ATTITUDES TO SCIENCE:
A STUDY OF VARIABLES LINKED TO HIGH SCHOOL STUDENT ATTITUDES TO SCIENCE

Renato Anthony Schibeci,

B.Sc., M.Ed. (Syd.), M.Sc., Dip. Ed. (N.S.W.)

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CERTIFICATE

I declare that this thesis is my own account of my research and contains as its main content work which has not previously been submitted for a degree at any University.

Renato Anthony Schibeci

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ABSTRACT

The major purpose of the study reported in this thesis was to investigate the influence of the home, school and peer group environments on high school student attitudes to science.

The study was carried out in three main stages. First, a model was developed to guide the investigation. The model, which hypothesised inter-relationships among the three educational environments (the home, the school and the peer group) and student attainment, was derived from a conceptual framework developed by Keeves (1972). Second, a number of preliminary investigations were conducted. These were designed to: (a) gather data on science teachers' perceptions of the objectives, especially the attitudinal objectives, of the high school science curriculum; (b) establish the reliability and validity of the affective instruments to be used in the final stage. Third, the model developed for the study was tested using the year 8 cohorts in two different high schools in the Perth metropolitan area. The generalisability of the model to the two different samples was assessed.

A number of conclusions may be drawn from this investigation of the influence of educational environments on student outcomes:
(1) The influence of background variables is generally not very strong. Typically, values for path coefficients from environmental variables to other variables are low. (2) There is a strong causal chain among the cognitive variables of the study: "general ability"

directly influences "initial achievement", which in turn directly influences "final achievement". (3) There is a strong causal chain among the affective variables: "initial science-related attitude" directly influences "general attitude", which in turn directly influences "final science-related attitude". (4) There are links between these two sets of variables (the cognitive set of variables and the affective set of variables), but these links are not as strong as those within the sets. For example, "general ability" influences "initial science-related attitude", but the link is not as strong as those within each set. (5) There are links between the background (independent) variables and the dependent variables, which have path values which are of the same order of magnitude as the 'within' values in (4).

The influence of background variables appears to be different for the two schools. This provides limited support for the notion that local influences should be further investigated. Home influences appeared, in general, not to influence science-related attitudes or achievement in any direct, substantial way. Keeves (1972) had arrived at a similar conclusion. However, one variable which appeared to be an important variable was the mother's expectations for the length of the child's secondary schooling; this appeared to be an important influence on the cognitive outcome variables in both samples. Of the peer group variables, the amount of homework reported by the three best friends appeared to be important at both schools.

The implications of the results of the study are discussed.

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CHAPTER 1

THE ORIGINS OF STUDY

> Finding out the way the world really works requires a mixture of hunches, intuition and brilliant creativity ... It is the tension between creativity and skepticism that has produced the stunning and unexpected findings of science (Sagan, 1979, p.62).

For Carl Sagan, the professional astronomer, science is an intellectual adventure full of challenge and stimulation. The scientist's drive to understand the unknown in nature is, in Sagan's view, a powerful stimulus indeed: "Understanding is a kind of ecstasy" (p.14). While many scientists would share this view of science as an exciting and stimulating enterprise, one may question the extent to which this view is shared by those for whom the study of science is compulsory, for example, students in the early years of high school in Australia.

In the U.S.A. in the 1950s, many university scientists believed that school science did not reflect the intellectual challenge and stimulation of science. Thus, it was one of the major goals of the curriculum reform movement of the 1960s to develop materials which would increase student interest in the scientific enterprise. These materials were designed to mirror the intellectual challenge and adventure of science. It was hoped by many that an increased interest in science among students would lead to the development of a large pool of scientists and technologists in the community, as well as a more informed general public. The extent of the curriculum reform effort in science was quite substantial. According to Welch (1979), between 1956 and 1975 the National Science Foundation (N.S.F.) in the U.S.A. devoted more than $US65 million to teacher education activities.

An important aspect of the science curricula developed with N.S.F. funds was the emphasis on objectives related to attitudes and interests. Some of these curriculum materials, with their increased emphasis on affective domain objectives, crossed the Pacific and were used in Australian schools. Among them were the Chemical Education Material Study (CHEM Study) and the Biological Sciences Curriculum Study (BSCS). The BSCS materials were adapted to provide an Australian biological orientation and were published by the Australian Academy of Science as the "Web of Life" project.

The curriculum development projects that followed these early efforts emphasised attitude objectives even more explicitly. Fraser (1979a) has noted that this increased emphasis on student interest was a characteristic of the "second generation" of curriculum projects. For example, Harvard Project Physics (HPP) had as one of its goals the reversal of declining enrolments in senior high school physics (Welch and Walberg, 1967). It was hoped that this aim could be achieved, in part, by developing in students positive attitudes to physics.

The first national curriculum development project in Australia, the Australian Science Education Project (ASEP), also emphasised objectives related to student attitudes and interests. It thus followed the trend established by the "second generation" projects in the U.S.A. The ASEP materials were designed to develop "skills and attitudes important for scientific investigation" and to "arouse and foster the interest of children in science" (ASEP, 1974, p.87).

1.1 CURRICULUM REFORM IN SCHOOL SCIENCE

An increased emphasis on science-related attitudes also became a feature of science curriculum guides of the various Australian States. It is worth examining developments in both New South Wales (N.S.W.) and Western Australia (W.A.) as the changes illustrate the curriculum ferment of the time, and provide an Australian perspective on the issues related to the role of affective domain objectives in secondary school science courses.

Science Curriculum Guidelines in N.S.W. and W.A.

In 1975, a new science curriculum for years 7-10 was introduced in N.S.W. high schools. In preparation for this, the Secondary Schools Board (1973) had published two years earlier a brief curriculum guide which consisted of the aims for the new curriculum, together with a list of six very broad content areas to be studied over the first four years of high school. The aims of the course were grouped into three categories: "attitudes and interests", "knowledge and understanding", and "skills".

This new curriculum represented a radical departure from previous practice. The earlier science curriculum for years 7-10 had consisted of a brief preamble (including aims), together with a detailed list of topics for study (Secondary Schools Board, 1968). The previous emphasis was very much on the content of the syllabus. In fact, detailed notes were provided indicating the depth to which each topic was to be studied. The aims, on the other hand, were treated in much less depth.

The new syllabus also provided an indication of the kinds of attitudinal objectives considered by the curriculum writers to be suitable for school science (Secondary Schools Board, 1973,). These objectives were for students:

1. To develop a lively interest in understanding the nature and behaviour of man and his environment.

2. To develop a belief in the value of:
   - thinking critically in an unbiased and open-minded manner;
   - the role of science in solving many kinds of problems;
   - community and personal health;
   - the conservation of our natural environment;
   - persevering with a task even though difficulties may arise (p.7).

