultimately, all natural phenomena must be capable of rational explanation, and that it is through science that such explanations will be found. That we cannot as yet account for all our experiences nor control all of our environment is taken to be due to our limited knowledge, not to the existence of a distinct sphere that is in essence inexplicable, unpredictable and uncontrollable without recourse to rites and rituals whose workings are incomprehensible.

It would be quite unrealistic to expect such a depth of commitment to science as this from the majority of the K G VI students, if any. It must also be recognised that these students have not been brought up in the sort of traditional cultural environment beloved of anthropologists. Nevertheless, in view of the very recent emergence of their society from a general domination by "traditional" belief systems, it is pertinent to enquire to what extent the students do believe in magic and whether this belief interacts in any way with their response to science. To what extent do they still accept the domain of the magical and does it influence the way in which they perceive science, its truth or its usefulness?

10.2 Obtaining data on belief in magic

There could be serious difficulties for a science teacher trying to uncover his own students' attitudes to magic, particularly when the teacher is a "whiteman". Most of the students are probably quite aware that magic is not considered acceptable to science and when asked a question by a science teacher the answer to be given should be the "scientifically correct" one. Similarly, it was the "whiteman" who proclaimed custom magic to be wrong and backward, so there is likely to be a reluctance to admit to a continued belief in it.

To some extent it was possible to make use of a relatively close and relaxed personal relationship with many of my students to encourage them to speak freely about their thoughts on magic, and to approach the topic in such a way as to reduce the element of direct challenge to the students to state their position. Some loosely-structured interviews with individual students and a wide-ranging discussion with a group of five were held to make use of these personal contacts but there was a tendency for these students to be the more articulate and out-spoken members of the school, rather than truly representative. The general background interview given to a larger, more typical selection of the students included questions on their religious beliefs, whether or not they had ever come across conflict between their religion and science, and what their reaction is, or would be, to such conflict (see Appendix 2), but this did not produce much useful information.

There was a need for an instrument which could obtain reliable information on attitudes to magic from a much larger sample of students. It was decided to try asking questions through another teacher who was not teaching science. A story was made up ("The Curse"), set in Papua New Guinea rather than the Solomon Islands so as to avoid problems of the students' identifying a lack of authenticity when dealing with traditional practises.

This story is of a second-year medical student, To'uluwa, returning to his village where he arrogantly and insensitively criticises traditional practices and is eventually accused of causing illness among the children through sorcery. A powerful sorcerer, known as a Vullai'i man, is called in; he uses magic to cure the children and to put a curse on To'uluwa, who has escaped but who eventually dies at the hands of thugs back in the city. (The name Vullai'i was deliberately chosen to be reminiscent of a widely-known tradition of magic on Guadalcanal called *vele.*)

This was presented to students in Forms 4 and 5 by their English teachers as a comprehension exercise, with any difficult words explained but no discussion of content, and was then followed by a series of questions requiring written answers: basically an example of the type of exercise the students were used to in English. The questions began as questions about the passage but then became less tied to it so as to allow expression of individual opinions and description of personal experiences of magic. These questions were varied slightly with later groups, in the light of responses from earlier ones. With two of the classes I personally led a follow-up discussion in order to clarify and confirm conclusions drawn from their answers. The story and the questions asked are given in Appendix 6. Altogether, the exercise was completed by seventy boys and forty nine girls.

The initial analysis examines the extent to which magic is accepted as real, effective practice, followed by an examination of the mechanisms which the students seem to feel lie behind magic. This reveals an interplay between magic and religion, between modern and traditional, in which science seems to play only a minor role.

10.3 The acceptance of magic

The general tenor of responses to "The Curse" ranges from complete acceptance of the events and an account of them based on magic as not only possible but very likely, through scepticism of such explanations, to a vehement rejection of all magic and superstition. On the basis of these responses it is not possible to make a simple division of the students into those who accept and those who reject magic, or to rank them in a meaningful sense on some sort of continuum between these two extremes. Some of the answers reveal some doubt, and there is often conflict between answers to different questions from the same student. This probably reflects genuine uncertainty and confusion on their part. Among those who reject magical causes for the events in the passage, there are some who still seem to accept magic as possible in other situations.[1]

Two of the questions asked whether the events in the story could really have been due to magic: To'uluwa's magic in the case of the children's illness and the Vullai'i' man's magic for their cure and To'uluwa's death. Only seven percent of the students unequivocally thought that To'uluwa could have put a curse on the children but thirty one percent were sure that the other events could be explained by the Vullai'i man's magic. Coincidence between events and predictions was quoted as evidence:

> "I think the Vullai'i man's magic is working because when To'uluwa disappeared the children get well and his curse on To'uluwa that wherever he was, would bring about his death have come true."
> (14/F/87)

> "Yes, I think they really had become ill because he had put a curse on them because before he returned to the village, they were very healthy but after he came back, they became ill and when he died, they were well again. It was too rare to be a coincident."
> (49/M/87)

The boys were twice as likely as the girls to accept magical causes in either case. Some students claimed that as a young educated person, To'uluwa would simply not know how to use magic, but nineteen percent suggested that To'uluwa may have been indirectly responsible for the children's illness through his behaviour angering spirits:

> "To'uluwa had not cursed the children but the anger of their ancestral spirits make the children ill. They were angry because To'uluwa critised them."
> (09/F/87)

> "No I don't think so but because of To'uluwa is criticising the village beliefs so might be the spirits of the magician blame him. Because I have heard someone that if you criticise a magician he will turn back on you and curse to."
> (26/M/89)

A further twelve percent were unsure about the Vullai'i man, but did not reject the possibility of his magic being effective. This suggests that at least forty percent of the students were prepared to accept magical explanations or the action of spirits, but to this must be added those who rejected the Vullai'i man's magic as the cause of To'uluwa's death simply because the death did not follow the pattern one would expect from magic:

> "I don't think so because if To'uluwa was dead from somkind of strange sickness that cannot be cured by the modern medicine then that was from the Vullai man's magic but his death was caused by his injured wounds. that was an accident."
> (33/F/87)

> "To'uluwa's death was caused by the 'rascals' and if he had died like just sitting in and collapse then that could prove the vullaii magic."
> (30/M/88)

These students are accepting the reality of magic: sorcery can work, but this story is not an example of it. Overall, the answers suggest that at least half of the students accept the existence and possible effectiveness of magic or other supernatural phenomena in causing sickness or death. The proportion is certainly greater than half for the boys, but significantly less than half for the girls.

The majority of students identified the unhygienic village conditions as the likely cause of the children's illness, even though some of these went on to accept the Vullai'i man's magic as the cure and as the cause of To'uluwa's death. In a few cases it was the form of the illness which led to its identification as a "natural" disease and not one due to sorcery: sickness caused by magic would have different symptoms. Although one or two students did explicitly take the line that "We know that disease is caused by micro-organisms not by magic", one should be very wary of suggesting that the students see scientific knowledge as a reason for the rejection of magic. The obvious success of science-based medicine does not necessarily deny the effectiveness of magic in its own sphere. On the contrary, it can actually help to reinforce a belief in magic. In a country of only modest medical resources, examples of the failure of "scientific" medicine to cure or even identify an ailment are all too common, and most students asked about this could recall at least one case. Such failures will not be accompanied by explanations from the doctor or clinical officer, either because an explanation is not available or because it is not the habit of professional medics to explain what they are doing in any situation. Peter Lawrence (1987) has pointed out how this contrasts with the behaviour of the traditional healer who will always explain the sources of illness and will even explain failures to effect a cure - usually in terms of counter-sorcery, thus maintaining the idiom in which he is working. The result of this is to make it clear that modern medicine, though powerful, is not omnipotent, and hence to leave space for alternative explanations and cures for illnesses.

In his detailed study of the decline of magic in England, Keith Thomas (1971) frequently makes comparisons between sixteenth and seventeenth century England and the present-day Third World. He sees a close parallel between the two on the continued reliance on traditional cures and makes the following comment:

> "The stubborn reluctance of the lower sections of the seventeenth century population to forgo their charmers and wise men resembles the unwillingness of some primitive peoples today to rely exclusively upon newly introduced Western medicine. They notice that men die, even in hospitals, and that the Europeans have virtually no remedy for such complaints as sterility and impotence. They therefore stick to their traditional remedies, some of which afford a degree of psychological release and reassurance not be found in Western medicine. They cherish the dramatic side of magical healing, the ritual acting-out of sickness, and the symbolic treatment of disease in its social context. Primitive psychotherapy, in particular, can compare favourably with its modern rivals."
> (Thomas, 1971: 206-207)

When dealing with traditional medical practices, a distinction can be made between custom medicine and custom magic. In general, students agreed that many illnesses responded to cures such as the use of various plants or their extracts that are available to all and require no specialised ritual knowledge; their application does not involve magic. Some afflictions, however, are identified as "custom sickness" and require the attention of a specialist with access to magic. With this distinction in mind, the Form 1, 3 and 5 students of 1991 were presented (as part of a wider written test) with the following two statements for consideration: "Some diseases are best cured by custom medicine" and "Some diseases need custom magic to cure them". The first was accepted by more than three quarters of the students in all three Forms, with very little decrease in support between Form 1 and Form 5. While fewer students accepted the need for magic to effect a cure in some cases, the proportions are still very high: only by Form 5 had it

fallen below 50%. In the same test, however, almost 100% of all students accepted bacterial or dietary explanations for the causes of at least some diseases.
The significant reduction in those accepting magical cures in Form 5 does seem likely to be genuine and not an artifact of the selection process at the end of Form 3. An analysis of the Form 3 responses shows that those who later returned to Form 4 were as likely to accept the statement about magic as those who failed to return. There were no consistent differences in responses between boys and girls, nor between those from rural and those from urban backgrounds in their acceptance of magic in medicine. Using school science examination results as a measure of ability in science, there does not appear to be a consistent or significant correlation between performance in science and the acceptance of magical cures, although almost all of those who later came back from Form 5 to study science in Form 6 did reject the statement about the use of magic.

10.4 The basis of magic

When students were asked in interviews and discussions what they thought was the source of magical power, two types of reaction were generally noted. The first was a sort of blankness, as though the question had never occurred to them before: the magic "just worked". The second was an immediate identification of spiritual powers behind magic, variously described as just spirits, ancestral spirits, evil spirits, or even "Satan". On further questioning, however, the first group generally conceded that magic spells did make use of spiritual powers.

Keesing (1982) describes the relationship between ancestral spirits and magical powers of the living as a key element in the religious beliefs and practices of one Solomon Island society, the Kwaio of Malaita. According to the Kwaio, magical influence over a particular aspect of life originated with a particular ancestor and it is only through the will of that ancestral spirit that the living can continue to exert the magical influence. Ancestral spirits, in turn, are the basis of the religion - indeed the whole cosmology - of the Kwaio. At the same time, however, Keesing points out that much of the common magic is carried out without the need for conscious reference to the spirits; it has moved from the realm of the spiritual to that of technology - at the immediate level, at least:

> "Magic is conceived by the Kwaio as, on the one hand, one of a number of kinds of interaction the living engage in with ancestors, a form of transaction. On the other hand, magic is viewed as one kind of technology ... Magic is relatively automatic in its operation (though the Kwaio neither know nor care how it might actually 'work'). If one knows the spell and a correct validation, the magic should normally 'work' if it is correctly performed."
>
> (Keesing, 1982: 52 & 54)

A similar point was made by Hogbin in a study of pre-Second-World-War North Malaitans. Although spirits were seen as the power behind magic, their response to the correct rites was taken to be automatic, so that the religious nature of such transactions largely disappeared, and one of Hogbin's informants compared the whole process with that of exchange in the market place (Hogbin, 1939: 107). This separation of the spiritual aspects of magic from its technological application may be providing a useful opening for at least some of the K G VI students to resolve the dilemma created by the vehement rejection of traditional religion demanded by the adoption of Christianity while at the same time "knowing" from personal experience that magic does work. Chowning (1977) describes the use of "impersonal magic", rather than dealing with gods and spirits directly, as characteristic of Melanesia and it is easy to see how this would allow the use of magic to continue when the connections with traditional religious beliefs has become unacceptable.

Keesing's view of Kwaio society seems to contradict Malinowski's statement that all primitive societies possess both science and magic insofar as he blurs the distinction between these categories. Malinowski seems to suggest that people see ancestral spirits as existing in a separate realm from human beings, not normally interfering in human affairs but available to be called upon in times of need. In most activities their existence can be forgotten about and the routines of daily life are controlled by the knowledge which Malinowski classifies as science. Keesing, on the other hand, insists that ancestral spirits are as much part of the Kwaio "real" world as the living are, and all activities must be carried out with the need to propitiate these spirits kept in mind. Certain aims can only be achieved by going through prescribed rituals and it is perhaps these acts that we might describe as "magic", but the mechanism by which these acts achieve their end is the same as that which controls all daily existence: the actions of ancestral spirits. Other writers have made a similar point about various Melanesian societies: spirits are part of the physical world, continually present, rather than occupying a supernatural or transcendental realm (Hogbin, 1964; Chowning, 1977; Stephen, 1987b).

But these acts of communication between human beings and spirits are also the basis of religion, so that the boundary between magic and religion too becomes indistinct. Chowning declared of Melanesia in general that "it is impossible to draw a clear distinction between magic and religion" (1977: 63), while Mary MacDonald concluded that "magic may be regarded as the characteristic form of religion in Melanesia" (1984b: 196). Perhaps the attempt to separate magic, science and religion in traditional Melanesian societies is more of an attempt to impose European divisions where they do not really exist. Other writers have also stressed the essentially integrated nature of the Melanesian worldview and the role of magic in everyday activities (Whiteman, 1984b; Fugmann, 1984). Sarton (1948: 37) made the same point about "primitive people" in general, arguing that the separation of science and technology from religion is a classification that "has no sense to them." It must be stressed that present-day K G VI students have not been brought up in the "traditional" sort of society that attracts ethnographers' attention. In particular they are nearly all at least third or fourth generation Christians. Nonetheless, many of them have insisted on the reality of their ancestral spirits and some have described to me how these spirits continue to play a part in everyday human activities:

> "... for the ancestors, I mean, they, sometimes, they're very helpful, yeah? If somebody wants to ... you know, we believe in black magic ... If somebody wants to kill you or something, they can still protect you. Say ... you know, sometimes in Malaita, if ... you are travelling on a road ... in a place a bit far from home and then sometimes there will be people on the road, or some other ... devils ... or ... they are roaming around too. Then, if you happen to come across this place where they are really bad, something that can kill people, a spirit or something ... er ... the ancestors usually give you a warning. ... They can either make you afraid so that you turn back and go back to the village, or make something come behind you, like a dog running or something after you. And then you can walk fast and then you can miss the chance of that ... whatever wanted to spoil you or kill you."
> (27/F/88, 8/9/92)

It is perhaps worth pointing out that this quotation comes from a girl who, though a Malaitan, has been brought up in Honiara, not in a rural area. Two other students, both sixth-form science students, described to me how ancestral spirits had visited them in dreams to warn of impending difficulties. Others have described encounters with spirits near traditional shrines, or how they have heard the voices of the half-spirit, half-human creatures said to inhabit the forests on some islands: the *kakamora* of Makira or *dodore* of Malaita. These various spirits of traditional religions are still taken to exist in a very real sense by many of the students, perhaps a majority.

A further point commonly made about Melanesian society is that this integrated worldview is essentially a religious one. Thus, Mantovani simply declared that "Melanesians were and are religious people" (1984: 1). Hogbin (1939) saw the religious system of North Malaita as the driving force behind the whole culture; while Lawrence (1987) described the Garia of Papua New Guinea as sweeping all knowledge under the carpet of religion, so that they have no secular tradition of knowledge at all. It is interesting, therefore to examine whether religion still holds the predominant position in the worldview of the K G VI students.

10.5 Magic and religion

When there is a clear rejection of magic, the student usually gives his or her Christian faith as the reason for this. When asked, as one of the questions on "The Curse", why there has been a decline in belief in magic, over fifty percent of the students cited the growth of Christianity as the reason. Similar responses came from interviews and discussions. There seems to be three ways in which Christianity counters magic. Some students declared that it prohibits the belief in and practice of magic. They suggested that magic is superstition and does not exist:

> "Finally, as I am brought up in a Christian family I am never taught to believe such spirits healing but only to believe in the power of God."
> (40/F/87)

A second group suggested that Christianity accepts the reality of magic but labels it as evil, the work of Satan. More commonly, however, there is the position that places less emphasis on evil but maintains that Christianity triumphs over magic through its greater power. Magical powers exist, but they are not as strong as the powers of the Christian God:

> "I would not be afraid of the Vullai'i man of his customs because I can use my power as well to destroy the Vullai'i man custom and heal the children (Christianity) but for his appearance I would be afraid."
> (04/F/87)

It is clear from many responses that it is belief itself which gives power to magicians and, hence, truly held Christian beliefs will protect one from their magic. Faith is everything.