Thus, in 1975, science teachers in N.S.W. were faced with a change from a content-oriented syllabus to an aims-centred one; the balance had shifted dramatically from <u>content</u> to <u>aims</u>.

In Western Australia, a similar shift in emphasis occurred in school science for grades 8 to 10. The earlier syllabus statement in science (Education Department of W.A., 1974) listed the following four broader objectives:

(a) Students should be taught scientific procedures such as observing, organizing information information, formulating theories, designing and carrying out controlled experiments, measuring, manipulating equipment and communicating and evaluating information.
(b) Students should be given an introduction to the present state of knowledge in the major science disciplines of astronomy, biology, chemistry, geology and physics. The emphasis should be placed on major unifying concepts and their application to the child's environment.
(c) Students should develop an attitude of enquiry, a willingness to suspend judgement and to consider new evidence and a tolerance of the view of others.
(d) Students should develop an appreciation of the tentative nature of scientific theories, an awareness of the impact of science on society and appreciation of contributions made by scientists (p.2)

In addition, there was a detailed statement of content to be covered in the three-year course. The current syllabus statement (Education Department of W.A., 1979), on the other hand, lists more specific objectives for each of the three educational domains: cognitive, affective and psychomotor. The affective domain objectives are:

Students should show:

(a) an attitude of inquiry and willingness to learn how the world is interpreted through the sciences;
(b) confidence in and a desire to use scientific procedures for seeking knowledge;
(c) a tolerance towards other scientific opinions and ways of interpreting experiments or events;
(d) a willingness to suspend judgement on scientific matters in discourse with others, consider new evidence and possibly modify their opinion;
(e) an appreciation of the environment and the impact of science upon the environment;
(f) a positive attitude to safety and the expense involved in dealing with science apparatus and situations (pp 4-5).

As in the case of the N.S.W. curriculum guidelines, there was a shift from a content-oriented syllabus to an objectives-oriented document. In each case, objectives have become more specific and receive a greater emphasis than in earlier documents. In particular, objectives in the affective domain are given greater prominence.

The importance of attitudinal objectives has also been highlighted in a recent policy statement dealing with science curriculum guidelines for grades K-12 by the Australian Science Teachers' Association. Five premises form the basis for the ASTA's policy document. While three of the premises deal with the general role of science in the school curriculum, the remaining two premises deal specifically with attitudinal objectives. These latter two state that "the teaching of science should be concerned not only with the development of knowledge and understanding of science facts and concepts, but also with the development of skills and attitudes", and that "science education can and should contribute to the achievement of those more general skills and attitudes which the community expects the school to develop" (ASTA, 1980, p. 51).

Clearly, at that time the Asociation believed that the formation of certain science-related attitudes was an integral part of general education. The specific attitudinal objectives for students listed in the Association's policy statement are (ASTA, 1980):

To develop attitudes which indicate:

- appreciation of, and a sense of wonder about, the natural world and its order;
- interest in the work of scientists and the application of science;
- a concern for wise management of natural resources and for wise application of scientific advances;
- a commitment to being honest, accurate, and open-minded (p.53).

These developments in high school science curriculum guidelines reflect the interest of curriculum writers in the affective domain. This interest is also shared by many people in the education community generally.

Importance of Attitudinal Objectives

The importance of attitudinal objectives has been stated by many educators. For example, Choppin and Frankel (1976) have written:

> It is almost universally acknowledged that educational objectives in the affective domain - those dealing with attitudes, interests and values - are of great importance (p.57).

The science education research community also regards the affective domain as important (Baker and Doran, 1975). Some crude indicators of this interest are the number of conference papers and dissertations in this area. Thus, about seventeen per cent of the 113 papers at the 1983 meeting of the National Association for Research in Science Teaching (NARST) were directly related to student attitudes. About thirteen percent of the 588 dissertations in science education listed in University Microfilms International's (1982) Catalogue were directly related to attitudes. In both instances, there would no doubt have been other studies that dealt indirectly with student attitudes.

Yet another crude indicator of interest in this area is a survey by Abraham, Renner, Grant and Westbrook (1982) of the priorities of a group of members of NARST in the U.S.A. Twelve areas of research accounted for two-thirds of the respondents' priorities. Of these twelve areas, research related to students' attitudes and values received the third-highest average rank.

Curriculum development projects reflect this emphasis on affective objectives. The "Science...A Process Approach II" (SAPA II) project lists as an objective that students "Show appreciation of, and interest in, scientific activities" (SAPA II, 1975, p. 36). The Science 5/13 Project (Ennever, 1972) lists as one of its objectives the development of "interests, attitudes and aesthetic awareness" in students. In the USA, the National Assessment of Educational Progress included the assessment of attitudinal objectives because it was "felt that the measurement of both attitudes toward science and experiences in science is important because these attitudes and experiences influence students' decisions and actions" (NAEP, 1979, pp. 3-4).

If arguments for the importance of affective domain objectives are examined, two distinct kinds of proposition can be detected. The first is a pragmatic one and is based on the assertion that attitudes and achievement are inextricably linked and that, therefore, the person interested in a student's cognitive achievement must also be concerned with affective factors. It is interesting, in this regard, that a meta-analysis conducted by Willson (1981) indicated that the relationship between attitude and achievement in science is not particularly strong. The second argument for affective domain objectives is an ideological one, namely that affective rather than cognitive factors are the more important goals of education. Payne (1977) has elaborated on this second position. He argued that affective variables influence a person's ability to "participate effectively in a democratic society", are necessary for a "healthy and effective life", and interact with "occupational and vocational satisfaction" (pp. 66-67). Whichever argument is advanced, affective domain objectives in science education are generally regarded as important. This has stimulated many studies of variables which might influence science-related attitudes, and attitudes to science in particular.

1.2 THE PRESENT STUDY

Science education researchers have generated a large volume of research into the determinants of students' science-related attitudes. Much of this research, however, has been limited in a number of important ways. These limitations, which are discussed more fully in the next chapter, include the following. First, many studies have lacked a guiding theoretical framework. Second, much research (especially early research) was confined to the study of simple bivariate relationships (typically, many studies have compared the influence of different curriculum materials on student enjoyment of science). Third, many reports have described investigations which have involved students for limited periods of time, typically a teaching quarter or semester (although in at least one case the treatment period was as brief as forty minutes!). Fourth, many researchers have used attitude instruments for which little or no psychometric data are provided in the research report; clearly, this throws doubt on the adequacy of the instrumentation used and, also, on the study as a whole.