> "... What I mean is that, (my belief) If you believe and scared of what they are going to do, then forsure it will happen but if you don't believe then nothing will happen."
>
> (29/F/87)

Of course it is sometimes wise to hedge one's bets:

> "I would not be afraid of the Vullai'i man. Firstly because I would not believe in such things. Secondly although these things existed, I have a God who protects me."
>
> (52/M/87)

One sixth-form science student described the difficulties he would face if he heard that someone was using magic on him, torn as he is between his Christian faith and his traditional heritage:

> "One thing too is that ... it is how we are brought up. You know, in the past, we ... our ancestors, say, they always worshipped spirits, yeah? And they ... they have a strong, I mean, belief in those spirits, yeah? And ... and that thing always ... er, I mean it is the thing, that kind of thing is always in us, yeah? So whenever ... whenever we heard that ... for me, yeah? ... when it says that somebody is trying to black magic you, I mean, even ... even I try my best not to believe in it, I would be affected by that."
>
> (33/M/87, 14/10/92)

As far as the majority of students are concerned, the link which existed in traditional Melanesian religions, between religion and magic, is still there. The powers that are referred to as magic are spiritual powers and as such come into the domain of religion. The term "magic" is itself now taken to mean the use of traditional spiritual powers and the adoption of a new religion makes such practices *tabu*. The belief in the essence of magic - the influence of spiritual powers on the physical world - remains, and may even be stronger as the new religion claims greater powers in this domain, but it may no longer be referred to as "magic". Writing about an earlier generation of Christian converts on Guadalcanal, Hogbin pointed out that the same word, *aru*, was used for magic and for Christian prayers:

> "The two forms of otherworldly power are conceived as working in the same manner and achieving identical results"
> (Hogbin, 1964: 91).

Lawrence too has shown how the missionaries among the Garia have unwittingly reinforced convictions of the reality of traditional deities rather than undermining them (1987: 31).

One student gave an interesting account of how both traditional and modern beliefs may be relied on in the same situation:

> "To prevent your self with that types of magic. We sometimes usually use some of the custom medicine. It can only be cured if you have the faith fixed on that custom medicines. For example at our home we usually have some old men and women who used to cured the attack of magic. They collect some leaves and part of the skin of a tree and gave them to the person who was attacked by magic and if the person have the faith

> of it will be cured. then he will be cured in two or 3 days after it had started. In addition we usually prayed to God to drive out the magic or demons that attacked the person."
>
> (48/M/89)

About a quarter of the students gave more generalised reasons for a decline in the belief in magic, with references to "civilisation" or "modernity". It is not really clear what aspects of life they see as civilised or modern, but their comments carried the general idea of societies moving away from their old beliefs under external influences and magic is simply one aspect these old beliefs. Magic depends on the support of the whole complex structure of traditional society and so must decline as this structure is weakened.[2]

Only a small proportion (less than twenty percent) of the students' responses to "The Curse" explicitly referred to the spread of scientific knowledge or attitudes as a factor in the decline of magic. In this group, the majority referred specifically only to the growth and success of medical knowledge, perhaps because that was one of the key uses of magic in the story, or perhaps because that is one of the main areas in which a belief in magic is still very strong. Only two students made more general references to science. Neither of these two were Melanesian and both had been brought up in Honiara. The following was a particularly attractive way of making the point:

> "Nowadays many people have stopped believing in magic because I think now we are more advanced in science, so we have scientists to provide reasons for things that happen around us. In the olden days, any strange happenings would be immediately said to be magic but nowadays there is always a reason behind everything."
> (38/F/87)

The clear links between magic and the spiritual world, between magic and religion, have meant that belief in magic is less susceptible to attack from science than from Christianity. This point is further emphasised when we look at the students' personal experiences of magic, and the areas of life to which these apply.

10.6 Students' personal experiences of magic

The simple statistics are that out of 119 students who answered questions on "The Curse", 88 said they had seen or heard of instances of magic. Out of these, 49 stated (or suggested) that they had seen the particular act of magic they described, while 39 stated they had only heard of it. Other accounts were also obtained from interviews. Girls were much less likely to have seen or heard of examples of magic than boys: 20 out of 49 girls had not seen or heard of acts of magic. This fits in with the clear impression obtained from interviews that girls have much more restricted social experiences than the boys. They simply do not have the opportunities to see or hear about events. The girls also, however, tend to be much more strident in their denunciation of magic as either "uncivilised" or "un-

Christian". Whether this is a consequence of their lack of first-hand experience of it, or whether this attitude prevents them accepting any occurrences as being due to magic, it is difficult to judge.

A wide variety of "applications" of magic were described, but the majority of examples that actually gave details fit into four groups: love magic, sorcery, curative magic and "conjuring". The first of these was more often described by boys than girls and only one girl actually claimed to have seen it in action rather than just hearing about it. It always acts on the girl to bring her to the boy, not the other way round:

> "Yes. I saw one boy back home who has this magic of making girls attracted to him. He said some things which I haven't heard before and called the girls name. The next day he went to see the girl which he knows but doesn't have a relationship. He put something in a P.K. chewing gum and gave it to the girl. The girl cried and came to his house that night."
> (52/M/87)

Another magic commonly described is that used for curing illness. Sometimes this acts simply to cure the afflicted person, but often its purpose is to seek out and take revenge on the person assumed to be the cause of the illness, since illness which responds to magic was almost certainly caused by sorcery itself:

> "Yes, just last week when my father suffered of a strange sickness the doctors could not even tell, one of our villagers came to cure him and he was cured. Next what he did was to reflect the illness to whosever the killer is by cooking a root on fire. Few days later we saw the man suffering from his own custom."
>
> (06/M/87)

The converse of this is of course magic used to cause sickness, or, more commonly, death:

> "Yes, I have known one example of someone using magic. He had cast a spell on a young lady. The spell is to curse the lady to have a very bad illness and can eventually die. In fact the young lady got a disease in which the doctors couldn't cure her. She even tried custom medicine but it's not worthwhile. Consequently she died after suffering for almost a year."
>
> (17/F/87)

Taking sorcery and curative magic to be two halves of the same process, they constitute together by far the largest category of magic that the students had experienced.

The final category can be labelled as "conjuring" because it seems to be magic with no definite purpose, merely an exhibition of magical powers.

> "Yes, a man from Malaita named Sudea. I know it was magic because he can cut his belly and get out his internal systems and put them back and the cutting will be healed. Moreover, he can get his eyes out and put them back again."
>
> (18/M/87)

What is interesting about these acts of conjuring is that the students accept them at their face value, as genuine acts of magic rather than sleight of hand. They are the standard sort of conjuring tricks - making objects disappear and re-appear elsewhere, for example - of "magician" entertainers all over the world, but these students live in a society in which magic is still acceptable as an explanation and they are quite prepared to see these tricks as magic.

Clearly, the major uses for magic are in dealing with the crises of life: sickness, death and, for adolescents at least, sexual conquest. This is as it always has been, as earlier references to Malinowski's writings illustrate, but perhaps the range of crises demanding the use of magic has been reduced. Largely gone, it seems, are the rituals, recorded as prevalent until quite recently, related to agriculture, to fishing, to the weather, or generally to ensuring the successful outcome of any venture (Hogbin, 1939, 1964). Isolated instances of old men who could disperse mist, control fish or bring rain were mentioned in the students accounts but these are clearly now very rare. Have these practices really gone, or have they simply been transformed? Have science and an associated materialist rationality replaced the need for intervention by spiritual powers in these areas, or has there simply been a change in the name of these spiritual powers? Perhaps the original unity of magic, science and religion has been fractured; but what are their present domains and powers?

10.7 Magic, science and religion: the balance of belief

The point made earlier about the relationship between magical practices and traditional religions needs to stressed. Magic never was a distinct set of practices to be distinguished from religion and science (Lawrence, 1987:20-21). Magic was a way of manipulating those forces that were the domain of the spirits that were themselves the centrepoint of religious belief. If Keesing is right, then even the everyday practices that Malinowski declared were the sign of a belief in the ultimate rationality of much of existence did in fact take place within a context of the permanent presence of ancestral spirits. For Malinowski the spiritual world and the concrete worlds of farming and fishing were distinct; for Keesing's Kwaio, the one world is as real as the other - indeed, they are both the same world:

> "... a world where one's group includes the living and the dead, where conversations with the spirits, and the signs of their presence and acts, are part of everyday life. ... No child could escape constructing a cognitive world in which the spirits were ever-present participants in social life, on whom life and death, success or failure, depend."
>
> (Keesing, 1982: 2-3, & 38)

Even the educated may still adopt a matter-of-fact approach to dealing with spirits that accepts them as part of the everyday world, as this excerpt from a discussion with a Form 5 girl reveals:

JL: If you want to appeal to these ancestors, either for help or because you want to do magic to someone else, how would you do it?
SS: You can just ask them. ... Just go to where they buried them and ask.
JL: You go to one of the special places, though?
SS: For the ancestors of long ago you can go to the places where they keep their skulls. Or if it's just a recent one, then you can go to their grave. Then you can just ask for anything you want and they will give you.
JL: So, you just ask for it?
SS: Yes.
JL: You don't have any special ceremonies?
SS: No special ceremonies.
(27/F/88, 8/9/92)

It must be recognised, however, that Christianity has not only attempted to prohibit the practice of magic and communication with ancestral spirits but also reduced the need for it. The Christian God is clearly seen by most of the students as a more powerful source of assistance and a greater protection from harm than the powers behind custom magic. No reason is given for this belief beyond the fact that it is "known" to be true. These children have been brought up in a society in which the Churches have considerable social power and the priests and pastors hold a very respected position - generally all referred to as *Mama*, a traditional title of great respect. They are under great social pressure to believe in the truth of it all. One can, of course, speculate on why the Christian Churches were able to establish such a position and perhaps the association between the technological superiority of "the whiteman" and his religion was important, but that is not really relevant to the present generation of young people[3]. In fact it seems more likely that today the Church is seen as not only distinct from science and technology, but even somewhat opposed to it. Certainly the automatic association between Christianity and the whiteman must be weakened with the presence of so many expatriates clearly seen not to be church-goers, nor in any way associated with church missions. A large amount of Christian fundamentalist literature attacking areas of modern science (particularly evolution, of course) circulates in Honiara and was often been brought to me by my students for an opinion.

It would be wrong, however, to suggest that the K G VI students all feel there are particular conflicts between science and religion, largely because contentious issues such as evolution are not part of the science course for most of them. A great majority of students replied in the negative when asked if they felt there were any conflicts or contradictions between their religion and the science they had been taught. Nevertheless, some of the more senior students that were interviewed were aware of issues in which such conflict might be found. For many of these there was just an unresolved conflict, but those who had come down on one side or the other tended to reject evolution in favour of the biblical version of creation. One of my best science students, explained that she "understood" evolution and accepted that scientists had evidence for it, but she did not "believe" it because it conflicted with the Bible. This may represent the views of many. Religion is the framework in which the students' belief systems tend to operate; science can be accommodated as long as there is no conflict - and generally there is not - but it does not achieve the same status as religious truths. Whiteman comes to the same conclusion about Melanesians in general:

> "Melanesian epistemology is essentially religious. That is, Melanesians rely primarily on religious knowledge as their basis for knowing and understanding the world in which they live."
> (Whiteman, 1984b: 87)

It would be unsafe to be quite so dogmatic as this when referring to the K G VI students - a highly educated minority in Solomon Islands society - but the general tenor of this statement certainly applies.

In the same article, Whiteman also emphasises that "Melanesian religion is pragmatic and concerned with material results" (p97). This same pragmatic approach to belief has been emphasised by Keesing about the Kwaio (1982: 52-54) and Firth about the Tikopians (Firth, 1940). (Although Tikopians, while inhabitants of the Solomon Islanders and represented among K G VI students, are Polynesian, not Melanesian.) This emphasis on practical outcomes might seem to favour science over both religion and magic as the dominant form of knowledge, but this is not always true. A group of students who firmly believed in the power of custom magic informed me that a magic spell will always work as long as it is performed correctly; if it were not so, they would not believe in it. The same group explained that the Christian God is more powerful than custom magic, but a complication arises here in that God has the option of responding either positively or negatively to a prayer. Ancestral spirits, they maintained, must respond in the desired way when appealed to, but the Christian God is not so obliged. This of course serves to emphasise the omnipotence of God: he cannot be manipulated by human beings, but makes his decisions based on the morality of requests. Hence the failure of appeals for action through prayer is seen to reinforce the power attributed to God, not weaken it. All that is needed are a few instances in which prayer is seen to achieve desired results to confirm belief in its practical powers.

This is exactly the same state of affairs which will weaken the acceptance of science as a universal truth system. Scientific knowledge, justifiably or not, claims to be correct - as it is presented in school at least. If this claim is true, science must always achieve the desired results. A single failure is enough to negate this claim since, unlike the actions of God, the actions of science do not have the options of distinguishing between the moral and the immoral. It was suggested earlier that the failures of scientifically based medicine to cure all ailments leaves an opening for the acceptance of alternative treatments and explanations. The widespread effectiveness of scientific medicine is accepted but it does not eliminate the belief in both traditional explanations and cures on the one hand and the power of prayer on the other. Somewhat paradoxically, it is in medicine that both the success and the fallibility of science are most clearly observed by the people of Solomon Islands.

It might appear that science and magic should both suffer from this weakness of disproof by a single failure. Both may even respond to failure in the same way: if a magic spell fails it is either because the ritual was not followed correctly or because of interference from other magic; when a scientific experiment fails to give the expected result, either the procedure was at fault or there were extraneous influences (friction and heat losses are common saviours in school laboratories). For the majority of people, as Lawrence (1987) has pointed out, the explanations given by the sorcerer are comprehensible and fit with their view of the workings of the world. When the scientist does give an explanation for failure it is likely to be in terms that are difficult to understand. In school laboratory experiments at least there is a tendency to assume a simplified model of reality so as to avoid these complexities, which may, for example, be aspects of science yet to be covered on the syllabus, but these may then be the very things which catch us out.

Ultimately then, magic has the advantage over science in that its interpretation of the workings of the world as being, in the final instance, under spiritual control is supported unwittingly by the teachings of Christianity. The original unity of Melanesian intellectual activity in a religious idiom has become somewhat dichotomised. Magic remains still essentially linked with religion while science has been separated off and perhaps left in the weaker position of the two camps through its divorce from the Melanesian heritage of the predominance of religion.

Science suffers from a further weakness in its acceptance of its own incompleteness: it does not claim to give the answer to everything, whereas magic is a complete worldview:

> "Magical or witchcraft explanations will answer questions that science leaves unanswered. Thus, the development of science and technology will not alone result in the disappearance of magic. Magic will disappear only if persons accept the scientific worldview, including its incompleteness, but this involves a conversion that cannot be assured by the empirical disconfirmation of magic or the advance of science."
>
> (Sharot, 1989: 277)

Thomas (1971) makes a similar point in accounting for the decline of magic in England. He considers the claims of social, technological and intellectual forces in bringing about this decline and points out that the widespread rejection of magic preceded many crucial scientific and technological developments - notably in medicine. He concludes that an intellectual change is the key to the demise of magic. Now Thomas's extended parallel between England of three or four centuries ago and present-day developing societies makes several very pertinent points of comparison, but on this crucial matter of the chronology of these various counter-magical influences, the comparison breaks down. New religions and new technologies effectively arrived simultaneously in Solomon Islands. Undoubtedly this new technology did much to reduce the practice of magic. It seems likely, however, that the opportunities for the intellectual changes that both Sharot and Thomas see as important for the rejection of magic only became available with the somewhat later introduction of Western humanistic education, and perhaps even then only for those who followed this education beyond the minimum levels. If a "critical mass" of intellectual change is necessary to precipitate a widespread desertion of magic, this may be some way in the future, and it may be unwittingly hindered by the amalgam of Christianity and traditional religious beliefs that has developed.

In the meantime, magic will still be resorted to in those crises of life which science does not address. Science and technology are accepted as valid in their appropriate spheres, without the need to adopt a scientific worldview. Hence, these K G VI students will continue to perform well in science examinations when that is what they are faced with, but, in the Melanesian pragmatic tradition, will turn to other sources of understanding when they feel the situation demands it. Perhaps, as science teachers, we should be satisfied with this. Perhaps we have no right to demand anything more.

CHAPTER 11 SUMMARY AND CONCLUSIONS

The aim in this thesis has been to search for social and cultural influences on various forms of response to science shown by the King George VI School students. With the origins of the thesis very much lying in practice, there is also a concern to examine implications for that practice. The purpose of this chapter is to review the influences that have been identified and to suggest some implications that they hold for the teaching of science. A further intention is to propose potential future research concerns in the light of the findings of this thesis. (In this chapter, references to earlier parts of the thesis are abbreviated to the relevant chapter, or just section number, in brackets.)

11.1 Between-student comparisons

Two factors have emerged as being of particular importance in the between-student comparisons: gender and urban/rural experience. This chapter will begin with a review of the significance of these two factors across the range of responses that were investigated.

11.1.1 The importance of gender

The effects of gender on achievement in school science are simply summarised. On average, girls achieve significantly lower than boys, at all levels from Form 1 to Form 5. The girls' performance in biology is relatively better than their performance in physical science, although in absolute terms the boys out-perform them in both areas. This situation alters little as the students progress through the school (Chp 4).

Two possible types of explanation for this pattern were investigated: one in terms of a particular cognitive skill - mechanical reasoning - and another in terms of attitude and interest.

The first of these investigations revealed that mechanical reasoning did correlate positively with science achievement, particularly with achievement in physical science, but generally more so for the boys than the girls. Furthermore, the boys' superior achievement in science was echoed in their consistently higher scores in mechanical reasoning. It was clear, however, that mechanical reasoning could not be taken to be a sex-linked, innate ability, since both boys and girls showed considerable improvement as they went through the school (Chp 5).