The present study was designed to overcome the limitations of much of the earlier research on the determinants of students' science-related attitudes. First, a model was developed to guide the inquiry, based on a conceptual framework devised by Keeves (1972). This model postulates a set of causal relationships between the home, the school and the peer group environments on the one hand and students' science-related attitudes on the other. The inclusion of the home and peer group environments is especially important since, as Kremer and Walberg (1981) have noted, there has been a paucity of studies of the influence of these background variables on student attitudes. Second, the multivariate nature of the study ensured that the over-simplification of educational phenomena, manifest in most studies utilizing bivariate relationships, was avoided. Third, the inquiry involved students during a full school year. This provided an opportunity for the investigation of change in science-related attitudes over a substantial period of time. Fourth, a number of preliminary investigations were conducted which ensured that the affective instruments to be used in the main phase of the inquiry would possess adequate psychometric characteristics.

Organisation of the Thesis

A study of home, school and peer group influences on student attitudes (and achievement) in school science provides the substance of this thesis. In Chapter 2, an initial analysis of some of the major issues related to the affective domain in science education is provided. In particular, the nature and role of attitudes which may be called "science-related attitudes" is discussed. In addition, a discussion of some of the relevant issues from the social psychological literature dealing with the construct of "attitude" and the process of attitude change is provided. It became clear from a study of this literature that the application of attitude change theories to educational contexts appears to be premature. The many attitude change theories developed in social psychology, derived in some cases from laboratory experiments, were not translated easily to the arena of real world educational phenomena. The literature did, however, provide important guidance in regard to potential problem areas. Chapter 2 also provides a review of studies which have investigated influences on student attitudes and the major findings of these studies are summarised.

The weaknesses outlined earlier of many of the studies reviewed led to the development of a model to guide the inquiry. The model was derived from a conceptual framework formulated by Keeves (1972), the salient features of which are discussed in Chapter 2. It is a particularly appropriate framework, since it has already been tested in an Australian social context.

Chapter 3 first summarises the results of the preliminary investigations which were undertaken. These include a study of teacher perceptions of science curriculum objectives and the validation of the affective instruments. Next, the methods and procedures used in the main study are summarised. This main phase of the inquiry focussed on the influence of variables representing the home, school and peer group environments on students' science related attitudes and achievement. The Year 8 cohorts at two different schools in the Perth Metropolitan area formed the samples for the main study. Year 8 (the first year of high school in Western Australia) was chosen as an appropriate grade level for the investigation because it is the beginning, for most students, of a systematic study of science. Third, the strategy used to analyse the data is described. Path analysis was chosen as a suitable method, and the particular technique chosen was the procedure known as causal modeling with latent variables, more specifically, the LISREL method (Jöreskog and Sörbom, 1978).

The model guiding the present study postulates a set of causal relationships among three educational environments (the home, the school and the peer group) and students' science-related attitudes (as well as achievement). Chapter 4 describes how the structural, process and attitudinal dimensions of these environments were assessed and gives a summary of the other variables in the study.

The results of the analyses of the data gathered in the main phase of the study are given in Chapter 5. From the conceptual model which guided the inquiry, a specific causal model was generated and refined using one of the two student samples. This causal model was then cross-validated with the data from the second student sample. Those variables in each environment which were strongly linked to attitudes (and achievement) are identified. It was possible to assess, in a limited way, the extent to which a model developed using a specific school community was generalisable to a different school community. In this way, the study provided a test of the notion of "local theories".

Finally, Chapter 6 draws the various elements together. The results and implications of this inquiry for educational theory and practice are discussed. In addition, some suggestions are made for future research in this area.

The great scientist Newton has been attributed with the observation that scholars build on the work of those who have gone before; in this way, our knowledge grows. It is important, therefore, to examine the research of others in order to set the stage adequately for the present study. To this earlier research we now turn.

CHAPTER 2

A CONCEPTUAL FRAMEWORK FOR THE STUDY

Given the central concern of this thesis, which is to identify determinants of students' science-related attitudes, it is important to examine two bodies of literature. The first of these is literature related to psychological research on the construct of "affect". The second is the literature directly concerned with research on factors which may determine students' science-related attitudes.

Social psychologists have been concerned with the study of the attitude-behaviour link for many generations. It is a common assertion among them that a person's attitudes are a good predictor of that person's behaviour. This basic assumption has stimulated much of the psychological research on attitudes. Science educators, as indicated in the previous chapter, also believe that attitudes and behaviour are linked. This assumption, however, is generally not made explicit. Nevertheless, there is a general belief that if student attitudes to science are positive, a number of desirable behaviours (such as higher and continuing science enrolments in school science) will result. This has stimulated much research on students' science-related attitudes. We begin by examining some of the psychological perspectives on attitude.

2.1 PSYCHOLOGICAL PERSPECTIVES ON ATTITUDES

A review of the general psychological literature related to 'affect' undertaken by Bills (1977) led him to conclude that psychologists, in the main, have tended to emphasize the physiological aspects of 'affect' and that terms such as 'emotion', 'mood', and 'temperament' commonly have been associated with this construct. This, he believed, was not what educators were talking about when they referred to 'affect'. In educational contexts, terms such as 'attitudes', 'values', and 'interests' were more relevant. He also noted that even among psychologists there was some confusion regarding the conceptualization of 'affect'. Despite this lack of clarity and consensus, he observed that there exists a large number of instruments which purport to measure what are presumed to be various dimensions of the construct.

There are, however, some characteristics of affective domain variables about which some agreement appears to exist. Payne (1977), for example, has noted that affective variables "vary in intensity", "represent varying degrees of inter-relatedness", "are relatively stable and enduring" and "vary in salience" (pp. 64-65). He also suggested that attitudes could predict a person's behaviour, although this has not been borne out consistently in empirical studies. These characteristics are relevant to one particular aspect of "affect" which concerns both educators and psychologists, "attitude".

The relationship between attitudes and behavior continues to be a source of controversy. Attitudes have been regarded as important by social psychologists because of their potential for predicting behavior.