The interpretation of these findings that is most convenient for the science teacher is that mechanical reasoning is a cognitive skill relevant to the understanding and manipulation of scientific concepts, and that it can be improved through exposure to mechanical devices. The attractiveness of this interpretation to the science teacher is that it suggests a simple strategy for improving the performance of the girls in science: increase their exposure to mechanical devices and give them greater manipulative experience with simple tools and machines.

Apart from the fact that it makes the classic error of assigning causality on the basis of correlation, there is another important criticism to be made of this interpretation. This is illustrated by taking one example of transfer from experience to the mechanical reasoning test performance that was suggested in the account: the greater understanding of the relative motions of two inter-connected wheels that was shown by the girls, and the rapid development of this understanding shown by the rural girls (5.6.2). It was suggested that this may have been the result of using sewing machines in the school. If this is the case, then the point to be made is that the girls were not just exposed to a particular piece of machinery, but were exposed to it in a context that they perceived as meaningful, judging from the relatively common comments by the girls on the relevance of home economics to their anticipated futures. Thus it may be that increasing the opportunities for the girls (and the boys too) to use and manipulate mechanical devices will only develop mechanical reasoning skills if those opportunities are seen to have personal relevance.

But this sort of discussion brings us to wider questions of perceived relevance, meaning and interest which may provide the link between science achievement and mechanical reasoning skills. The link may not be a causal one but simply one that arises from both of these outcomes being related to personal perceptions of what is relevant and meaningful.

The data in this thesis on attitudes towards and interest in science are quite complex when analysed in terms of gender differences. There are similarities, but no exact parallels, between patterns observed in attitudes and achievement. Both boys and girls have similar images of scientists and the nature of science (6.4). The image of a scientist is such that one might expect it to deter the girls in particular from an interest in science. It is clear, however, that the students distinguish between the pursuit of scientific knowledge and that knowledge itself. Scientific knowledge is almost universally accepted as useful, or potentially useful, at a national level. The differences occur in the extent to which it is regarded as personally useful or relevant, and in which topics are considered to be of interest or personal significance. Both boys and girls expressed great interest in biology, notably but not exclusively human biology and related topics such as disease. Some interest in physical science exists among both boys and girls at Form 1, although to differing degrees and often in different topics. This interest tends to decline quite rapidly among the girls but to develop among the boys (7.2). Both boys and girls, however, profess a similar degree of interest in and enjoyment of science lessons in general, giving broadly similar reasons for this interest and enjoyment. These reasons comprise various proportions of interest in the subject matter itself, its perceived usefulness, and an enjoyment of the variety offered by science lessons compared with many others, notably arising from practical work (7.1).

Neither boys nor girls commonly suggested the potential vocational usefulness of school science as a reason for regarding it so highly. This statement is only true for the girls, however, if one takes a narrow view of "future vocation" to mean paid employment. This was generally the way the girls themselves interpreted it, but they, almost all, also accepted that marriage and motherhood would inevitably form a part of their future (7.3). Here they did see a practical relevance for their school science, and this focussed entirely on the biology. For the boys, an interest in biology arises largely from a personal curiosity about their own bodies. With the girls, this curiosity is supplemented by an awareness of their future roles as guardians of family health and diet and, for rural girls at least, their role in farming.

Despite this, it is clear that there are parallels between the occupational aspirations of the students and their preferences in science. Although significant proportions of both boys and girls aspired to occupations that would make use of scientific knowledge, this almost exclusively meant biological knowledge for the girls, manifested as an interest in medical careers. Jobs making use of physics attracted boys almost exclusively. This gender-typing of the labour market is reflected in a common, but not universal, gender-typing of science into biology as feminine and physical science as masculine. There was some tendency among both boys and girls to label science in general as masculine, but this was a minority view (7.4).

The investigation of concept development among the students was neither envisaged as a possible explanation for differences in performance, nor was it primarily intended as a between-student comparison. Nonetheless, it does provide data that reveals gender-based differences. Whereas no noticeable differences were found between boys and girls in the nature of conceptualisations developed, the level of acceptance of scientific interpretations of concepts was much lower among the girls than among the boys (8.4, 8.5, 9.4.4). There is clearly a similarity here with performance, supported by correlations described above (8.5, 9.4.4), and perhaps this is no surprise. The development of acceptable conceptualisations could, after all, be taken to be a measure of scientific achievement. At this level of inter-student comparison, therefore, this difference in conceptual development in itself neither reveals anything new nor explains anything already known. It remains an observation to be explained, much as the differences in achievement do.

From observations of conceptual development among the girls, and the relatively larger correlation between their science performance and their primary school performance, it was suggested that science is much more of an academic activity and less of an aspect of the real "life-world" for girls than it is for boys (4.2.5, 9.6). This in turn brings us back to questions about the degree of contact between what is taught in science lessons and the students' life experiences - both present and anticipated future. Although these concerns may not be the only ones which open up opportunities for effecting change, it seems they must be dealt with if that change is to be significant and far-reaching, at least with regards to the gender-based influences described.

11.1.2 Urban/rural experience

Attendance at a Honiara primary school for at least three years leads to an advantage in science achievement at King George VI School over those who attended rural primary schools only, for both boys and girls (4.2.2). It appears to be the urban experience which is responsible for this effect rather than primary school quality, although the latter is important for selection to the school initially.

Other urban/rural effects were also observed, but some of these are gender-linked. Urban boys scored higher in mechanical reasoning than boys from rural schools, but this effect was not consistently observed with girls. On the other hand, rural girls improved their mechanical reasoning score with passage through the school more significantly than their urban sisters, but the same cannot be said of urban and rural boys (5.4).

Although urban and rural students were equally as positive about school science in general, there were differences in their topic preferences. Rural students showed a greater preference for biology topics over physical science topics when compared with students with Honiara primary school backgrounds. With one exception, however, these differences in preference were relatively insignificant compared with those shown in an analysis by gender (7.2). The exception was the greater interest shown by male and female urban students in finding out how engines work. This was interpreted as an interest arising from more immediate personal experience and perceived relevance of engines for those who live in the only settlement with significant traffic levels.

This sort of observation raises the question of just how an urban environment enhances performance. The evidence that it has the cognitive effect of improving mechanical reasoning ability is equivocal, in part because of its gender dependence. It seems likely that urban life offers the possibility of increasing mechanical or spatial abilities, but whether these possibilities become a reality or not depends on other factors. Experiences that are superficially the same may, in effect, be quite different for different students. It is the meaning of those experiences to the individual which determines their effect, not just their "objective" content. The individual must be receptive to the potential content of an experience because it makes contact with what is significant, or may be seen to be significant in the future, in the life-world of that individual. Thus, to be a girl may be a more important influence on responses to science than to live in Honiara. This is not necessarily because a girl in Honiara has less contact with the elements in urban life that may be important for aspects of cognitive development - which may be technological or may be related to the spatial geometry of towns - but because those elements are perceived to be of little relevance to the immediate existence and to the options for the future that a girl sees before her.

In these perceived possible futures we see clear urban influences. In simple terms, living in a town raises the occupational aspirations of the students and presents them with a wider range of options. This effect is, once again, significantly gender-linked, being much more noticeable with the girls than the boys (7.3). Urban life leads to a wider awareness of the range of occupations available, and also offers examples to the girls of women taking up these options. It is in Honiara that extension of the role models available to girls into new spheres is visible: women becoming pilots and electricians were examples quoted in interviews. In general, however, this does not extend, to mechanical and engineering occupations, which remain solidly perceived as male domains to both rural and urban students.

It should be noted that these interpretations of the "urban effect" seem to suggest that there is little the science teacher can do to effect changes. They rely on the presence of wider social pressures rather than particular pedagogical practices. Beyond the presence of the school in this urban environment, which it may be hoped would lead to some sort of influence through exposure, there might appear to be little that teachers can do. But this may be taking too narrow a view of the options available, and a later section will make some suggestions of just what action may in fact be possible to effect changes where they are seen to be needed.

Many of the observations made here about achievement, attitudes and aspirations are similar to those made in other societies, particularly those relating to gender-based differences. It seems likely that there are common elements in most societies which mitigate against girls' success in school science and against girls seeing large parts of science as relevant to their lives. These elements are almost certainly bound up with the low social and cultural esteem afforded to women, their lack of autonomy, and the expected dominance of child-rearing and family care in women's lives (see Brydon & Chant, 1989, for an account of how these themes persist across a range of otherwise dissimilar cultures). Once again, it may appear that the origins of these achievement and attitude differences in broad social or cultural forces may leave them beyond the power of the teacher to modify, but it will be suggested later that this is not entirely the case. Before that, however, an examination will be made of one area in the thesis in which inter-cultural, rather than inter-student, comparisons were the main emphasis.

11.2 The students' construction of concepts

A comparison of the understandings of concepts shown by K G VI students and those shown by students elsewhere reveals similarities and differences (Chps 8 & 9). An interpretation of this is that these understandings arise partly through common human physiology interacting with a common physical environment, partly through the influence of socially available sources of knowledge, and partly in response to school science teaching (9.6). The relative contributions of each of these sources will depend on the physical phenomenon in question, the individual student, and the social and cultural background.

Common elements are more likely to be found where perception dominates interpretation. Thus there is a similarity between descriptions of the processes in a burning candle given by Solomon Island and European children, especially the younger ones (8.4). Interpretations of the process of vision are perceptually dominated simply because they are interpretations of the process of perception itself. The same sorts of models of vision appear in different societies, although with different emphases, which may be traceable, in part, to shared sources such as the media (9.5).

Whether or not an individual moves beyond perception depends at least partially on that individual's response to the source of alternative analysis. The K G VI boys were willing to accept the model of burning offered in science classes for the interpretation of this common life-world event, but the girls were less so as school physical science remains largely divorced from their significant life-world. Notice here that it is not the significance of the phenomenon itself in the student's life-world which is important so much as the significance of the source of knowledge. The girls see physical science as a largely irrelevant concern and are unmoved by it outside its restricted jurisdiction of the science classroom or examination.

Where concept formation is influenced by socially available knowledge we might expect between-country differences to be greater. Thus, the understanding of the concept of "animal" develops through the need to establish shared meanings in language and within the constraints of a local ecology, leading to subtle differences between the Solomon Island understanding and that observed in Africa or in industrialised countries (8.5). Explanations deriving something from *kastom* may have an influence, but seem to be attenuated. This may be due partly to a general lack of concern in Melanesian tradition for explanations of normal natural phenomena (as opposed to events that were unusual or broke with expected order: Oliver, 1955; Stephen, 1987b), but it almost certainly also reflects the distance which exists between most of these secondary school students and traditional cosmologies. There is also a relative absence of alternative sources common in the more developed world: books, television, films, museums, parents with some science education, toys and science-based technology. These effects combine to increase the significance of school science lessons as a source of conceptualisation of the physical world.

This should not be interpreted as meaning that school will be more successful in Solomon Islands than in, say, Britain at getting students to accept scientifically "correct" conceptions. The limited data available, on interpretations of vision for example, suggest that success rates in this respect may in fact be very similar (9.4.4). There are two ways in which the influence of school science may act. The first is by providing the materials, the concepts, out of which the students can build their models of the physical world. Hence we find the increasing use of scientific terms in students' explanations as they go through the school; often used to construct "alternative" models, however, rather than those intended in teaching. The second influence from school science may be to encourage curiosity about accepted aspects of the world, suggest that there are in fact phenomena in need of explanation, and show that explanations are possible. Certainly, Form 1 students showed little evidence of having thought about the phenomena investigated here in terms of constructing any sort of explanatory model. Such models were generally built up slowly as the students moved through the school. There is an area in need of further investigation here. It would be useful to establish more clearly whether there are such general effects of schooling through a comparative study between secondary school students and those who complete only primary education.

Whether or not school science succeeds in establishing the intended scientific interpretations is a different matter from that of showing that it may have some influence, although clearly the latter is a prerequisite for the former. It was pointed out above that the high positive correlation between science performance and the acceptance of scientific conceptualisations suggests that the same sort of factors may be responsible for both, and it is these factors which must be addressed if both are to be improved.

11.3 Implications for practice

It is tempting when examining evidence such as that presented in this thesis for pointers to improved practice to seek out only the negative points, the weaknesses that must be corrected. One looks for evidence of influences that are inhibiting performance or producing negative attitudes and suggests corrective action. In doing this it is easy to overlook the positive findings, the influences that encourage an interest in and a desire to learn more about certain topics, for example. The intention here is to adopt a more balanced approach, making suggestions for countering negative influences on students' responses while identifying others that may usefully be built upon.

11.3.1 The aims of the science course

Before making any such suggestions, however, it is important to establish just what are the wider objectives towards which improved practice should be directed. This involves an examination in a Solomon Island context of some of the wider issues raised in the first chapter of this thesis. Is the aim of the school science course to produce specialists or to provide some sort of scientific literacy for all? If it is the former, what sort of specialists are required? If it is the latter, what are the form and purpose of this literacy? Is the aim to improve the mean level of scientific knowledge or to increase the awareness of the nature and potential of science? Is it to bring about a change in the students' worldview and the nature of their thinking? Or is it simply to encourage a more positive attitude towards science and technology? Most likely the intentions will be a mixture of all of these and more, and certainly the official view of the science curriculum is that it should suit both specialists and non-specialists, local needs and international criteria, be both complete in itself and a preparation for further study (Yager, 1993: 59-60).

With science being part of the compulsory core of secondary education in Solomon Islands up to Form 5, it is sensible to treat the course to this level as a 'science for all', with élite, specialist approaches to science postponed until Form 6 - broadly in line with suggestions argued by Fensham (1985). The case for this approach is particularly strengthened by the generally poor state of science education at the primary level. The fact that secondary school science is not in reality a science for all, since access to secondary school is very restricted, adds to, rather than detracts from the argument. Those who do reach secondary school will form the future élites in a variety of fields, scientific and non-scientific, making decisions and influencing development directions. It would be foolish not to provide them with a broad grasp of the power, purposes, implications and limitations of science in a small country trying to hold its own in an increasingly technological and scientific world.

11.3.2 Content emphasis

In discussing the implications for content selection of adopting a generalist science approach, Fensham (*op cit*) gives two criteria: content which has "social meaning and usefulness for the majority of learners", and content which allows learners to "share in the wonder and excitement" of science. There are strong indications that, among the K G VI students, these two criteria may be at least partially satisfied by similar content. For very many of the students, an emphasis on biology in the science course would clearly increase the relevance of that course and satisfy much curiosity, which can in turn provide a source for the wonder and excitement aimed at in the second of the above criteria. It seems that this strategy would also benefit the most disadvantaged students. A strong case can be made too that such an emphasis would satisfy important national needs in a country heavily dependent on its organic natural resources and also threatened with ecological damage through external commercial pressures on those resources.

Warnings by Millar and Driver (1987) about abandoning content in favour of decontextualised "process skills" are very relevant to the Solomon Islands situation. Quite apart from the very pertinent arguments that Millar and Driver put forward, based both on cognitive psychology and the nature of science, it was clear from the responses of the K G VI students that the content of the science course was a major source of its attraction. Personal relevance lies in the content not in the methods. This should not be taken as advocating a didactic approach to science teaching. An emphasis on content has been so often taken to imply such pedagogy, whereas there is in fact no reason why it should. Pedagogy has more to do with an attitude to the nature of knowledge than with the content of that knowledge. In the words of Millar and Driver (op cit: 56), an emphasis on content is important because:

> "The aims should be the development of a deeper understanding of the concepts and purposes of science. For science, we would argue, is characterised by its concepts and purposes, not by its methods."

This may perhaps be going too far in the opposite direction in its characterisation of science, but it does provide a useful corrective to the misrepresentation of science as pure method without content.

An emphasis on biology does not of course mean the exclusion of physical science, but the selection of physical science content has to be considered very carefully. The nature of physics as practised by a physicist tends to lead to an emphasis on basic principles and general laws, frequently reduced to mathematical abstractions. Similarly, chemistry tends far too rapidly to what appear to the students as abstractions, in the form explanations at the atomic level. The attraction of physics and chemistry for the majority of these Melanesian students, however, stems from two sources:

explanations of immediate and every-day phenomena and - in keeping with Melanesian pragmatic epistemology - the practical applications of knowledge. Thus, an interest in mechanics is an interest in machines and engines; electricity becomes a popular topic when it is approached from the point of view of applications encountered daily; and the chemistry course remains a mystery to many because it fails to show its purposes.

Perhaps it could be argued that a technology course would be more relevant than a physical science course, but this closing chapter is not the place to get involved in a detailed discussion of this point. A personal opinion is that a separate technology course, or technology as a part of a wider science course might be useful and popular, but there is still a need to get the message across that science is more than just technology. The application of science in technology may be a pedagogically useful place to start, and it may be advisable not to wander too far from such an approach, but there is a need to show and to raise an interest in the wider purposes of science in generating knowledge and understanding.

11.3.3 The value of practical work

A plea needs to be made for the pedagogical value of practical work in science. Although student practical work seemed to have become established as a core element in science teaching in the wave of curriculum development projects of the 1950s through to the 1970s, its role and its effectiveness became increasingly challenged throughout the 1980s (Kahn, 1990). One version of this attack on practical work in school science is represented by a World Bank document of 1986 (Haddad & Za'rour, 1986). This appeals to cognitive theory to claim that practical work is only important for pupils at the "concrete stage", or for "low ability students who depend on concrete experiences", but it is clear throughout that it is a concern over cost that is really driving the argument. School science laboratories are expensive and it would be convenient for an agency like the World Bank to demonstrate that they are, in fact, unnecessary for effective science learning. (Although there is a tendency for this paper to refer to "teaching", "transmitting" and "delivery", rather than learning.) Other criticisms of the use of practical work in science learning have, however, tended to stress the common misuse of such work rather than simply to dismiss it entirely (Wellington, 1981; Klainin, 1988; Kahn, 1990; Ware, 1992). They criticise the lack of direction and clarity of aims, as well as the over-optimistic aims and claims, of much that is done in school laboratories, but still argue for a central role for practical experiences.