Evidence is available in the literature, however, which suggests that a person's expressed attitude often is not always consistent with the person's behavior. One of the best known studies in this vein was La Piere's (1934) investigation of racial prejudice. The attitudes expressed in questionnaire responses by owners of hotels and other establishments at the prospect of Chinese guests were generally negative. However, these same owners, with one exception, did not reject a Chinese couple who actually asked to use their establishments. Oskamp (1977) cites studies which have yielded similar findings. These research studies suggest that attitudes cannot always be used to predict behavior consistently. Nevertheless, efforts continue to be made to develop theories which can be used to predict behavior. For example, Ajzen and Fishbein (1980) have developed a "theory of reasoned action" which they believe will do just this. Although this theory appears to be a sound one, it will need to withstand rigorous empirical testing. There is a sufficient body of research, such as that discussed by Ajzen and Fishbein (1980) and Oskamp (1977) to indicate that an important link exists between attitude and behaviour. This link, however, is a complex one, and for this reason it is not always possible to identify a particular attitude which is the crucial determinant of a specific behaviour. Other, important determinants may be at work: personal habits, social norms and a variety of other possible influences. Nevertheless, it would be difficult to sustain an argument that attitudes were not important determinants of behaviour.

Among psychologists (and, in particular, social psychologists) there is a measure of agreement about the essential features of the "attitude" construct. Shaw and Wright (1967) have defined an attitude as "a relatively enduring system of affective evaluative reactions based upon the ... evaluative concepts or beliefs which have been learned about the characteristics of a social object" (p. 10). The key element of the construct, as proposed by these authors, is the evaluative reaction. This aspect underpins most of the procedures which have been developed to measure attitudes in both psychology and education. Other conceptualisations of "attitude" have been suggested, particularly those in which two additional elements are proposed: a cognitive component and a behavioral component (Zimbardo & Ebbesen, 1977). The evaluative reaction to a psychological object, however, appears to be widely regarded as the crucial component of an attitude.

It is worth noting that the social psychological literature related to attitude and attitude change is quite large. Indeed, more that fifteen years ago, Shaw and Wright (1967, p. ix) claimed that attitude research occupies "a central position" in social psychology. Nevertheless, the research appears to have had only a limited impact on science education research in recent times, despite the long history of concern of science educators with science interests, attitudes, and values (Cooley & Klopfer, 1963; Cooley & Reed, 1961; Maw & Maw, 1970; Yager, Engen, & Snider, 1969). There are few examples of the application of theories of attitude change in science education contexts. Among the few recent exceptions is the work of Shrigley (1980) and Steiner (1980). A majority of science education researchers in recent years appear to be either unaware of these theories or alternatively, to regard them as not appropriate for application in an educational context, despite the exhortations to the contrary by Shrigley (1983a).

Shaw and Wright (1967) also make a distinction among beliefs, attitudes and values. In their view, a belief is clearly cognitive in character; it is the acceptance of a proposition that is held without emotional commitment. If an affective element is present, an attitude exists. That is, if a belief that a particular object exists is considered preferable or non-preferable to some extent, then the belief becomes an attitude. Values are generally regarded as being more enduring than attitudes, and are taken to underlie a person's way of life. Attitudes include the affective reactions which form part of the valuing process. Oskamp (1977) wrote that values are "important life goal or standards of behaviour for a person" (p.13).

Clearly then, the psychological study of attitudes has been stimulated by the view that a person's behaviour can be predicted from a knowledge of the person's attitudes. Although science educators do not generally state this position in explicit terms, a similar stimulus operates. This is clear from the research literature on students' science-related attitudes, to which we now turn.

2.2 SCIENCE-RELATED ATTITUDES: THE LITERATURE

A number of attempts (for example, Shrigley, 1983b, and Johnstone and Reid,1981) have been made to apply the psychological views discussed briefly above to science education. Other researchers have attempted to benefit from the well known taxonomy of the affective domain by Krathwohl (1964). Thus, Klopfer (1976) produced a two-dimensional taxonomy of affective objectives in science education using Krathwohl's taxonomy as one dimension and 'phenomena' as a second dimension. Klopfer indicated that the phenomena to which some affective behaviour was sought from the student could be divided into four categories: 'events in the real world', 'activities', 'science' and 'inquiry'. These divisions were sequenced so as to suggest "increasing formal, structural attention by the student to the phenomena in the successive divisions" (1976,p.301). More recently, Ormerod (1983) has developed a model which rejects Krathwohl's taxonomy, and replaces it with a hierarchy "described merely by increasing degrees of motivation". Thus there is a continuum from "inspiration to take further study on own initiative" at the positive end of the spectrum to "school destruction" at the negative end. No justification or rationale, however, is provided for the basis of the continuum. There are thus differing frameworks which have been proposed for the affective domain in science education, although these can only be described as tentative at present. Nevertheless, there are some basic distinctions which are of value to researchers in this area.

Attitudes to Science and Scientific Attitudes

Several authors have distinguished between attitudes to science and scientific attitudes. Thus Aiken and Aiken (1969) in a review of the literature on attitudes to science, discerned three dimensions of science-related attitudes: like vs. dislike of science; like vs. dislike of scientists and their activities; and adherence to "scientific method". The first two dimensions involve genuine attitudes (in the sense developed by Shaw and Wright (1967) and discussed earlier in this chapter) in that they involve an evaluative reaction to an attitude object. The third dimension is clearly more cognitively-oriented than affectively-oriented.

Gardner (1975a) distinguished between attitudes to science, within which he included interest, enjoyment and satisfaction, and scientific attitudes, dispositions such as 'tolerance of the views of others' which scientists are presumed to display in their scientific work. Thus he was distinguishing between attitudinal objectives which had a clear emotional component and those which did not. A similar distinction has been made by Moore and Sutman (1970). Thus, the attitudinal objectives labelled 'attitudes to science' involve an evaluative reaction which Shaw and Wright (1967) considered to be a key component of "attitude".

Curriculum writers commonly include the attainment of a number of "scientific attitudes" as objectives for science curricula. The SAPA II project lists as one of its objectives to "develop values, attitudes, value systems and value judgement criteria not only applicable to science-related experiences but transferable to day-to-day experiences throughout life" (SAPA II, 1975, p. 36). Other examples of these attitudinal objectives are "honesty in reporting data", "open-mindedness", "rationality", and "objectivity." These have been perceived by many science educators to be the attributes of scientists in their professional work and hence desirable as objectives for school science curricula. Various authors (Haney, 1964; Heiss, 1958; Kozlow & Nay, 1976; Nay & Crocker, 1971) have proposed lists of these "scientific attitudes". A number of these have been examined by Doran (1980) who pointed out that, while there is no "accepted" list of components of the "scientific attitude", several common elements emerge from the many schemes that have been developed. The literature related to scientific attitudes is quite large, as the review by Gauld and Hukins (1980) shows.

Gauld (1982) recently has examined the nature of scientific attitudes and their role in science education. He noted that there have been two types of argument proposed for encouraging particular scientific attitudes in students. The first is that students will learn about the scientific enterprise more effectively if they "act out" the role of the scientist. The second is that scientific attitudes are desirable personal attributes for all to have. In Gauld's view, both arguments assume that "scientists really are motivated by the scientific attitude as it is presented by science educators" (p. 111). However, he has cogently argued that this assumption is false. That is, the particular conception of the professional behavior of scientists held by science curriculum developers is "completely untenable and may, at best, be associated with the less successful scientist!" (p. 118). His arguments are based on studies of the psychology of scientists (Mahoney, 1979), the ethics of science (Mulkay, 1979) and historical case studies (Holton, 1978).

As well as the development of certain "scientific attitudes" among students, science curricula generally attempt to promote the achievement of positive student attitudes to science. Recently, Munby (1980) has indicated that "attitudes to science" is used as an umbrella term, because of the number of different psychological objects examined in research studies. Thus, papers which purport to be studies of attitudes to "science" in fact may be studies of attitudes to any one of the following: attitudes to science instruction, attitudes to science careers, attitudes to science itself or attitudes to specific science issues, such as "energy research".

Many variables have been investigated for their possible influence on student attitudes. The research literature in this area is quite large as is exemplified in the reviews by Gardner (1975a) and Ormerod and Duckworth (1975). More recent reviews have also appeared including a review of studies of preservice teacher attitudes by Morrisey (1981) and a review of research in the U.S.A. by Haladyna and Shaughnessy (1981). The present author undertook an early limited review (Schibeci, 1976) and, more recently, a comprehensive review for Studies in Science Education (Schibeci, 1984a). These reviews of variables which might influence attitudes have surveyed hundreds of studies, from which a small number of conclusions may be drawn. These are summarised below.

Variables Related to Science-related Attitudes

Many variables have been investigated for their possible influence on attitudes to science, including the following: academic ability and achievement (Gatta, 1973; Goiran, 1976; McBurney, 1975; Richardson and Stanhope, 1971; Wynn and Bledsoe, 1967); cognitive style (Wareing, 1981); creativity (Starr and Nicholl, 1975); curriculum materials (Choppin, 1974; Robinson, 1980; Welch and Walberg, 1972); kinetic structure (Simmons, 1980); learning environment (Fraser & Fisher, 1982; Haladyna, Olsen & Shaughnessy, 1982; Power, 1981); practical work (Yager, Engen and Snider, 1969); sex (Greenblatt, 1962; Hasan, 1975; Meyer and Penfold, 1961); and teacher in-service (Willson and Lawrenz, 1980). The studies noted here represent a very small sample of the literature devoted to research on science-related attitudes.

What conclusions can be drawn from this large body of literature? Ormerod and Duckworth (1975, p.4) drew a number of conclusions from their review. They first noted that a distinction should be drawn between the biological and physical sciences; they believed that the physical sciences, in particular, were perceived to be difficult by students. In addition, they drew the following conclusions on a number of variables which appeared to influence students' science-related attitudes:

- Interest in science ripens at an earlier age than interest in any other major area of study.(p.4)
- Practical work is one of the major attractions of science for pupils but discovery learning is an over-rated teaching strategy.(p.4)
- The attraction of the physical sciences for girls is far weaker than it is for boys.(p.4)
- The influence of the teacher is of great importance.(p.4)
- Science and scientists have acquired an unfavourable image in pupils' minds, due to the confusion of science as a discipline and its possible undesirable applications.(p.4)
- Home and family background can influence attitudes towards science (p.4).

Haladyna and Shaughnessy (1982) reported a meta-analysis of forty-nine attitude studies conducted in the U.S.A. between 1960 and 1980 with primary and secondary school students. They summarised their findings as follows:

> (a) There are small differences in attitudes for boys and girls;
> (b) sex interacts slightly with many variables but in no systematic way;
> (c) programs generally have a variable, positive effect on attitudes; and
> (d) some learning environment and teacher variables have been found to be highly related to attitudes. However, the evidence is not yet conclusive as to which of these teacher and learning environment variables are most predictive (p.558).

Haladyna and Shaughnessy's (1982) conclusions are based on a more restricted set of studies than those reviewed by Ormerod and Duckworth (1975). Thus, while the former conclude that sex differences are small, the latter suggest differences are more substantial, and it is especially important to distinguish between physical and biological sciences. Haladyna and Shaughnessy's conclusion that science programs have variable effects is supported by Gardner's (1975b) earlier review of the effect of science curriculum on attitudes. The recent review by Schibeci (1984a) also supports this finding. In addition, these reviewers agree that the teacher exerts an influence that cannot be ignored, although they do not concur on the particular ways in which the teacher might exert an influence.

If we summarise the major recent reviews of research on the variables which influence students' science-related attitudes (Aiken and Aiken, 1969; Gardner, 1974, 1975a, 1975b; Haladyna and Shaughnessy, 1982; and Schibeci, 1984a) we can draw the following tentative conclusions:

(1) The relationship between science attitudes and interests on the one hand and other educational variables (such as ability and intelligence) on the other is generally reported to be a weak one. The correlation coefficient between attitude and achievement is rarely reported to be higher than +0.3. The association between cognitive variables and attitudes is, very likely, a complex one and hence simple bivariate studies shed a limited amount of light only on this link.

(2) Comparatively few studies appear to have been conducted on personality-attitude relationships in science education. Those that have been conducted suggest that personality variables may have an important influence on student attitudes; this of course, is hardly surprising.

(3) Males generally hold more favourable attitudes to science than females. In addition, males usually display interest in physical science while females display interest in biological science.

(4) It appears that, in general, student attitudes to science (in terms of average scores for classes) decline with increasing grade level.

(5) The general pattern which emerges from studies of other structural variables (such as socio-economic variables) is that these do not appear to influence attitudes in a substantial, direct way. The influence of such variables is probably subtle and indirect; it is likely that such influences will be detected only in multivariate studies.

(6) Studies of the association between school variables (such as the learning environment) and attitudes to science are not as plentiful as one would expect. It is reasonable to expect that this class of variables would have a significant influence on attitudes, and that more studies of classroom climate in science classrooms would be fruitful. Those studies that have been reported so far support this view.

(7) There has been a very large research effort into the influence of various curriculum development projects and various instructional strategies on student attitudes. No unequivocal conclusions can be drawn from all this work, however, as the results reported by various researchers vary widely. It is, of course, difficult to isolate the influence of this group of variables from the influence of other variables.