The data in this thesis suggest that laboratory work is of value to the K G VI students on several grounds. First of all, it is clear that it contributes to the enjoyment of science (7.1), which can be a key to developing overall positive attitudes to the subject and to encouraging students to continue with science in higher education. That is to say, it is likely to be of value for both the future science specialists and non-specialists. But the students' comments made it clear that it is not just a "fun" element in practical work which they see as important. Practical work is important for bringing home to them that science is about the real world, the concrete world of their everyday experience. This gives the subject a pertinence and a meaning within the framework of traditional Melanesian pragmatic attitudes to knowledge.

Strong arguments can also be put forward for the cognitive benefits of practical work for students in developing countries. Kahn (1990) points out that schools must provide the experiences that are otherwise unavailable in the wider society. Ware (1992) puts forward two reasons why "hands-on" science may be particularly important to an understanding of science concepts, rather than just their memorisation, in developing countries. The first is that such concepts may be "counter culture" and hence in greater need of being anchored to a concrete, observable reality. The second derives from the fact that science is almost invariably being taught in the learner's second language in developing countries and the manipulation of the concrete may provide greater understanding than the uncertain translation of a relatively unfamiliar language (see also Strevens, 1976).

The responses of the K G VI students have shown that experience of handling equipment and materials and of translating scientific concepts into concrete examples is important for giving science meaning, and hence improving understanding. It seems likely that, if carefully planned, it can also do much to promote spatial and manipulative skills that may have suffered through the lack of such experience in out-of-school early childhood. This is a particularly important purpose to practical work in that it is likely to benefit the most disadvantaged of the students: girls and students from rural areas.

A point to be stressed, however, is one made by the more thoughtful of the criticisms of much contemporary school science practical work. Any practical work must have well-defined and realistically attainable purposes. It must be well planned and devised to meet those purposes. To rely on vaguely conceived notions of "discovery learning", or to assume that cognitive and conceptual development will occur simply through contact with science equipment is inadequate.

The organisation of laboratory work in a Melanesian school should take advantage of traditional attitudes towards discussion and consensus. Students are likely to be more at ease with small-group activities than with work carried out individually. Discussion and the production of conclusions by the group should be encouraged. Care must be taken over any public presentation of conclusions to the class, however, to avoid any hint of public "shame". Single-sex groups are likely to be more effective for the girls than groups in which boys and girls are mixed.

11.3.4 "Taking on society"

In the earlier summary of influences of gender on responses to science, the point was made that much of this influence works through attitudes engendered and encouraged in structures, practices and expectations of wider society, outside the school and certainly outside the walls of the science classroom. This may give the impression that opportunities for action to effect changes in these attitudes are largely beyond the reach of the science teacher, perhaps not his or her responsibility, and beyond his or her sphere of influence. But to think this way is to miss the way in which the school and the classroom is a microcosm of the wider society. This society reaches into the classroom and the practices in the classroom have effects beyond its walls. The teacher must see the actions, discourses and social relationships of the classroom as both a reflection of and a potential influence on those outside. This relationship between the classroom and society, or between the school and society, is clearly not a symmetrical one, and the teacher cannot realistically hope to "take on the world" within the classroom, but to accept the limited effects of one's actions is better than to ignore those effects. There is an urgent need for research into what actually goes on within classrooms in developing countries in general, not just in Melanesia. Ethnographic school and classroom studies have become common in industrialised countries but remain rarities from developing countries (King, 1989; and see Va'a, 1987, for one of these rarities in a Pacific country). Results of any such research must be made available to teachers (or, better still, teachers should be involved in the research) so that they may begin to see their actions as both narrowly pedagogical and more widely social in implication.

At the school level, specific action to counter gender effects must include the removal of the gender basis for the home economics/manual arts option. Both subjects should be made part of the compulsory core for all, for at least the first year or two of school. An attempt must be made to widen career aspirations among girls and rural students. Careers advice should not just be seen as something given in a student's last year at school, when stereotypes have already become established, but as a continuous process of consciousness-raising, aimed at breaking down stereotypes, and at increasing the awareness of all students of the range of occupations available.

Perhaps most importantly, there must be a conscious policy in the school to encourage a sense of independence and autonomy among the girls. They must be made to feel in control of their own lives. This would involve a critical self-analysis by staff of their own expectations of the girls and would certainly meet resistance from both inside and outside the school community. Sensitivity would be a key to success in this process. Confrontation and the appearance of making direct assaults on accepted social norms and traditions would probably be counter-productive, but it seems likely that it is through the development of the girls' sense of empowerment in their own lives that the most effective changes can be achieved.

11.4 School science and worldviews

In general terms, the evidence is that exposure to school science does not bring about a radical change in the K G VI students' worldview (Chp 10). They do not leave after five years of science with their understanding of the fundamental nature of reality totally altered. They do not accept all of the conceptualisations and explanations of science as replacements for those available from other sources. But then, it would be probably be very surprising if they did! Science cannot offer solutions to many important questions, and it would be wrong of us to pretend that it can. There are important issues in these students' lives, times that they may see as crises, in which science can offer them neither hope nor comfort. In such times they turn to traditional sources of insight, or to Christian beliefs which have, in many ways, succeeded in making contact with those traditions far better than science could hope to do. Science may be co-opted into their pragmatic worldview when needed for practical purposes, yet it still remains essentially outside it because of its non-religious nature (10.7).

What does seem to happen is that the students are selective in what they accept from science and when they apply it. Scientific knowledge and scientific analyses of phenomena have their domains, but there are other domains in which science does not apply. This is an observation which has been made in other cultures, and not only those in non-industrialised societies. Carey (1986) found just this effect in Zambia, while Solomon (1987) has pointed out how English school children may make use of scientific concepts when they realise they are operating in the world of school science, but then switch to an alternative set for "life-world" purposes. Teasdale (1990) has shown how this notion of separate domains has influenced approaches to Australian Aboriginal education. There the aim has commonly become one maintaining a strict distinction between the domain of school knowledge and that of traditional belief, through fear that the former will obliterate the latter. This is less likely to be the case in Solomon Islands, where traditional cultures are not in the position of being dominated by an alternative local but alien culture. Traditional culture most certainly has been altered by exposure to outside influences, and continues to be so, but school science does not seem to playing a major part in this process.

This notion of domains is an important one in interpreting the students' responses to science education. There is no active resistance to scientific knowledge on the part of these students. If anything, the contrary is the case. They are, in general, thirsty for education and willing to absorb whatever they can from school science lessons. Resistance occurs, but it is not an active resistance through conscious effort. Nevertheless, they must live and operate in a world in which there are sources of knowledge and interpretations that are contradictory. To compartmentalise the world into domains, each with its appropriate framework of understanding, is not perverse but an effective survival technique.

It may be helpful, in pedagogical terms, to be aware of and to respect the boundaries between domains. Although the point has been made that school science needs to make contact with the everyday life-world of the students if it is to be seen as meaningful, Solomon (1987) has suggested that this can also lead to difficulties. Learners may possess a set of concepts that they commonly make use of in familiar situations which conflict with the relevant scientific concepts, or they may have ways of thinking about such situations which differ from those encouraged in science. In such cases, there may be confusion as life-world concepts interfere with those of science. This, after all, is the basis of much of the recent constructivist analysis of children's learning. To abandon attempts to deal with these meaningful aspects of the students' lives, however, would be to throw out baby and bathwater, and some strategy is required to deal with this problem, if it occurs. Solomon herself suggests the need to provide the students with clear cues that enable them to shift from a life-world way of thinking about a situation to a scientific way, i.e. domain boundaries must be kept clear and well signposted. It can be argued, however, that one aim of science teaching is in fact to extend scientific approaches firmly into the learner's life-world, to break down domain boundaries. To decide on a strategy for use with any particular group of learners demands information both about the way in which they conceptualise the meaningful aspects of their world and the way in which they respond to different teaching approaches. It would be useful to establish some research into both of these matters in Solomon Islands, and indeed in other developing countries.

In practice, it does not seem to be so important to achieve a fundamental change in worldview if the intention is simply to improve achievement in school science. There was no evidence that such achievement is related to the adoption of a particular way of seeing the world. To paraphrase again one notable girl student: it is possible to understand without having to believe. If intentions are somewhat wider than improving performance - changes in attitude, perhaps - then one might hope for some shift towards a more "scientific" worldview, whatever that might be taken to mean. But one should be realistically modest about what can be achieved at this level, in four hours per week.

School science does make inroads into other domains and does bring about changes in the way the students interpret the world, but the process, at best, is one of slow accretion, not of sudden and radical change. Once, after teaching Archimedes' Principle to some Form 5 students, I set them a question about why it might be dangerous for a fully-laden ship to sail from salt water into fresh water. One boy, after answering the question correctly, added this comment:

> "That reminds me of an incident in S. Malaita. They loaded their canoe with copra to take to a ship in a big river nearby. When their canoe sank they said that it is the people who were jeolous (because of the money they were about to get,) made the devil sank their canoe. Now I can understand the real reason why it happened."
>
> (21/M/87, 7/5/91)

This student did not undergo a sudden conversion on gaining this insight, but that can surely never be a realistic intention of science teaching. This particular incident nevertheless indicates a successful piece of learning that arose through making contact with a meaningful part of the student's world. A modest success in itself, but perhaps just the sort that we should be aiming for and willing to accept.

CHAPTER NOTES

Chapter 1

1 Perhaps changes in the tone and concerns of World Bank publications on education are as clear an indicator of this process in action as any. See, for example the emphasis placed on the quality of learning by Lockheed and Verspoor (1991) in their review of the potential for improvement of primary education in developing countries, and their criticism on the earlier stress on numbers, enrolment rates etc. Similarly, the Jomtien concern with quality and effective learning can be contrasted with the UPE calls of the 1960s and 1970s.

2 As indicated in this chapter and elsewhere in the thesis, the term "constructivist" can be applied to a wide range of theories of learning, including that of Piaget (e.g. Driver, 1983: 51). It will generally be used in this thesis in the way in which it has become understood in recent science education literature: to apply to post-Piagetian ideas which are concerned with the way in which understandings of physical concepts met in formal education are heavily influenced by existing conceptions of the world, built up through personal experience of it. They are epitomised by the writings of Rosalind Driver and Ernst von Glasersfeld.

3 Joan Solomon (1993) suggests that the choice of terminology reflects a framework for analysis of children's ideas. "Alternative conceptions" is favoured by those who sympathise with the children-as-scientists notion inspired by Kelly's Personal Construct Theory (Kelly, 1955). Those who use the term "misconceptions" are generally more concerned with the difficulties children have with school science, and how these may be overcome.

4 It is interesting to note that Lumsden & Wilson (1981) and Hallpike (1979), though working in entirely different traditions, both emphasise the co-evolution of culture and cognition - although they also treat the two as being distinct from each other.

5 To provide a balance to this opinion of one famous scientist, it is worth giving that of another, yet more famous, Albert Einstein, who declared, "Common sense is nothing more than a deposit of prejudices laid down by the mind before you reach eighteen" (Mackay, 1991: 80).

6 Note that although Kelly's theory is a <u>Personal</u> Construct Theory, this does not mean that he was unaware of cultural influences on the individual's constructs. He does in fact advocate "gaining access to personal constructs through the study of the culture in which they have grown" (Kelly, 1955:

179), but this point has not always been given the weight it deserves by later constructivists who have taken on board his ideas.

[7] Einstein's knowledge of physics was undoubtedly better than his knowledge of the history of science, but the importance of the Greek natural philosophers in the development of science has been made by others too, and it is their development of geometry, with associated logic, which has been stressed in comparison with the arithmetical and algebraic development of mathematics in the East. Dorn (1991), however, has suggested that one of the chief distinctions of Greek science was its essential uselessness compared with the emphasis on application in Mesopotamian, Egyptian and Chinese science. This, in turn, he relates to differences in the economic and political structures of these various societies.

[8] This heritage is also shared by Islam, and the Koran makes essentially the same point as Genesis: "all that is in heavens and on earth are made subservient to man" (Hassan, 1981: 193). Hassan also argues that Islamic absolute monotheism provides a further spur to scientific discovery through its total demythologisation of nature - a process begun under Judaism. This finds an echo in Weber's "disenchantment of the world", in modern society (Gerth & Mills, 1946: 155)

[9] I am aware that this is an idealisation of much real scientific practice and in particular that tradition and authority do play a role in at least the initial attitudes to new scientific ideas through the existence of dominant "paradigms" and a scientific establishment (Kuhn, 1970). For the purposes of the point being made, however, I feel this idealisation is acceptable. One could even use the framework being discussed here, of cultural interaction, to analyse the actual practice of science in terms of an interaction between the idealised culture of science and the everyday culture of common sense, and the society in which the science is practised.

[10] Although, perhaps under pressure from the disappearance of "pure" cultures, there seems to be a move away from this position. See, for example, the collection of essays edited by Carrier, 1992.

Chapter 2

[1] Bray & Packer (1993: 169) give a figure of "over 80 vernaculars", but this probably includes dialects.

2 See, for example, Chowning's criticism of the claim that Melanesia is characterised as a region in which women have particularly low status (Chowning, 1977).

3 cf. Vanuatu, US$ 1120; Papua New Guinea, US$ 820

4 The Seventh Day Adventist Church decided to forego subsidies and kept its secondary school, Mbetikama, near Honiara, under its total control.

5 In practice, one or two PSS had already started Form 4 by 1991, although this seemed likely to lead to administrative complications since PSS are under provincial government control, not central government as NSS are.

6 The SDA school at Mbetikama also had Form 6 students but they were considered to be outside the system, and were not eligible for government scholarships for tertiary education. This situation was changed in 1991, when the Mbetikama sixth-form was accepted as part of the overall pool and could be considered for scholarships.

7 Although the Enrolment Survey includes a brief review of data from previous years, its most detailed figures are for 1988. These can be used to compare the claimed 1988 Standard 3 enrolments with the 1986 Standard 1 figures from the National Census, Standard 4 with Standard 2, and so on. When this is done, the 1988 numbers are always significantly higher than those of 1986, with one exception:

1986 & 1988 Primary Enrolment Numbers

1986 enrolments (Census data)		1988 enrolments (Enrolment Survey)		change, '86 to '88
Std 1	7367	Std 3	7870	+503
Std 2	6249	Std 4	6803	+554
Std 3	6139	Std 5	7047	+908
Std 4	5801	Std 6	5789	- 12

Whereas a decrease in numbers would have been easy to explain, in terms of drop-outs, and is probably to be expected, this increase is puzzling. The two data sets have been collected by different methods: the 1986 figures were given by the families of the pupils, while the 1988 figures were from school returns. This may provide a clue to the origins of the differences, but any explanation must be speculative. The 1986 figures show a trend in the form of a continuous decrease from Standard 1 to Standard 4, which could be explained by increasing enrolment rates and population growth over the years, and by dropping-out; but no such easily-explicable trend appears in the 1988 figures. Figures for "repeaters" are given elsewhere in the 1988 data, and these do not account for the unusual pattern. There are other reasons to be suspicious of the 1988 returns. They claim to reveal, for example, that primary school enrolments increased by 25% in one year - an increase that it would surely have been difficult for the system to absorb.

8 The 1982 Education Statistics Bulletin for Solomon Islands suggested assuming that children may initially enrol in primary school at the age of six, seven, eight, or nine and the simplest model would have one quarter of all children enroling at each of these ages, if the enrolment rate were 100%. Assuming no drop-outs, we would therefore expect the following proportions of each age to be in primary school:

Age, years	6	7	8	9	10	11	12	13	14
% in school	25	50	75	100	100	100	75	50	25

The modified reference population would therefore be taken to be 25% of those aged 6 or 14, plus 50% of those aged 7 or 13, plus 75% of those aged 8 or 12, plus 100% of those aged 9, 10 or 11. The actual weighting used can be adjusted according to the observed enrolment pattern, but adjustments of the above ratios were found to make little difference in Solomon Islands. (Solomon Islands Government, 1982)

9 The "Education for What?" report of 1973 had set a target rate of 77.6% by 1986 (Bugotu, *et al*, 1973: 130-132). Note that this target had effectively been met by 1981, but ground had been lost by 1986. In fact, if the 1984 figures referred to earlier are correct, there had been a massive deterioration in the previous two years. The 1973 report was optimistic in both over-estimating the likely growth in primary school places and under-estimating the population growth.

10 To give an accurate picture of the position of girls in the primary schools the proportion of primary school pupils that are girls must be compared with the proportion of girls in the whole population. The ratio of these two proportions gives a relative enrolment factor (REF), which will be unity if girls are as well represented in schools as they are in the population at large, greater than one if they are better represented in schools and less than one if they are under represented. The table below gives the proportions and the REF for each province and for the country as a whole. In this table, the percentage of females in the general population is calculated for the six to sixteen year old age group. This age range covers the majority of those in primary school and using it rather than a wider range reduces the distorting effect caused by the migration of young men in their late teens to Honiara and Guadalcanal in search of work.