On the last point, Heikkinen (1973) also observed that many studies (not confined to science education) revealed a decline in attitudes to school subjects during the year. He concluded: "A course which can merely sustain initial favourable attitudes during the school year would be making major advances in the affective domain of classroom learning!" (p.80). Hadden and Johnstone (1983) also noted a decline in attitudes and were moved to describe the first year of high school in Scotland as "the year of erosion [of attitudes]". (It should be noted, however, that they attribute the erosion mainly to the decline in the attitudes of the girls in the sample.)

It will be clear from this discussion that the task of reviewing the literature on science-related attitudes is, unfortunately, not especially rewarding because of the limited number of conclusions which can be drawn from such a large body of research. It is easy to sympathise with Mallinson (1977) who wrote: "A retrospective examination of the studies on attitudes leads to frustration" (p.167). The most cursory review of research on determinants of students' science-related attitudes will immediately reveal major weaknesses in the studies undertaken which are, unfortunately a feature of too many reports. Some of these weaknesses, mentioned briefly in the first chapter, will now be discussed more fully.

Weaknesses of Attitude Studies

Haladyna, Olsen and Shaughnessy (1982) list six problem areas in many research studies on science-related attitudes. These are the following: lack of a theoretical framework; varying definitions of attitudes; a lack of integrative research findings; a haphazard selection of variables; a lack of valid instruments; and poorly conceived, designed and analysed studies. Several of these problem areas are discussed in more detail below.

Lack of a theoretical framework. One problem which plagues attitude research in science education is the lack of a theoretical framework. This is despite the efforts of some scholars to develop a theoretical basis for attitude research. For example, theoretical frameworks have been developed for: attitudes (Shaw and Wright, 1967); for attitudes in science education (Brown, 1979; Klopfer, 1976; Ormerod, 1983); and attitude change (Johnstone and Reid, 1981; Oskamp, 1977; Shrigley, 1976, 1978, 1980; Steiner, 1980). There are thus a number of frameworks which may be used to guide research in this area.

Use of a limited number of variables. It is clear from the present review that a wide range of variables has been examined in the search for those which may have a substantial influence on students' science related attitudes. Nevertheless, there are some gaps. Reference was made earlier to Kremer and Walberg (1981) who noted the paucity of studies involving home and peer groups variables. Fortunately, more studies in this area are now beginning to appear, as can be seen in studies from Haladyna, Olsen and Shaughnessy (1983) and Simpson and Troost (1982). Furthermore, there are a number of influences such as that of the mass-communication media which may be important, but are difficult to assess (Lucas, 1983; Sadava, 1976). In this context, also, the need to study variables in the presence of other, potentially important variables, should be carefully considered. Educational phenomena are typically complex so that the study of simple relationships involving a limited number of isolated variables is not likely to result in important findings. Fortunately, the number of studies of simplistic relationships are now being published less frequently.

Use of too brief a 'treatment' period. Attitude studies in science education have involved periods from as brief as forty minutes (Mallon and Bruce, 1982) to those which last over a year. The practice of studying attitudes at the end of short periods (perhaps up to a month) is based on the assumption that attitudes can be changed (a reasonable assumption), that they can be changed relatively quickly, and that these attitude changes are stable, that is, they endure beyond the 'experimental treatment' period. This latter assumption must be validated empirically, of course, especially after very brief experimental treatments. Crawley and Krockover (1979) and Koballa (1982) have noted the problem of the durability of attitude changes. In his review of studies of the attitudes of student teachers, Morrisey (1981) noted:

> None of the studies tried to determine how long the exhibited change in attitude toward science and science teaching by elementary student teachers lasted. A determination that a certain course or treatment during a course results in a change of attitude toward science and science teaching does not indicate how long lasting the change is nor whether there will actually be any change in science teaching (p.173).

It is clear, then, that the use of very brief treatment periods is highly questionable until empirical support for the practice has been established.

Validity of the affective instrument. Mallinson (1977) wrote "Many of the attitude inventories are 'home-made' with little evidence of their reliability or validity" (p.168). The problem was also noted by Renner, Abraham and Stafford (1978) who said

> The continued proliferation of instruments is a necessary evil until a battery of well developed, reliable and valid instruments can be developed ... Some sort of critical evaluation of existing instruments needs to be made and continually updated (p.69).

Particular weaknesses in attitude instruments noted by Gardner (1975c) were: lack of a theoretical construct; the reduction of multi-dimensional attributes to a single dimension; and a lack of a logical connection between the scales used and the experimental treatments. Despite these criticisms, it is not unusual to continue to read reports of studies which used insufficiently validated instruments. For example, Simmons (1980) cites the use of an instrument to measure attitudes which was developed as part of a doctoral study. She wrote: "The validity of ... the Affective Test was attested to by four colleagues" (p.70); this was the only reported data on a validity determination. In a recent study of attitudes of college students toward chemistry and computers, Cavin, Cavin and Lagowski (1981) wrote that they considered "the items to have validity for measuring students' attitudes" (p.331). No information at all was given about the psychometric qualities of the instrument. Extensive evidence of the poor psychometric qualities of many attitude instruments has been provided by Munby (1980). He noted that in many cases no reliability measures were provided, nor were attempts made to establish convergent and discriminant validity. His conclusion was based on a survey of more than 200 attitude instruments. The continued use of a plethora of attitude instruments (the reliability and validity of which have not been convincingly established) is likely to have contributed to the inconclusive nature of the research evidence in this area. For this reason, particular care was taken in the present study to establish that the measures of science-related attitudes used were psychometrically sound.

Data Analysis and Theory Development

Reference has been made to studies which have been confined to the study of simple bivariate relationships. In the main, these have involved the study of the correlation between a dependent and an independent variable. For example, one teacher behaviour or a cluster of teacher behaviours is investigated for possible links with student attitudes. Tatsuoka (1973) has emphasised the weakness of such studies. He pointed out that in a univariate analysis the apparent effect of any particular variable on the criterion variable could be different from the effect that variable might have in the presence of other variables. He continued by stressing that methods were available for overcoming these problems, and that multivariate analysis, by considering all the variables simultaneously, sheds light on how each one contributes to the relation. He cautioned, however, against the uncritical use of sophisticated techniques that have become more readily available as "canned" computer programs.

The present study was designed to overcome the problem of investigating potentially important variables in isolation from one another. Recent advances in multivariate analysis have allowed the forging of links between data analysis and theory development. Boyle (1970) summarised the possibilities in this way:

> Rather than leaving data analysis and theory construction as two separate steps, these techniques provide a model in terms of which the theory is expressed, and then directly evaluate the model through the statistical procedures (p.461).

Boyle was referring specifically to path analysis. The method, wrote Wolfle (1980), requires the researcher "to think about a cause, particularly systems of intercausal connections ... and provides an explicit link between a priori theoretical notions of causal connection and quantitative estimates of causal impact" (p.183). He stressed the need for a theory which would provide a framework against which the results could be viewed.

Anderson, Ball, Murphy and associates (1975) have written "If a model is an accurate reflection of reality, path analysis can provide estimates of the strength of the causal connections ... It cannot generate the correct causal model from the data" (p.271). These methods, then, require a researcher to develop a mathematical model which can then be tested.

There have begun to appear an increasing number of studies of attitudes to science which have used multivariate methods to investigate both school and non-school influences. Among these are studies by Brown (1976), Haladyna, Olsen and Shaughnessy (1982, 1983), Power (1981) and Simpson and Troost (1982).

Many studies not specifically concerned with science education have indicated the importance of the influence of home, school and peer group variables on student cognitive and affective achievement, for example, Biddle, Bank and Marlin (1980), Cuttance (1980a, 1980b), Hauser (1971), Hoge and Luce (1979), Marjoribanks (1978a, 1978b, 1979), Peschar (1975), Portes and Wilson (1976) and Sewell and Shah (1968). Kremer and Walberg (1981), however, noted the paucity of studies on home and peer group influences on student learning in science:

> Science educators have paid little attention to student motivation, home environment, and peer environment variables in the study of science achievement. Nevertheless the consistent, positive direction of findings observed in studies of these constructs makes a strong case for their inclusion in future research. Student motivation, and home and peer environment factors appear to be important correlates of science learning. They deserve closer attention from the science educator since academic achievement associated with these constructs is subject to environmental intervention, either through instruction or counselling.
>
> The consistency and parallelism of results observed in studies of student motivation and home environment with previous work in general education suggests the need for further direct investigation of these constructs (pp.20-21).

Some of the general research related to these variables has been critically examined by Averch, Carroll, Donaldson, Kiesling and Pincus

(1974). They have pointed to some significant weaknesses in the studies reported in the literature including the following: the concentration on cognitive achievement to the exclusion of other, equally important outcomes; cost implications of research results have been ignored; classroom processes are not studied (Dunkin and Biddle, 1974, would certainly concur with this criticism); and finally, doubts about the validity of the measures of the constructs used in the studies. Despite these weaknesses in the studies reviewed, Averch <u>et al</u> (1974) believed that there was considerable evidence that non-school factors (such as students' socio-economic background) were important. In addition, they believed that, on the evidence available, these non-school factors may be "strong enough to 'swamp' the effects of variations in educational practices" (p.177).

Bryant, Glaser, Hansen and Kirsch (1974) reviewed a number of studies of the influence of background variables on educational outcomes as part of the National Assessment of Educational Progress sponsored by the Education Commission of the States in the U.S.A. These authors wrote:

> The principal large studies investigated show that one can expect to account for between 20 and 50 percent of the variation in academic outcomes (as measured by test scores) by variation in sex, race, home and family background, school characteristics and motivations, expectations, attitudes, and desires of individual students. Within this range there is substantial variation in association between background variables and outcomes, depending upon the nature of the outcome, the age group of the students, and the specific background factors considered. For example, sex is a more important predictor of scores in the twelfth-grade science than in science scores for ten-year-olds, or (let's say) scores in reading at any age (p.177).

Clearly, home and peer group variables may be fruitfully explored as possible determinants of students' science-related attitudes.

Important Features for a Study of Science-Related Attitudes

In order to avoid many of the pitfalls alluded to above, a research project in this area would need to incorporate a number of elements. Among the more important of these elements are that the study should:

(a) have a sound theoretical basis;

(b) include both school and non-school variables;

(c) include the study of a large number of relevant variables;

(d) use a longitudinal approach;

(e) allow the use of a multivariate analysis strategy; and

(f) be applicable in an Australian social context.

Fortunately, an appropriate conceptual framework is available for such a study, that developed by Keeves (1972) in his study of the influence of three educational environments (home, school and peer group) on attitudes and achievement in science and mathematics. The next section describes this framework and the modified form of it which was used in the present study.

2.3 A MODEL FOR THE STUDY

The framework developed by Keeves (1972) was particularly suitable because it had been developed and tested in an Australian context. This section describes the Keeves framework and then notes the ways in which it was modified to generate a specific model for the present study.

Keeves' Framework for the Study of Educational Attainment

In a study of educational attainment, Keeves (1972) developed a conceptual framework, based on the work of Bloom (1964) and Dahloff (1969), which identified three classes of educational environment: the home, the school and the peer group, as representing the major non-personal variables which are thought to influence student achievement. In this framework, three aspects of each of the three environments are regarded as being important, a structural dimension (relating mainly to socio-economic characteristics), an attitudinal dimension (relating mainly to expectations of respondents) and a process dimension (relating mainly to practices in the environment).

It is trite, but nevertheless true, to observe that educational phenomena are complex. The model developed by Keeves is an attempt to contribute to our understanding of some of the more important aspects of these phenomena. In simple terms, it postulated that changes in educational outcomes are a function of the type of environment, and the dimensions of the environment in which the student learns. Thus, student performance and attitudes are influenced by school, home and peer group variables. The complex inter-relationships postulated among the various elements of the model are illustrated in Figure 1. Keeves' model, however, goes beyond the analysis of possible influences on student learning. It postulates a set of causal links among student learning variables and the different dimensions of the educational environments.

Keeves thus postulated a model which was concerned with change in student performance over time. The antecedent conditions he identified were the initial level of educational achievement, general ability and attitude towards school learning. The performance outcomes which he investigated were final levels of educational attainment, attitudes and achievement. It is important to note that the model is not a simple input-output model. Rather, it is concerned with a complex set of inter-relationships among the variables.