Representation of females in primary school, by province

Province	Proportion of females, % 6 - 16	Primary sch.	REF*
Western	47.8	48.3	1.01
Isabel	48.3	46.2	0.96
Makira	48.6	46.1	0.95
Honiara	48.7	44.6	0.92
Guadalcanal	47.5	43.4	0.91
Temotu	48.5	43.4	0.89
Central	47.3	41.5	0.88
Malaita	47.8	40.3	0.84
All Provinces	47.9	44.3	0.92

$$* \text{ REF} = \frac{\text{Proportion of school population that is female}}{\text{Proportion of 6-16 population that is female}}$$

11 A third, minor point to be born in mind is that Malaita Province comprises not just the island of Malaita itself, but also the small, remote, Polynesian outliers of Ontong Java and Sikaiana, where enrolment rates are likely to be low. These islands contribute only about 2% of the province's population, however.

12 When a new Provincial Secondary School was built at Ruavatu on Guadalcanal in the late 1980s, it was given two dormitories for boys and one for girls. The existing ratio of 2:1 seems to be officially accepted, if not condoned.

13 The importance placed on religion is also evident from the 1973 committee's recommendation that the proportion of time allocated to religious instruction in primary schools be increased from 4% to 10% (Bugotu, *et al*: 52-53)).

14 Although all secondary schools benefited from the large World Bank/AIDAB Secondary Expansion Project which included the supply of considerable amounts of equipment, particularly items useful in the junior forms.

15 There was considerable frustration among many science teachers in 1992, when an overseas-funded science curriculum development project was mooted. The frustration arose because criticisms were made of the existing curriculum. The science teachers were quite aware of the defficiencies, but had been unable to do anything about them due to restrictions imposed on course alterations which ultimately arose from financial constraints. Now that finance for a radical change might become available, the locally-based teachers were considered unsuitable for effecting this change since they had not changed the previous, inadequate syllabus!

16 Arising from the "Education for What?" report and the establishment of the Solomon Islands School Certificate to replace the Cambridge Overseas examinations.

Chapter 3

1 The school was only able to achieve this rate of boarding among the girls by allowing considerable over-crowding in the girls' dormitory, whereas there was adequate dormitory space for 100% boarding among the boys if necessary. It was sometimes necessary to offer some girls from Honiara primary schools a place in Form 1 only on condition that they be day students, at least for the first year. On the other hand, there were students from Honiara who chose King George VI School because they wanted to continue to live at home and not board. This was generally more common among girls than boys, and was probably as much a decision of the parents as the children, based sometimes on a mistrust of school supervision, and perhaps sometimes on a desire to keep the girls at home, where they could be useful with domestic labour.

2 In the case of Pawa, assuming "not stated" cases are mostly subsistence farmers, this proportion, at over 70%, is close to that in the country's population as a whole - see section 2.2, previous chapter. In view also of the relatively high proportion of girls at Pawa, it could be claimed that this school is the most representative of the Solomon Islands population at large.

3 An interesting example of the division of labour along gender lines occurring almost automatically was provided on the occasions that I accompanied mixed groups of students on expeditions, as part of the Duke of Edinburgh's Award Scheme. On arrival at a camp-site, without any discussion, the girls would set to to make a fire and prepare food, while the boys built the shelter for the night.

4 Although he contrasts this with the free association allowed between brothers and sisters among people on the north coast of Guadalcanal.

5 It should be noted, however, that the school rules on physical sexual relationships were very severe, by Western standards, reflecting the puritanical attitudes of Malaita more than anywhere else in the Solomons. (In at least some parts of Solomon Islands other than Malaita, it seems that sexual mores were traditionally less strict: Scheffler, 1965: 78-79). For a boy and a girl to be found alone together in a "remote" part of the school, especially after dark, was enough to merit their expulsion, no proof of sexual acts being necessary - an offence known colloquially as "dark-cornering".

Chapter 4

1 The survey used data from schools in Isabel, Western Province, and Honiara. As an example of differences in provision of facilities, 100% of Honiara schools examined had a radio, compared with 51% and 64% for Western and Isabel Provinces respectively. Western Province had 34% partially-trained or untrained teachers, and Isabel 38%, but the figure for Honiara was only 10%.

2 One effect that arose from combining different cohorts was to reduce the percentage of variance in the science scores accounted for by any given set of relevant predictor variables. Thus, for example, about 50% of the variance in science score for the 1990 cohort was "explained" by four variables, whereas the same four accounted for only about 30% of the variance in the combined cohorts' scores. Similar results were observed when other cohorts were analysed separately. There are clearly "cohort effects", arising from differences between the composition and experiences of different cohorts, which are lost in the process of combination

3 A substantial amount of data on the students' performances in Piagetian-style tasks was in fact gathered. This has not been presented here, partly for reasons of space and partly because it was broadly revealing patterns that have been commonly observed elsewhere, but also very largely because it was found that a Piagetian approach was not producing any useful insights.

Chapter 6

1 "Science is the most important subject in the curriculum" is presented as a belief statement while "Science is as important as the 3R's" is presented as an attitude statement on the same diagram. (Shrigley, Koballa and Simpson, 1988: 670)

2 There is at least a worrying hint in the 1988 article by Shrigley, Koballa and Simpson of the notion that attitude <u>must</u> predict behaviour and, if necessary, the definition of attitude must be modified to incorporate this "essential" link.

3 "Scientific attitudes" is yet a third category which is not a concern here: see Gauld & Hukins, 1980, for a review of this topic.

4 Maddock (1980), investigating the attitudes of students in Papua New Guinea, concluded that attitudes towards science generally continued to become more positive with more schooling, rather than tailing off after the early years of

secondary school. The attitudes he was investigating, however, were not entirely comparable with the other investigators cited, tending to fall somewhere between "attitudes to science" and "scientific attitudes". He also found little or no relationship between his attitude scale scores and achievement.

[5] As a point of interest, Rennie and Punch found that their notion of affect was "related more strongly to previous than to subsequent achievement", suggesting that the uni-directional treatment of the attitude-behaviour link may indeed be too simple.

[6] Interestingly, Gardner (1985), making the same observation about research into the related area of interest in science, sees this methodological predominance acting in some countries as a cultural inhibitor of research into interests: "Cultural, because research on interests is embedded in a psychometric, logical-positivist, empirical approach to educational research which is not universally shared" (p 16).

[7] The linguistic and cultural problems can be exemplified by just one item taken from such a scale devised for use with American adolescents: "It's neat to talk to my parents about science" (Misiti, Shrigley & Hanson, 1991).

[8] Schibeci (1984) considers "developing nations" as one of the few areas for which the development of new attitude scales can be justified.

[9] Perhaps the most legitimate comparison which can be made is between the scores obtained by the same individuals on the same test administered at different times. For this reason, this technique is particularly useful for longitudinal studies of attitude development, or for assessing the effectiveness of some form of intervention (as, for example, in Kelly, 1986). This was not an explicit purpose of the research into attitudes carried out with K G VI students.

[10] Several students clearly welcomed this opportunity to talk about problems they were having with subjects, particularly when parts of science were causing them problems. This willingness to talk increased the sense of confidence that there comments were truthful and reliable.

[11] One weakness with the scales was the low discrimination indices of some items. In some cases this was undoubtedly due to poor item quality, with many students choosing the "I am not sure" option, and these items were weeded out or improved during initial trialling stages. Another cause, however, was the general popularity of science, which skewed the responses towards the positive attitude end for many

items. This can be seen as a problem arising from having such a restricted population for the scales.

Internal consistencies as high as 0.70 and 0.74 (Cronbach's alpha) had been obtained for the national value and personal enjoyment scales, but only 0.58 or 0.59 for the others.

[12] This quotation is particularly interesting because it comes from a girl who did very well in science and was a very original thinker. She one day confided very tearfully to me that she was treated by both boys and girls as being rather "strange". She felt this was because she was a Melanesian girl who was so very good at science. She went on to study medicine at university and told me later that she would really like to go into bio-medical research. One can wonder whether her exalted image of a scientist in this quotation acted more as an encouragement than a deterrent.

[13] The original purpose of this exercise was to see whether the students did actually associate particular personal characteristics with people involved in occupations that demanded scientific knowledge. Follow-up interviews suggested that, although some useful information might be obtained this way, it was largely failing in its main purpose. The reason for this seemed to be that the students did not associate character traits with occupation at all strongly, and were allocating people to occupations largely on the basis of gender and age, coupled with a lot of random choice! For the "pure science" jobs, however, there was a tendency to choose someone who would not have distractions such as a family or a social life, because it was felt that the work would take up so much time.

[14] It was with this potential for the school to influence, and the shortage of external, especially local, sources of images in mind, that the Science Teachers' Panel produced a booklet entitled "What is a Scientist?", as part of the Form 1 course materials. This book contained photographs, brief biographies and descriptions of the work of a number of Solomon Island men and women engaged in scientific or technological occupations. The explicit aim was to provide examples of the wide applicability of science and possible role models for the students. This had been introduced too late for any effects that it may have had to be investigated as part of this research.

[15] This total is particularly impressive from students who have, in general, relatively little knowledge of occupations in a modern economy. Archaeologist, geologist, food quality testing, weather forecasting, marine biologist, aircraft designer, mining, and astronomer were among those occupations suggested as needing scientific knowledge, although some of these received only one mentioned.

Chapter 7

1 Although mathematics was one of the most popular of subjects, it was also commonly cited as a subject that was disliked. Among the girls, it was the commonest subject so cited, so there appears to be a considerably polarisation in attitudes towards it.

2 That the boys are more interested in science than the girls in some sort of absolute sense, rather than just relative to other school subjects, is suggested by records of school library borrowing habits, kept over 1992 for the whole school. In the junior forms, the girls made greater use of the library, borrowing, on average, twenty to twenty five percent more books per student per year than the boys. The boys, however, were three or four times more likely than the girls to borrow science or applied science books, including books on biological subjects. In Form 4 and Form 5, the girls' borrowing of science books was similar to that of the boys, although the level of library use had fallen so low by this stage that the figures must be considered very unreliable.

3 Thailand seems to offer a fascinating exception to this rule. For example, Newton & Newton (1992) record that Thai students' images of chemists are often female, and Klainin (1989) records the superior achievement of Thai girls in upper secondary schools in both physics and chemistry. The suggested explanation is that the physical sciences in Thailand are not male dominated in terms of students, teachers or curriculum developers.

4 When the students were asked what qualities they thought were needed in a good teacher, the greatest emphasis in their answers was on the willingness and ability of the teacher to explain.

5 There is at least a hint here that the lack of enthusiasm that the girls tend to show for the physical sciences does not have to be seen as entirely inevitable - in the sense that it may be beyond the control of the science teacher. Some support for this comes from the topics selected by the 1991 Form 5 group at the end of their course as the ones they had enjoyed most. These students were asked to choose up to five of the topics they had most enjoyed, and the six most frequently chosen are shown below:

Most popular science topics, as chosen by 1991 Form 5 students.

Boys	Girls
Electricity (74%)	Reproduction (52%)
Forces (54%)	Electricity (48%)
{Reproduction (43%)	{Forces (44%)
{Motion (43%)	{Genetics (44%)
Ecology (37%)	{Ecology (40%)
Carbon chemistry (23%)	{Micro-organisms (40%)

Figures in brackets show percentages of students choosing each topic.

There is no evidence here for a narrowness of interest and lack of interest in non-biological topics among the girls. Conversations with the girls in this group revealed that their interest in the physics topics had been aroused by a combination of an activity-oriented approach and an emphasis on everyday applications. The teaching about electricity had also been welcomed for having partially demystified a phenomenon which had become an inescapable part of their lives.

6 Some of these experiences will be shared by all cohorts as they pass through each grade, insofar as they are determined by the prescribed aspects of the syllabus such as content and certain practical activities. Other experiences, determined by teacher behaviour and idiosyncratic events, will not be shared, and "cohort effects" are likely to be exhibited by the preference data. Such effects are always likely anyway, since no two cohorts are identical and will, therefore, respond differently, even to similar events. As a consequence, it can be difficult to interpret certain apparent developments - particularly dramatic ones - in what are only cross-sectional, not longitudinal, data.

7 Notice also how the 1990 Form 4 girls showed relatively little interest in learning about electricity (Table 6.1), and yet these same girls, at the end of Form 5 in 1991, ranked it as the second most popular topic (table in note 4, above).

8 The same list of topics that was presented to the K G VI Form 1 students was also given, at a similar time, to Form 1 students in three other secondary schools: Waimapuru NSS, on Makira; Pawa PSS, on Ugi, off the coast of Makira; and Luasaleba, on Santa Cruz, in Temotu Province. The general pattern of preferences was remarkably similar in all schools, with two notable exceptions. Firstly, a significantly greater interest was shown in "Living things in the sea "by the Luasaleba students, almost all of whom come from Temotu Province, which is a region of small

islands where life is intimately connected with and dependent on the sea. The second point of note is that the interest shown by the K G VI girls in the "Engines" and "Electricity" topics was very much higher than that shown by the girls elsewhere. Given that one of the most significant differences between Form 1 intakes to K G VI and these other schools is the much higher proportion of girls with an urban background, this seems to support the analysis, above, suggesting that urban experience is influential on girls' interests in applied physics topics.

[9] No significant effects from mother's occupation could be detected, on either boys' or girls' aspirations. Both girls and boys who had both parents working seemed more likely to have a definite career in mind, rather than none, but the effect was not statistically significant.

[10] Little (1978) has commented on the unrealistically high occupational expectations of students in less developed countries. These aspirations clearly fall into that pattern, but they suggest that the lack of realism is less acute among rural girls from farming backgrounds.

[11] The girls' opinions of home economics were rather variable, and this may have been related to teacher characteristics. In general, however, it retained quite a strong following. This contrasts with the situation found by Foreman (1984) in Trinidad and Tobago, where home economics was unpopular because it was seen as a preparation for domestic service only. In Solomon Islands, "domestic service" is simply not seen as an option for secondary school girls and, hence, the subject is not seen in this light. It _is_ seen as a preparation for marriage and motherhood, but these are aspects of the future accepted, it seems, by almost all of the girls. Since the course is taught in the context of a "modern" home, with sewing machines and gas stoves, it may resonate with girls' aspirations for a more desirable form of an inevitable future.

[12] In a relatively small, close-knit community, such as Solomon Islands, apparently minor events can have a rapid effect. In 1991, an ex-K G VI student became the first Solomon Island female to gain a commercial pilot's licence. In 1992, when a scholarship for pilot training became available to Form 6 students, there were more girls than boys applying for it, from K G VI. It would be interesting to investigate, in situations like this, the ground-breaking role that non-Melanesian girls might be playing.

[13] Although observations that science-related occupations tend to be male dominated, or that boys perform better in class, may be made by rural or urban students, more general statements about the inherent superiority of boys in science

seem to come more frequently from students with exclusively rural primary schooling. This was particularly noticeable among the boys, but it would be wrong to read too much into this, given the small number of such statements that were made.

[14] It must always be kept in mind, however, that these data arise from a single school in which the average performance in science, in national examinations, is the highest in the country. It may be that data from a wider sample would reveal that this overall positive attitude to science in general is in fact linked to this above-average performance.

Chapter 8

[1] Although he had indicated as much, earlier on, when he stated that a "particular social environment remains indispensable" for the development of formal operational thought (Inhelder and Piaget, 1958: 337).

Chapter 9

[1] It is now accepted that this position is indefensible without first knowing what the experiences are which influence children's conceptions of vision. It may be, for example, that urban children's greater exposure to artificial sources of light has an impact on their ideas. It would certainly seem possible that understanding of more complex optical phenomena, such as lenses, might be influenced by experience of optical instruments, and it is possible that such experience may influence ideas about vision too. The choice of vision as a topic for investigation can, therefore, be seen as somewhat arbitrary, although it has clear advantages over a topic such as electricity, which does not form part of a basic universal experience of the world.

[2] His account also includes references to other notions expressed by children which find echoes in later work by other researchers, but these are, unfortunately, very brief.

[3] This statement is not true! This exercise with the match was actually part of a series of exercises with a match and a lamp carried out to determine whether the students believed that the distance light travelled depended on the brightness of the source and the level of ambient light in the surroundings. As such, it is not directly relevant to this investigation of vision, but it does, incidentally, provide some useful information on the topic. The intention declared in the text can be seen as a subsidiary one.

4 Interestingly, one girl suggested that human beings cannot see when there is no light but that may be due to a weakness in their eyes:

JL: If there is no light at all ... everything is totally dark, can you see anything?
SS: ... No. ... But at home people say that ... er ... there are those birds? ... They are at night ...
JL: Bats or birds?
SS: Birds.
JL: Owls?
SS: Mmm [Not sure about the name?] ... They have good eyes for seeing in darkness ... better than people.
JL: And can they see when there's no light at all?
SS: I think so .... Maybe. [laughs]
(08/F/92)

5 This suggests that the apparent doubling of the proportion using the physicists' model between Form 3 and Form 5 must be treated cautiously, given that there is a selection process after Form 3. In view of the positive correlation between acceptance of this model and performance in science (which, in turn, correlates positively with the selection examination results), this selection process may be favouring those who are using the accepted conception of vision. If we look at actual numbers, instead of proportions, there was a 40% increase in acceptance between Form 3 and Form 5, not 100%: from 15 students to 21.

6 Notice that for both ways of representing this relationship, the effect is weaker at Form 5 than at Form 3. This is to be expected if the post-Form 3 selection examination reduces the range of abilities present in the cohort.

7 It is interesting to note that for one of the situations which Andersson and Kärrqvist used to examine their subjects' ideas ("Problem 1"), the idea of "visual rays" seems only to have been inferred from the answers rather than read directly from statements. The analysis of this question seems to be that in order to choose a particular response, the subjects must have been working with a "visual ray" model, without their having to make this model explicit. Furthermore, it is for this particular question that the authors claim this type of model was most common. To derive apparently logical implications from children's accounts is a risky business.

Chapter 10

1 In analysing the students' answers it was important to try to distinguish between those which seemed to be treating it as merely an "academic exercise", an English comprehension exercise aimed at assessing understanding of the passage, and those which seemed to be expressing a genuinely held opinion. While it was not always possible to be certain when the former was occurring, many cases of the latter were quite clear, particularly when evidence external to the passage was brought in: "This sort of thing happens in Solomon Islands too" was not uncommon. It was often helpful to look at a respondent's answers as a whole in order to understand his or her answers to individual questions.

2 A personal anecdote illustrates this belief that the efficacy of magic depends on the maintenance of wider aspects of *kastom* by its practitioners. I once took a group of students on an arduous five day walk along the Weather Coast of Guadalcanal and for part of the way we were accompanied by two local young men. One of the students fell ill with rather non-specific symptoms of fever, nausea and headaches. This was identified as a "custom sickness" and one of the accompanying locals claimed he could cure it, since he was a "custom man". Although we were not allowed to watch this cure, I later learned that it involved the suffering student being taken to the beach at night and rubbed all over with a particular leaf while certain words were uttered. The cure was 100% effective as the patient then returned and demolished a huge meal, the first he had been able to eat all day! Later that evening the "custom man" refused to enter the room in which we were all seated because he would have had to pass under some of the girls' clothes which had been hung up to dry. For a man to pass under anything associated with women is strictly "tabu" in many Solomon Island societies and would have defiled this man in a custom sense. He explained to us that it was only by observing such tabus that he was able to keep his power to carry out cures such as the one described; to forsake custom ways means to lose custom powers. It should be pointed out that this "custom man" was a young man - a policeman - with at least some secondary education.

3 Hogbin (1939) believed that this was only an important consideration in the very early years of mission activity and suggested that the promise of eternal life and hoped-for relief from providing for ritual sacrifices became more important reasons for conversion. He also suggested that the power of the Christian God and the authority of the Bible were established by observations such that a Christian can eat food cooked by a menstruating woman without coming to any harm.

APPENDIX 1

Personal Background Questionnaire

This questionnaire evolved through several versions. Changes were introduced either because the students did not seem to have some of the information requested, or simply to clarify questions which seemed to be causing problems. There were some differences in the questions used with different Forms, but the two versions reproduced here were both intended for Form 2 students.

Earlier version

Name .... Sex: Girl Boy

Age: years

1) Where do you live? Place: .... Island: ....

2)(a) Please give details of all primary schools you attended:

Grades	School name	Place	Island

3) What does your father do for a living? ....

4) If your mother also has a job, please state what it is:

....

5) Please put ticks in the correct boxes to show your parents' level of schooling:

	None	Primary	Secondary	Higher	Don't know
Father					
Mother					

6) How many brothers do you have? ....

How many sisters do you have? ....

7) Please list the three subjects that you enjoyed most when you were in form 1, in the order in which you preferred them:

1st............... 2nd............. 3rd.............

8) Put a tick in the box next to the sentence which is true for you. If neither sentence is true for you, leave both boxes empty.

When I first came to K G VI, it was my first time to come to Honiara.

When I first came to K G VI, I had been to Honiara only a few times before (five times or less).

9) Do you know what sort of job you would like to have when you leave school?

Yes No

10) If your answer to question 9 was "Yes", please write down what sort of job you think you would like to do when you leave school:

....

11) Think back to the science lessons you had in form 1. Which things that you learned about did you find the most interesting? Write down the three most interesting things, in the order that you preferred them:

1st: ....

2nd: ....

3rd: ....

12) Here is a list of some things that you might learn more about in science lessons. Read through the list and decide which ones interest you most. Put them in the order in which you would be most interested in learning about them. Write 1 in the box by the most interesting, 2 in the box by the next most interesting, 3 for the next, and so on.

The stars, the Moon and the planets

Plants, seeds, flowers, and how they grow

How a car engine works

Chemical reactions

Your body and how it works

Electricity and machines that use electricity

How to make materials like concrete and plastic

Animals and birds and how they live

How to make a telescope and microscope

Living things in the sea

Diseases, what causes them, and how to prevent them

Later version

1. Name .... 2. Sex ....

3. Form .... 4. How old are you now? ....

5. Are you a day student or a boarder? ....

6. Where do you live when you are not at school? (Please name the village or town and the island it is on.)

....

Have you always lived there? ....

If your answer was "No", please write down the other places you have lived in and the years that you lived there.

....

....

....

7. Please give details of the primary school (or schools) that you attended:

Grades	Name of school	Where is it? (place & island)

8. What is your father's occupation? (If he is retired or deceased, please state what he used to do.)

....

9. Does your mother have a job outside the home? ....

If "Yes", what does she do? ....

10. How many brothers have you got? ....

How many sisters have you got? ....

11. Please tick the one sentence out of these which is true for you:

A. I live in Honiara.

B. Before I came to K G VI I had been to Honiara more than three times.

C. Before I came to K G VI I had been to Honiara only three times or less.

D. Before I came to K G VI I had never been to Honiara.

APPENDIX 2

Personal Background Interview Schedule

This also developed with use and the version given here is the final one. It should be remembered, however, that this schedule acted only as a structure and certain aspects would be developed more than others with different students, depending on general responsiveness and responses to particular items.

Name Date
Form Age Sex Day/Boarder

Where is your home?

Do you live there when you are not at home, or do you stay somewhere else? Do you generally go there during the holidays?

Where do you prefer living, at home or in Honiara? Why?

What does your father do?

Does your mother work outside the home? If so, as what?

Where did you go to primary school?

Do you have any brothers? Younger/older?

Do you have any sisters? Younger/older?

When you are at home are you ever expected to look after younger children? Do you enjoy it?

When you are at home during the holidays, what do you enjoy doing?

When you are at home, are you expected to help with work? What sort of things do you do?

Do you think you are expected to do a lot of work?

Are your brothers/sisters expected to work as much as you?

Do you ever get a chance to do any work that uses tools, such as repair work about the house, or fixing motors? If not, would you like to do work like that?

I want you to try to remember when you were small. Before you went to primary school. What sort of things did you play, or play with, or enjoy doing?

In your home area, are boys treated differently from girls when they are small? If so, how?

Do you think they are treated differently when they get older? When does this different treatment start? What differences are there?

Here at school, what do you like to do in your spare time?

Do you do much reading? If so, what sort of things do you like to read?

Do you like watching movies? What sort?

Are you in any clubs or societies, in school or outside school?

Would you say that you had lots of friends, or just one or two?

Do you ever like getting away from people and doing things entirely on your own?

Have you any idea what you might like to do when you leave school? If so, can you say why you would like to do that?

Have you enjoyed being at school, or are you looking forward to leaving?

Which subjects, if any, do you like most at school? Why do you like them?

Which subjects do you dislike? Why do you dislike them?

Do you find science difficult?

Which parts do you find difficult? What is the difficulty?

Do you find maths difficult?

Which parts of your science course have you most enjoyed? (For form 3 students, a written list of topics studied in the last year or so given at this point.)

What was it about them that you enjoyed?

Which parts did you dislike or find boring?

Why did you dislike them?

Do you enjoy doing practical work in science? What is it about practical work that you like/dislike?

In class, or during preps, do you prefer working with someone else, or in a small group, or on your own?

When you don't understand something, do you ever ask the teacher to explain? Do you ever ask a friend? Do you ever try to understand by using a book?

What sort of behaviour do you think makes a teacher a good teacher?

What sort of things do you not like a teacher doing?

Do you prefer having female or male teachers, or doesn't it matter to you? (If a preference, why?)

Do you think any of the science you have learned about has been useful to you in your life so far? If yes, which parts and why?

Do you think any of the science you have studies might be useful to you later on in your life? If yes, which parts and why?

Do you think of yourself as being a very religious person? Which church do you belong to?

Have you ever found that there is a conflict between your religious beliefs and anything you have learned in science? If so, what? If you ever came across such conflict, which side do you think you would support, your religion or science?

When scientists are doing their work, what sort of things do you think they do?

Where do you think you might find a scientist working? In a laboratory? a factory? an office? outside?

I want you now to try to imagine a scientist at work. Try to form a picture of a scientist doing whatever it is that scientists do. ... Now I shall ask you some questions about this scientist that you are imagining.

Male or female? Black or white? Young or old?

Is this scientist smartly dressed, casually dressed, or dressed in some special clothing?

Is he/she working alone or with others?

Do you think this scientist is likely to be a shy, quiet sort of person, or a talkative, sociable type of person?

Where do you think you get these ideas from about what a scientist is like?

Do you think you are the sort of person who could be a scientist? Why/why not?

Can you name any jobs in which the person doing the job has to make use of a lot of scientific knowledge?

Would you like to have a job which makes use of science a lot? Why/why not?

Do you think science is more interesting or useful to girls than it is to boys? Why/why not?

Do you think boys are better at some parts of science than girls are? If so, which parts? Why are they better at those parts?

Do you think girls are better at some parts of science than boys are? If so, which parts? Why are they better at those parts?

Would you rather have been in an all boys/girls school, rather than a mixed school like this one? Why/why not?

Do you think teachers, or some teachers, treat the girls differently from the boys, in class? If yes, in what ways?

Do you think the girls and boys in your class generally get on well together? Do they ever have arguments? Do the boys ever try to boss the girls about? Do the girls ever try to tease the boys? If yes (to any), why do you think they do that?

According to your custom, do girls and women generally have to do what they are told to do by men? If so, is that true for any men, or just, say, wantoks or family?

How do you feel about that? Is it alright, or should it be changed?

Do you think it is changing at all?

Do you think custom ideas and rules are still very strong in your home area? Can you give any examples?

APPENDIX 3

Mechanical Reasoning Test

DO NOT WRITE ON THIS PAPER OR MAKE ANY MARKS ON IT AT ALL

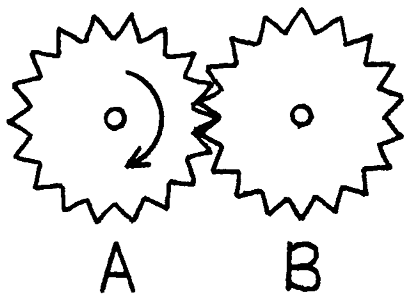
Give all of your answers on the separate answer sheet

Read each question, then look at the answer sheet and choose the answer that you think is correct

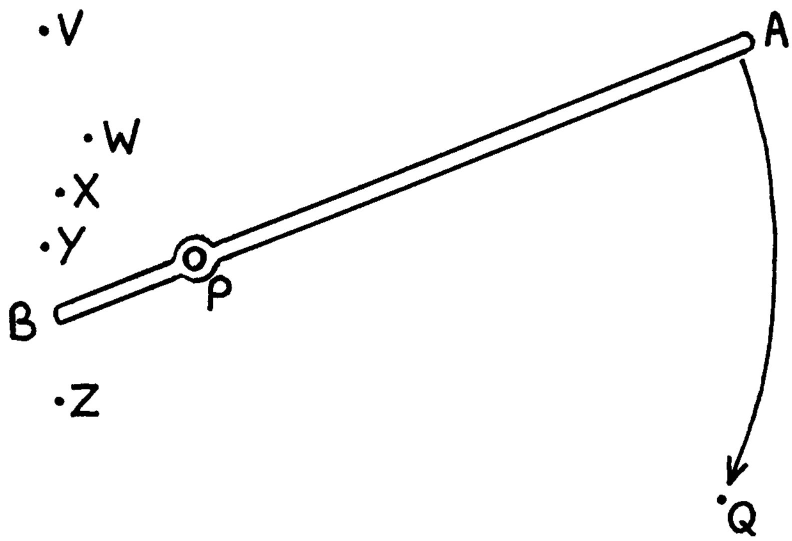
Question 1

The toothed wheel A turns in the direction shown by the arrow.

In which direction does wheel B turn?



Question 2



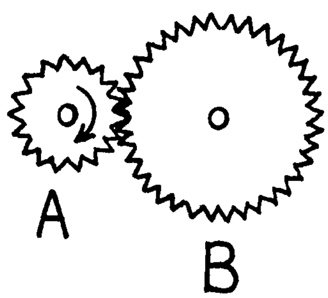
AB is a long bar with a pivot (or hinge) at P, near to end B. The end A is pushed down to the point marked Q.

Where does the end B move to?

Question 3

The toothed wheel A turns one complete revolution. (This means it turns round once.)

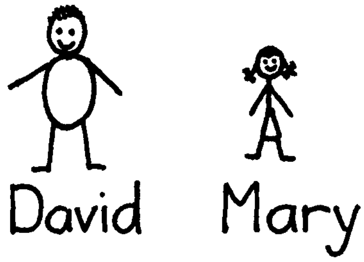
How many revolutions does it make wheel B turn through?



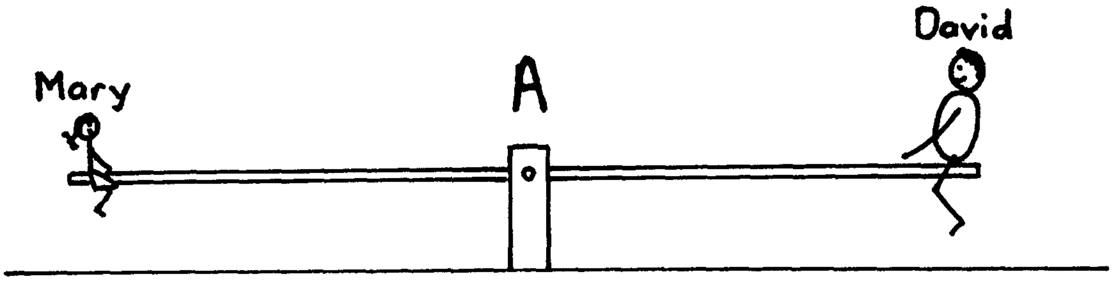
Question 4

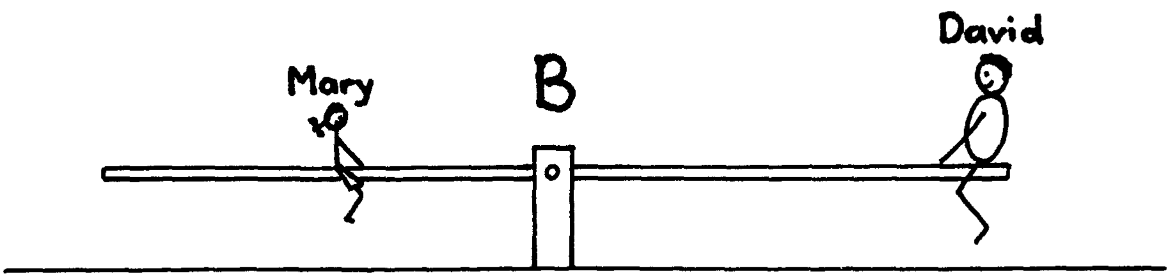
David wants to play on the see-saw with his sister Mary.

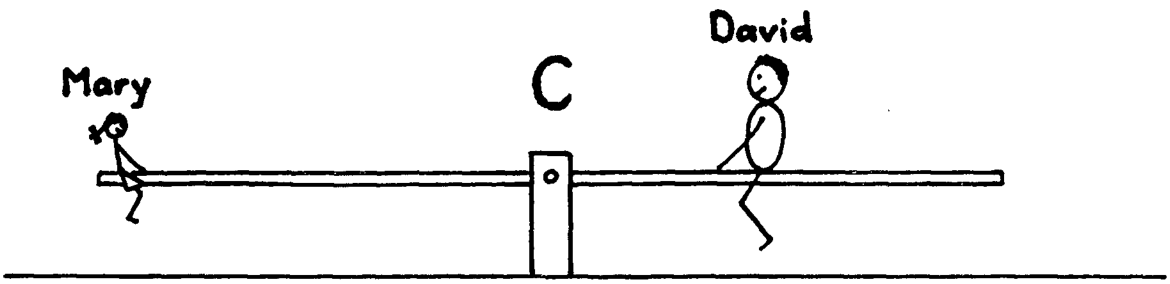
David is much bigger and heavier than Mary.



Which one of the drawings below - A, B or C - shows how David and Mary should sit on the see-saw so that they balance it?



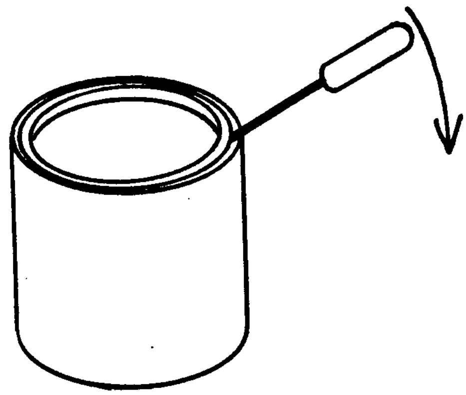




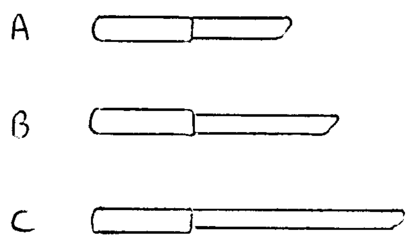
Question 5

The lid on this tin of Milo is stuck really tight.

I want to use a knife to lever it off, as shown in the drawing



The drawings below show three knives - A, B and C. Which one should I use so that I can lever the lid off with the smallest force?



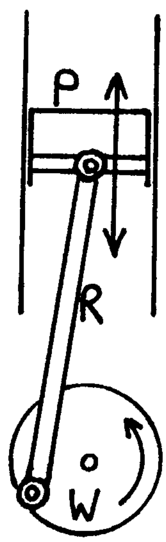
Question 6

The rod R joins the piston P to the edge of the wheel W.

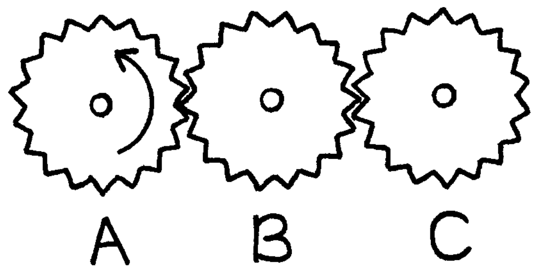
As W turns round, P is pushed up and down.

W is turning in the direction shown by the arrow on it.

At the moment shown in the drawing, is P moving upwards or downwards?



Questions 7 and 8



The toothed wheel A turns in the direction shown by the arrow on it.

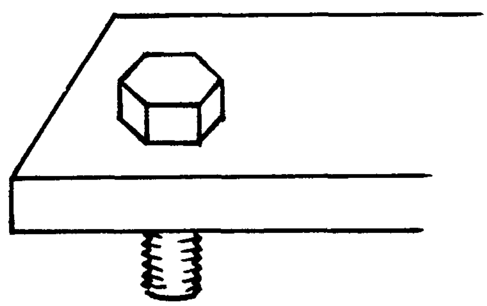
7) In which direction does it make wheel B turn?

8) In which direction does it make wheel C turn?

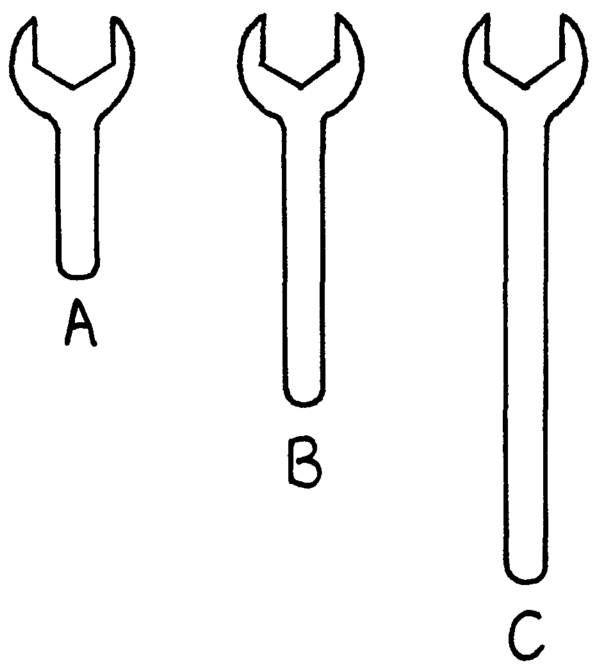
Question 9

The nut in this diagram is stuck really tightly in the metal plate.

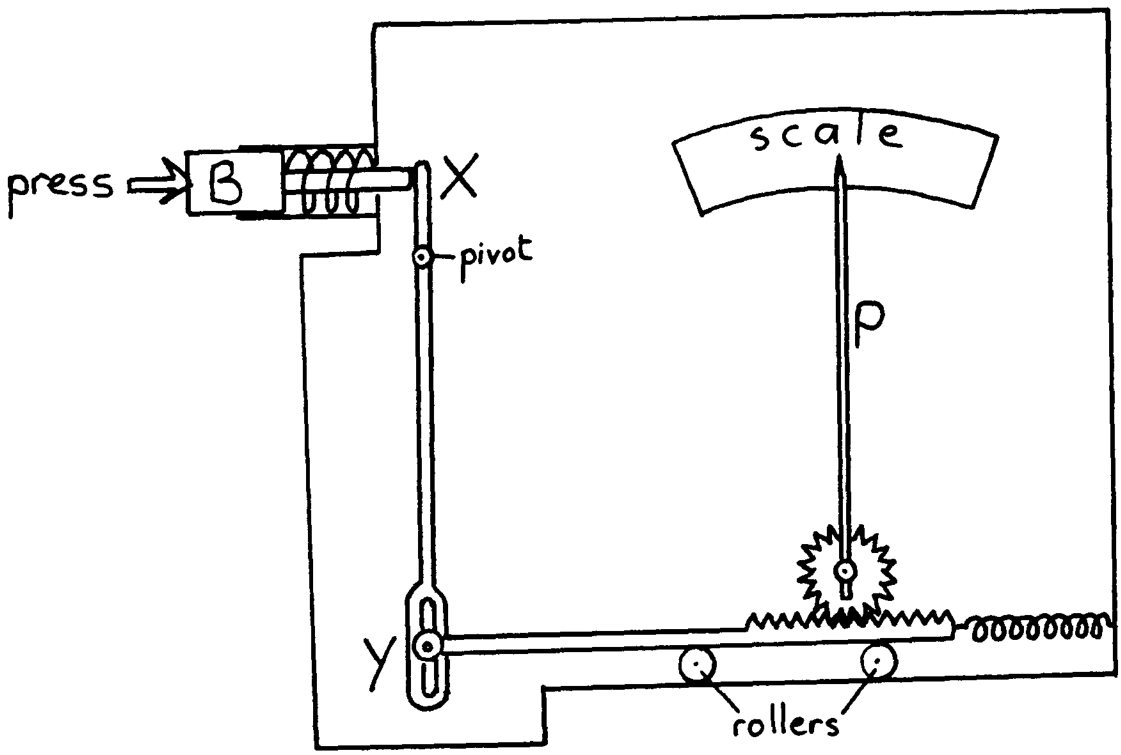
I want to unscrew the nut with a spanner.



The drawings below show three spanners - A, B and C. Which one should I use so that I can unscrew the nut using the smallest force?



Question 10



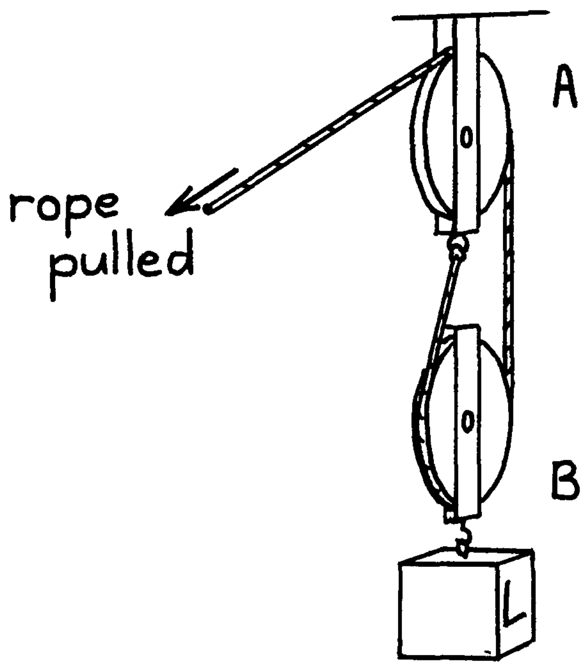
When the button B is pressed, it pushes on the end X of the lever XY and it makes the pointer P move across the scale.

Which way does the end Y of the lever move?

Questions 11 and 12

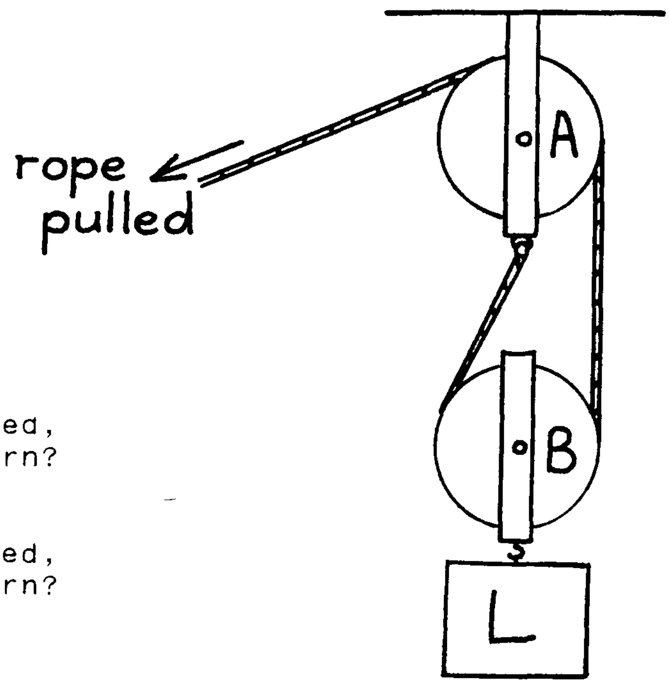
The drawing shows a pulley system with two pulley wheels, A and B.

When the rope is pulled, the pulley wheels turn and the load L is lifted up.



Here is another drawing of the same arrangement.

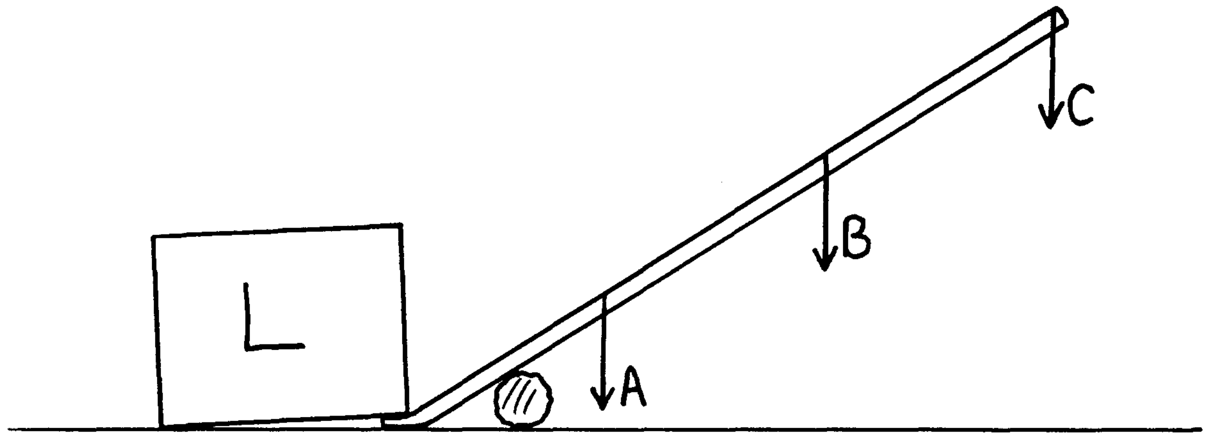
Here are two questions about it:



11) When the rope is pulled, which way does wheel A turn?

12) When the rope is pulled, which way does wheel B turn?

Question 13



I want to lift the heavy load L by pressing down on the lever.

At which point - A,B or C - should I press down to lift the load using the smallest force?

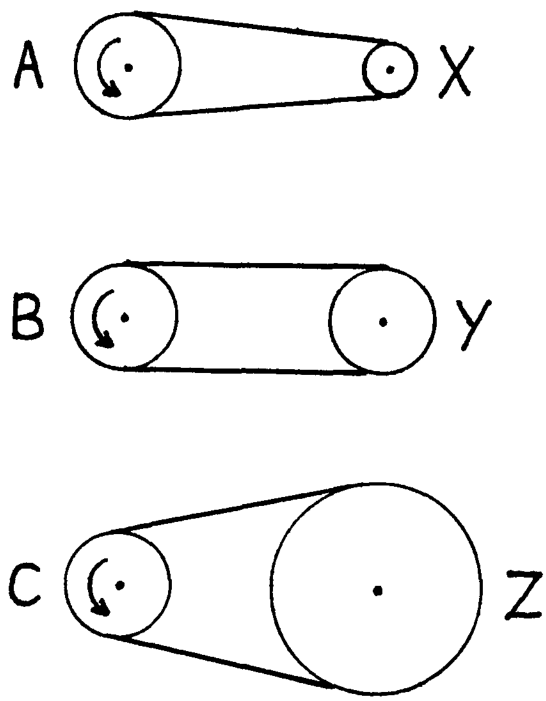
Question 14

AX, BY and CZ are pairs of pulley wheels joined by rubber bands.

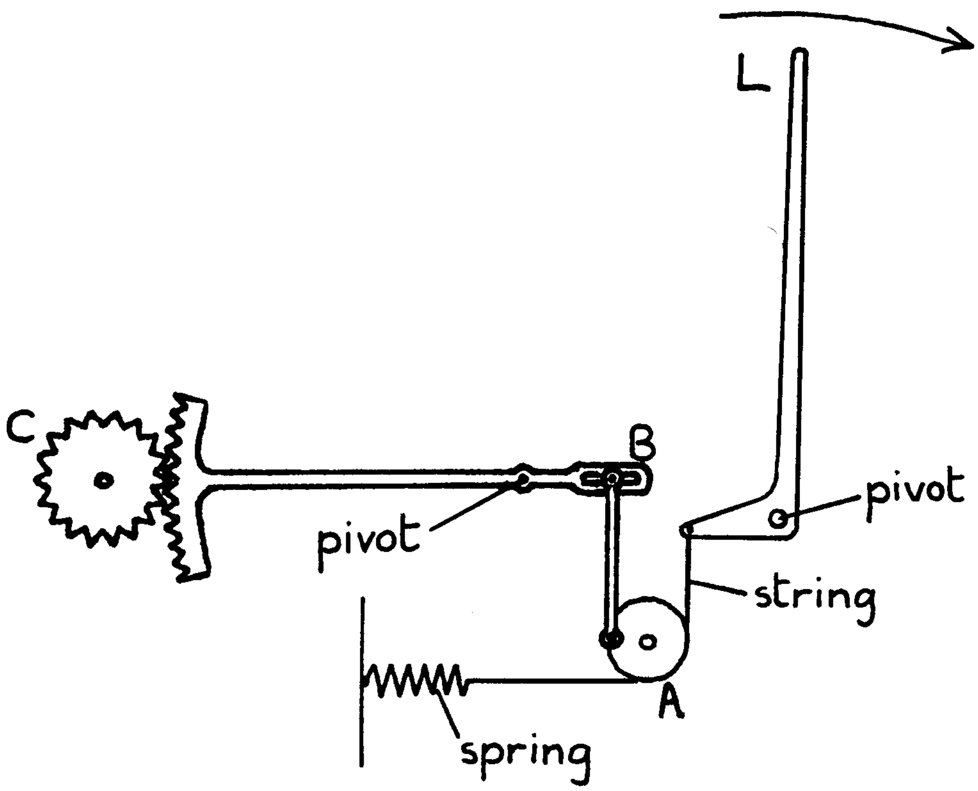
A, B and C are all the same size. X is smaller than Y and Y is smaller than Z.

A, B and C are all turning at the same speed.

Which of the other wheels will be turning fastest: X, Y or Z?



Questions 15, 16 and 17



The lever L has a string fastened to the end of it. This string goes round wheel A.

The rod R is fastened from the edge of the wheel to the end B of a lever.

At the other end of this lever is a toothed bar which moves over a toothed wheel C.

The lever L is pulled in the direction shown by the arrow.

15) Which way does wheel A turn?

16) Which way does the end B of the lever move?

17) Which way does the wheel C turn?

APPENDIX 4

Attitude to Science Scales

The following items were used in an attempt to assess attitudes on eight scales. Students were asked to respond to each item on a five-point rating, from "I agree strongly" to "I disagree strongly". A mixture of positive and negative items was included for each scale. The items are shown here divided into their separate scales but were presented to the students in the order indicated by the number given with each item.

Biology, Personal Value

1. Things I learn in biology will be useful for the sort of job I would like to have.
9. Biology helps me to understand things that happen in my everyday life.
17. Many of the things we learn about in biology will be useful to me in later life.
25. The things that are important to me personally have nothing to do with biology.
33. It is very important for my future that I do well in biology.
41. I find that biology is useful to me in the problems of my everyday life.

Biology, Personal Enjoyment

6. A lot of biology lessons are boring.
14. We have too many biology lessons.
22. I like reading books about biological topics.
30. I like working on biology problems.
38. I like doing practical work in biology.
46. I would like to learn a lot more biology.

Biology, self-concept

4. I do better in biology than in most other subjects.
12. Girls are usually better than boys at biology.
20. I usually understand what we are being taught in biology lessons.
28. I remember most of the things we are taught in biology.
36. I find biology difficult.
44. When I start a biology prep I often think, "This will be difficult".

Physical Science, Personal Value

5. The things that are important to me personally have nothing to do with physical science.
13. It is very important for my future that I do well in physical science.
21. Things I learn in physical science will be useful for the sort of job I would like to have.
29. I find that physical science is useful to me in my everyday life.
37. Many of the things we learn about in physical science will be useful to me in later life.
45. Physical science helps me to understand things that happen in my everyday life.

Physical Science, Personal Enjoyment.

3. I enjoy reading books about physical science.
11. I enjoy doing practical work in physical science.
19. A lot of physical science lessons are boring.
27. We have too many physical science lessons.
35. I would like to learn a lot more physical science.
43. I like working out physical science problems.

Physical Science, Self-concept

8. I find physical science difficult.
16. I find it difficult to remember a lot of the things we learn about in physical science.
24. When I start doing a physical science prep I often think, "This will be difficult".
32. Boys are generally better than girls at physical science.
40. I do better in physical science than in most other subjects.
48. I usually understand what we are being taught in physical science lessons.

Science, National Value

2. Scientific knowledge will be one of the most important contributions to the development of Solomon Islands.
10. Scientific discoveries will give us the best way of controlling disease in Solomon Islands.
18. It is important for as many people as possible in Solomon Islands to know some science.
26. Science is not really useful for people living and working in the rural parts of Solomon Islands.
34. Most scientific ideas are no use to Solomon Islands.
42. Scientific knowledge is only really useful to a small number of people in Solomon Islands.

Science as a Truth System

7. Custom ideas and explanations can often be trusted more than science.
15. Science tells us the truth about the world around us.
23. I find it hard to believe some of the things we learn about in science.
31. Scientific ideas are foreign and are unsuited to our culture in Solomon Islands.
39. If scientific ideas disagree with my religion I will trust my religion more than science.
47. The methods of science are the best way of finding out what is true and what is false.

APPENDIX 5

The Question of Rationality in Science and Magic

A key element of the process of "becoming modern" is the development of a rational attitude and ways of thinking which are deemed to be characteristic of science; superstition and magic are to be rejected and replaced with a scientific approach to life (Inkeles & Smith, 1974, pp 28 & 32). Max Weber saw the march of rationality in all walks of life as part of an inexorable process of modernisation that leads to "the disenchantment of the world". For him, science is "chained to the course of progress" and has been a motive force in the development of the Western society that we hold up as "modern". He specifically contrasts scientific thought with that which he felt characterised "primitive" societies when he describes the meaning of science in these terms:

> "It means the knowledge or belief that if one but wished one *could* learn it at any time. Hence, it means that principally there are no mysterious incalculable forces that come into play, but rather that one can, in principle, master all things by calculation. This means that the world is disenchanted. One need no longer have recourse to magical means in order to master or implore the spirits, as did the savage, for whom such mysterious powers existed. Technical means and calculations perform the service. This above all is what intellectualization means."
>
> (Weber, 1968, p 298)

Implicit in these ideas is that "traditional" thought and action based on it - and magic in particular - are irrational and, hence, qualitatively different from scientific thought. Malinowski essentially adopted this view when he distinguished magic from science: while both are directed towards practical aims and both involve a body of theory and principles, science is characterised as relying on observation and reason, whereas magic relies on the experience of emotional states (1948, pp 86-87). Lévy-Bruhl (1923) similarly contrasted modern and primitive thought as being "rational" and "mystical" respectively.

Such a position has been contested by several writers. Lévi-Strauss (1966) has argued vehemently for the acceptance of magic as a valid intellectual response to a thirst for objective knowledge, not suggesting that it is a crude proto-science but that it is a comprehensive and self-contained approach to natural phenomena requiring the same sort of mental operations as science. Echoing Malinowski, he insists that genuine scientific activity has been a characteristic of even the most primitive peoples, although his argument is largely based on the dubious assumption that technological activities such as pottery and weaving could only have arisen from a process of hypothesising and experimentation. In a very influential paper, Horton (1967) has argued that science and traditional forms of thought are very similar in aim and process but are built on different idioms: the former an impersonal and the latter a personal idiom.

One of the difficulties behind the question of the rationality or irrationality of belief systems is the interpretation and application of the term "rational" to thought and action. Jarvie and Agassi (1970) define a *rational act* as simply one performed by someone holding beliefs which show that the act will be conducive to some desirable end. When it comes to defining *rational belief*, however, they present the rather vague statement that the belief must satisfy "some standard or criterion of rationality which has been adopted, such as that it is based on good evidence, or is beyond reasonable doubt, or is held open to criticism etc." Lukes (1970) suggests that there are universal criteria which can be used to assess the rationality of beliefs: logic and "correspondence to a common reality". As a representative of the totally relativistic approach to the sociology of knowledge Barnes (1974) argues against the universality of both of these criteria and says of science in particular that it "should possess no special status in sociological theory, and its beliefs should cease to provide reference standards in the study of ideology or primitive thought" (p43). The problem with this approach is that it must end all discussion, since it argues that there can be no common agreement on what constitutes truth or reality. It is worth noting that Barnes does not feel that this difficulty applies to his own predilections in sociological theory which he describes as both "correct" and "universally applicable" (p44). One must wonder at a hidden agenda in his analysis of science, perhaps arising from a perceived need to establish the legitimacy of sociology. Whereas earlier sociologists - most notably those of the Chicago School - were keen to show that their subject was comparable in esteem and rigour to the natural sciences, the relativist prefers to adopt the tactic of reducing the status of the natural sciences.

There is no real difficulty in accepting rationality of action among all people in the sense defined by Jarvie and Agassi. It implies the ability to deduce logically valid conclusions from given premises and it is difficult to see how any group of people could survive if their behaviour was not at least partially rationally directed. The problem is that by starting from a suitable set of premises, rational thought can be used to lead one anywhere one wants. As Barrow states when discussing what is usually accepted as the epitome of rationally directed intellectual activity, mathematics: "... *any* statement can be shown to be a true deduction from *some* set of axioms" (1992, p143). Rational thought in itself, therefore, is an insufficient guide to the truth of any description of the world. What is important is that the conclusions one arrives at are continually checked against "reality" as a way of assessing one's basic premises. It is this critical assessment of predictions and conclusions against events in the real world so that underlying assumptions can be accepted or rejected that distinguishes science from both magic and religion, for which the basic assumptions constitute an inviolate dogma. This is closely linked to the notion of openness to alternatives that Horton (1967) takes to be one of the distinguishing features of science, but the need for this openness only arises from this critical testing of predictions.

Barnes emphasises the social behaviour of scientists by concentrating on what they actually do and then contrasts this with an idealised version of scientific activity which few scientists would claim to follow in any case. He persistently fails to evaluate the results of their activity beyond characterising them as models or metaphors, i.e. representations of reality but not reality itself, thereby harping back to the fundamental epistemological question which has puzzled philosophers but rarely bothered scientists. By paying little attention to the results of science and their correspondence to a reality which he shares in large part with all of us, despite his protestations to the contrary, he has no need to consider the undoubted success of science. Lévi-Strauss similarly is dismissive of this success in a single meanly-granted sentence: "The theoretical and practical results differ in value, for it is true that science is more successful than magic from this point of view, although magic foreshadows science in that it is sometimes also successful" (1966, p13). These two authors are both concerned to show how little essential difference there is between science and other forms of thought. But in doing this, they ignore the very power of science which has been so much responsible for its success, not just in explaining and predicting natural phenomena, but in attracting new "believers". In his efforts to reduce science to merely another cultural variation of thought with no claim to special status, Barnes ignores, or feels there is no need to examine, this success. This leaves him, in practice, wandering on the periphery of science when he believes he is analysing its essence:

> "By ignoring the achievements of science, by ignoring whether a theory is right or wrong, by denying progress, the sociologists have missed the core of the scientific enterprise."
>
> (Wolpert, 1992, p122)

APPENDIX 6

The Curse

A story from the Trobriand Islands of Papua New Guinea

The village was very proud of To'uluwa, the eldest son of chief Ibena. While many of the village children now attended primary school and a few had even been to the secondary school on another island, To'uluwa was the first young man from the village to go to university: far away in Port Moresby, a place so remote than no one else from Vakuta had ever visited it.

Furthermore, To'uluwa was at university to study medicine: the white man's kind as practiced by the missionaries, not their own custom medicine. Great benefits for the village were expected, and Ibena was very fond of reminding the villagers of this. Not that he boasted of his son, but he was clearly a very proud father.

To'uluwa had been away at his studies for two years before visiting his home again, and he was welcomed back with great honour and excitement. A feast was held to mark his return for the holidays and everyone was fascinated by the stories he had to tell of his life in distant parts.

It was not long, however, before some of the joy at his return turned to disappointment, particularly among the older men - his father's age-mates. Something in To'uluwa's behaviour towards them was very irritating. His greetings and his way of addressing them, while containing all the correct words demanded by custom and respect, somehow suggested that he now looked down on these old men who ran the affairs of the community and who together preserved the wisdom and the secrets that been part of the village for many generations. To'uluwa was now very fond of criticising many of the practices of his own people, calling them "backward", "unhealthy", or even "uncivilised" - whatever that meant. He was very willing to tell anyone who would listen just what was wrong with so many of the things that were done in the village, from the preparation of food to the design of houses, and just what changes he thought should be introduced.

He was still Ibena's son, however, and out of respect to his father the old men kept their complaints to themselves. The village children, in the meantime, were always delighted to sit around the young man and listen to his tales of the amazing sights he had seen and of the strange ways of other people in that far-off place of Port Moresby.

It was about two weeks after To'uluwa's return that the strange illness began to afflict the children of the village. The symptoms were always the same: fever, diarrhoea and stomach pains, and although none of the children seemed in danger of dying, they were very unwell and incapable of any activity. The usual noise of children playing by the shore or in the forest behind the village quickly disappeared as more and more of them succumbed and did not seem to recover.

The village, of course, immediately sought the help of Kanukubusi, the truly ancient keeper of so much traditional medicinal knowledge. Kanukubusi's powers of healing were famous throughout the island and all were confident that he would know the cure. Only one voice in the village cast doubts on Kanukubusi's skills: young To'uluwa, the second-year medical student. He spoke disparagingly of Kanukubusi's abilities and told all who would listen that the only sensible thing to do was to send for the mission doctor in Okinai, or to take what he called "samples" to the hospital there, where he said the doctor would "analyse" them - whatever that meant.

After several days it became clear that even Kanukubusi's wisdom was not prevailing against this mysterious disease. He had made use of all the medicines he knew, taking care in his choice of plants and preparing them in exactly the ways demanded by the customs and wisdom of generations past; but still there was no improvement in the children's condition.

At a meeting of the old men, Kanukubusi told Ibena, "The power of my medicines is well known to you. Time and time again you have seen them work, so you know how effective they are. But now something powerful is working against them. It is clear that this sickness is the result of a curse, a curse on the children that has been laid using a very potent magic."

All those gathered there were disturbed. Whoever would do such a thing to the children? It seemed so unlikely, but Kanukubusi knew more of medicine than any of them, and his knowledge of magic and its ways was greater than that of anyone else in the village. If he said this was happening, who could doubt it?

"To fight such a curse is beyond my powers", continued Kanukubusi. "To destroy this curse and to discover who is behind it we must seek the help of a Vullai'i man. We must send to Gumasila for a Vullai'i man."

This really did cause alarm. The Vullai'i men - who could never be called by their individual names - were the most powerful magicians in the Trobriand Islands. Only very few of them existed, preserving the secrets of the strongest magic: a magic so strong that it could, if the Vullai'i man so desired, destroy a whole village. Sending for a Vullai'i man was a very serious step to take, and would also cost the village dearly in pigs and armshells, or whatever else the magician demanded to ensure the effectiveness of his work. Nevertheless, if the powers of Kanukubusi were exhausted the village had no alternative. A canoe was despatched immediately to Gumasila to ask for the help of this feared man.

As a young man, To'uluwa was not of course invited to this meeting and was not involved in making this decision. He made it quite clear, however, what he thought of the whole business, talking freely of "superstition" and "ignorance". He even risked bringing shame (or worse) on his father, Ibena, by the way he behaved when the Vullai'i man arrived. His scorn of this fearsome figure was clear to all of the villagers, but the visiting magician either did not notice it or decided to ignore it.

No one, of course, was allowed to see the Vullai'i man at work. He remained alone inside a specially prepared house for almost the whole day, emerging just before dark to announce his findings to the whole village, which had been waiting a short distance away for several hours.

When he appeared the magician wore a grotesque mask, twice the size of a normal human head. The last rays of the setting sun seemed to be concentrated on to just this mask, picking out intense, almost luminous, white streaks across the cheeks but apparently unable to penetrate the black, lifeless depths of the eyes. By wearing this mask, the Vullai'i man indicated that the words he was about to speak came not from him, but from the spirits with which he had been in consultation. He was now but a mouthpiece for these invisible beings.

Now, the spirits never speak directly. They do not reveal their secrets in simple language but wrap them up in words that reflect their mysterious origins. This can sometimes make it very difficult to follow what is being said, but it soon became clear to the villagers listening that evening that Kanukubusi's fears were being confirmed: someone had indeed put a curse on the children - a powerful, malicious curse that showed disregard, even hatred, for the whole village. The curse could be dispelled by the awesome powers of the spirits working through the Vullai'i man, but there would always be a danger of the curse returning unless the one who had brought it in the first place was put to death!

The listeners were horrified, but the real shock to them came when the voice from the mask told them that the one responsible for the curse was someone from their own village: a young man, the voice said, a young man who had been to distant places to learn the secrets of the awful, alien magic behind the curse. This young man was responsible for the suffering of their children. Only his death could remove this suffering permanently.

There was only one person in the village that fitted this description; only one young man who had travelled out of the Trobriands. Ibena was distraught, shocked at the thought that his own son could do such a thing, and terrified by the realisation that the spirits were calling for To'uluwa's death. The rest of the villagers were stunned to hear such accusations against one in whom they had had so much pride. But who could doubt the Vullai'i man? Who would dare to?

There were some old men, including Kanukubusi, who muttered to each other that they were not surprised at all and, saddened as they were for the sake of their old friend Ibena, they knew what action would have to be taken.

Orders were given for To'uluwa to be seized. He struggled and raved, the disdain with which he had so far treated the proceedings turning to fear and panic. He yelled at them all, calling them "ignorant" and screaming that the old men were just "fools". He knew what fate they had in store for him.

It was now night and To'uluwa's execution could not be carried out in the dark. It must be light when he was killed, so that all could witness it, including the evil spirits that he must have called upon to carry out his wicked business. To'uluwa was flung into a house, the strongest in the village, and the door was fastened securely and blocked with heavy stones. There he was left, still sobbing and screaming, to await the dawn and his own death.

When the morning came, however, the men who came to fetch To'uluwa were dismayed to find the house empty. A large hole cut in the rear wall of the house, and a missing canoe from the beach made it obvious what had happened. Many said that To'uluwa must have called on the same evil beings he had used to curse the children in order to help him escape. This proved his guilt even further, as if the word of a Vullai'i man were not enough proof. Others claimed that such spirits would not have dared to enter the village when a Vullai'i man was present, and they hinted at their suspicions of Ibena. No one had the heart to follow up these suspicions, however. They felt that Ibena had already suffered enough. Indeed, he was clearly a broken man: no longer the proud and upright chief that he had known for so long, but a pitiful, old man who muttered and wept to himself all the time. They did not know it then, but within six months Ibena would be dead, dying of shame and a broken heart.

It was clearly useless to try to follow To'uluwa - there were so many ways he could have gone, and he had too great a start on them. The Vullai'i magician reminded them that only if To'uluwa died could the village be sure that the sickness would not return. With the sorrowful agreement of the village elders, he not only worked his magic that would cure the children but also put a curse on To'uluwa. This curse, he said, would find To'uluwa wherever he was, and bring about his death. There could be no escaping its effects. For this double piece of work and also, perhaps, because the Vullai'i man <u>had</u> noticed To'uluwa's scorn at his arrival, the village paid dearly in pigs, shells and other valuable commodities.

The children did not recover immediately but after a few days some improvement was noted and by about two weeks after To'uluwa's disappearance all were well again. This, claimed Kanukubusi and others, proved yet again the truth of the magician's accusations and the power of his magic.

But what about To'uluwa? What happened to him? Well, he arrived back at the university for the start of the next year and he continued his studies, although his friends noticed a great change in him and he seemed to have great difficulty in concentrating on his work. One night towards the end of his third year there, he was walking home from town when he was attacked by a gang of "rascals". They beat him and stabbed him so severely that by the time he was found next morning, he was close to death. He was taken to the hospital but died of his wounds shortly after arrival. The news got back to his village much, much later but it surprised no one. All had known that the Vullai'i man's curse would find To'uluwa eventually. In fact, when stories of his death reached the village, most of the people pretended they simply did not know of To'uluwa at all.

All this happened some time ago. Is the story true? Well, I was told it by a friend of mine who had studied at the university for three years. He had shared a room with someone from one of the Trobriand Islands: from Gumasila in fact, the very island from which the Vullai'i man had been called. This man's father had been present when the canoe from Vakuta had arrived to call for the Vullai'i man. Although the people of Vakuta have never been willing to talk of the affair, the Vullai'i man made sure that news of his "success" there spread around, enhancing his reputation. So, who am I to doubt the word of a dreaded Vullai'i man? I don't think I dare to!

APPENDIX 7

The Curse: Questions

1. Do you think it was right for To'uluwa to criticise things in the village that he thought were "unhealthy"? Give reasons for your answer.

2. When the children became ill, do you think the villagers were right to rely on Kanukubusi's custom medicine, or should they have followed To'uluwa's advice? Give your reasons.

3. Do you think the children really had become ill because To'uluwa had put a curse on them? Explain your answer.

4. Would you have been afraid of the Vullai'i man? Give your reasons.

5. The children recovered and To'uluwa died. Do you think this was because of the Vullai man's magic? Give your reasons.

6. Do you think the events described in this story really could have happened? Explain your choice of answer.

7. Have you ever seen or heard of anyone doing magic? If so, describe what you saw or heard about.

8. "Nowadays not many people believe in magic."
Do you think this is true? If so, why do you think many people have stopped believing in magic?

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