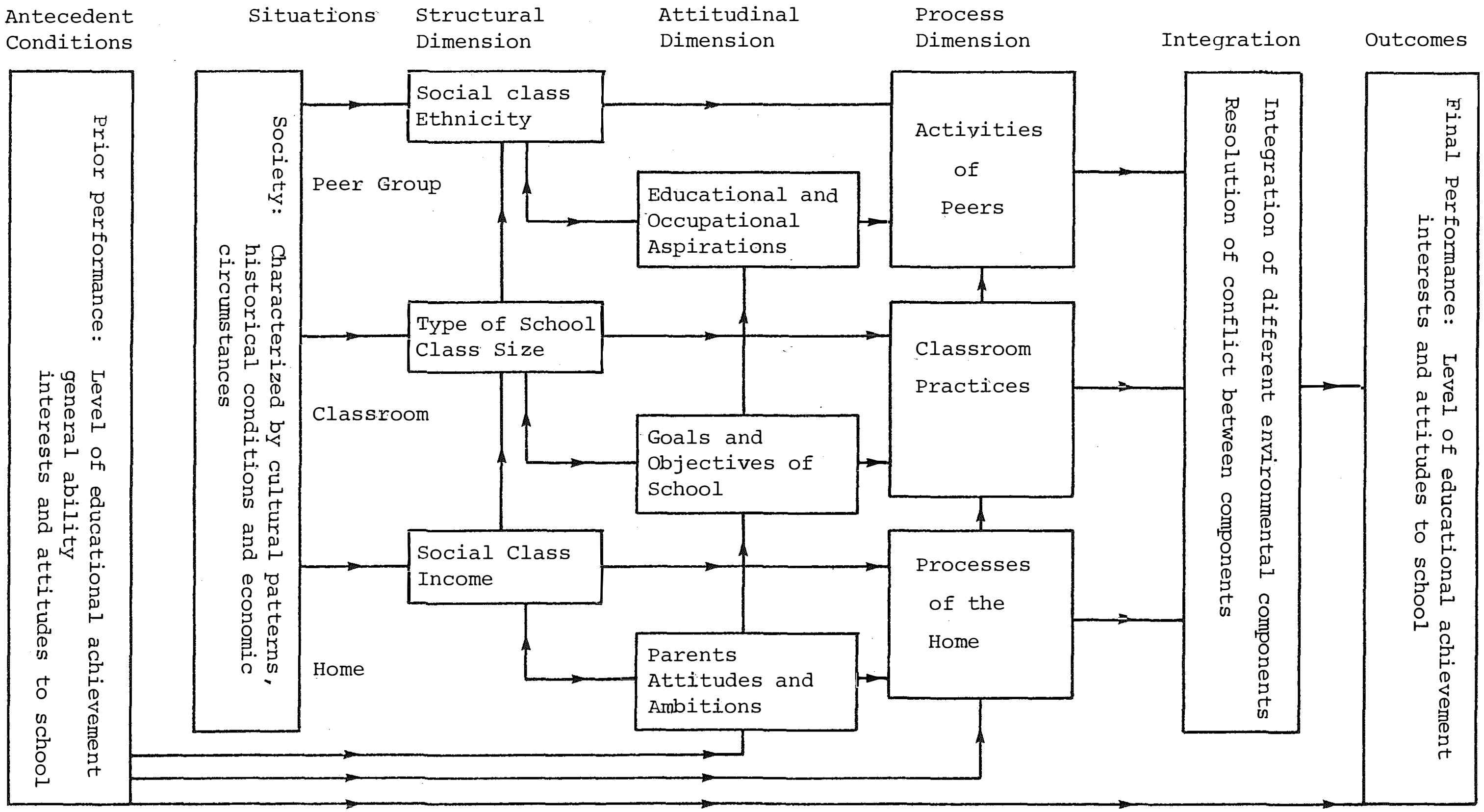


Figure 1

A Conceptual Framework for the Study of Educational Environments

(Keeves, 1972, p. 39)

In developing this conceptual framework, Keeves (1972) made a number of explicit assumptions. It is worth citing these assumptions:

- The subjects of inquiry are individuals, not groups of persons (p. 29).
- At every moment the individual is located within a unique environment and the behaviour of the individual is influenced by that environment (p. 29).
- The behaviour of the individual may be attributed to factors that are internal to the person (p. 30).
- An educational environment contains human actors who interact with and influence the behaviour of an individual in that environment (p.31).
- An educational environment is related to the characteristics of the society in which it is set (p. 32).
- The characteristics of an educational environment are influenced in part by its unique location in society (p. 32).
- The characteristics of an educational environment are related to characteristics of the principal actors in that environment (p. 32).
- Educational environments are characterized by some degree of constancy (p. 33).
- Educational environments are distinguishable from each other and differences between them can be observed in terms of specific characteristics (p. 33).
- Educational environments may be effectively characterized by a limited number of components (p. 35).
- Educational environments may be classified in terms of observable characteristics using both qualitative and quantitative information (p. 33).
- The effects of a given educational environment on an individual cannot in principle be predicted with certainty (p. 33).
- Earlier events influence later events and not vice versa (p. 34).

This set of assumptions appear to be eminently reasonable and to provide a sound basis for the present study.

It is interesting, in particular, to note the eleventh assumption, that is, both quantitative and qualitative data may be used to characterise educational environments. Quantitative data, as Keeves (1972) noted, have the advantage of being able to be incorporated into causal models. For this reason, Keeves chose to gather quantitative data only. He used a random sample of schools from which to draw his student sample of subjects for his study. The present study, on the other hand, was designed to allow an intensive study of two metropolitan high schools within a particular educational system (the government school system) of one Australian State (Western Australia). It was expected that an intimate knowledge of the two schools, built up during the study, could be used to understand in depth the causal models developed in the study. That is, this intimate knowledge could provide "flesh" for the "bones" of the causal model.

Keeves' (1972) model, then, proposed that students' prior achievement and attitudes influence their motivation and attentiveness, which in turn influence final achievement and attitudes. The model is an attractive one because it meets the *a priori* criteria discussed in the previous section. In summary, the model (i) has a sound theoretical basis; (ii) includes both school and non-school factors, unlike the majority of attitude studies; (iii) includes the study of a large number of relevant variables; (iv) incorporates a longitudinal aspect, suggesting a longer term study of science-related attitudes than is usual; (v) requires the use of multivariate analysis; and (vi) has been tested in an Australian social context with generally supportive results. This last criterion is especially important since models developed in other countries are less likely to be appropriate in Australia unless they have been tried out and received empirical support in a local setting.

Modifications to Keeves' Approach

A simplified model was developed from Keeves' detailed framework to fit with the setting and major concerns of the present study. This simplified model allowed specific causal models to be generated which could be tested against the data collected in the study. It is given in Figure 2. The model should be considered in conjunction with the assumptions cited earlier which were made by Keeves, and which were also assumptions of the present study. Among the more important assumptions is that educational environments are characterised by some degree of constancy. Thus, the home background variables are assumed to be constant during the full ten-month period of the study. These home variables may influence final outcomes directly as well as indirectly through the entry characteristics and a causal chain to the final outcomes. The school and peer group variables of this study, on the other hand, logically could not be expected to influence entry characteristics. They could, however, influence final outcomes directly as well as indirectly *via* the intermediate outcomes.

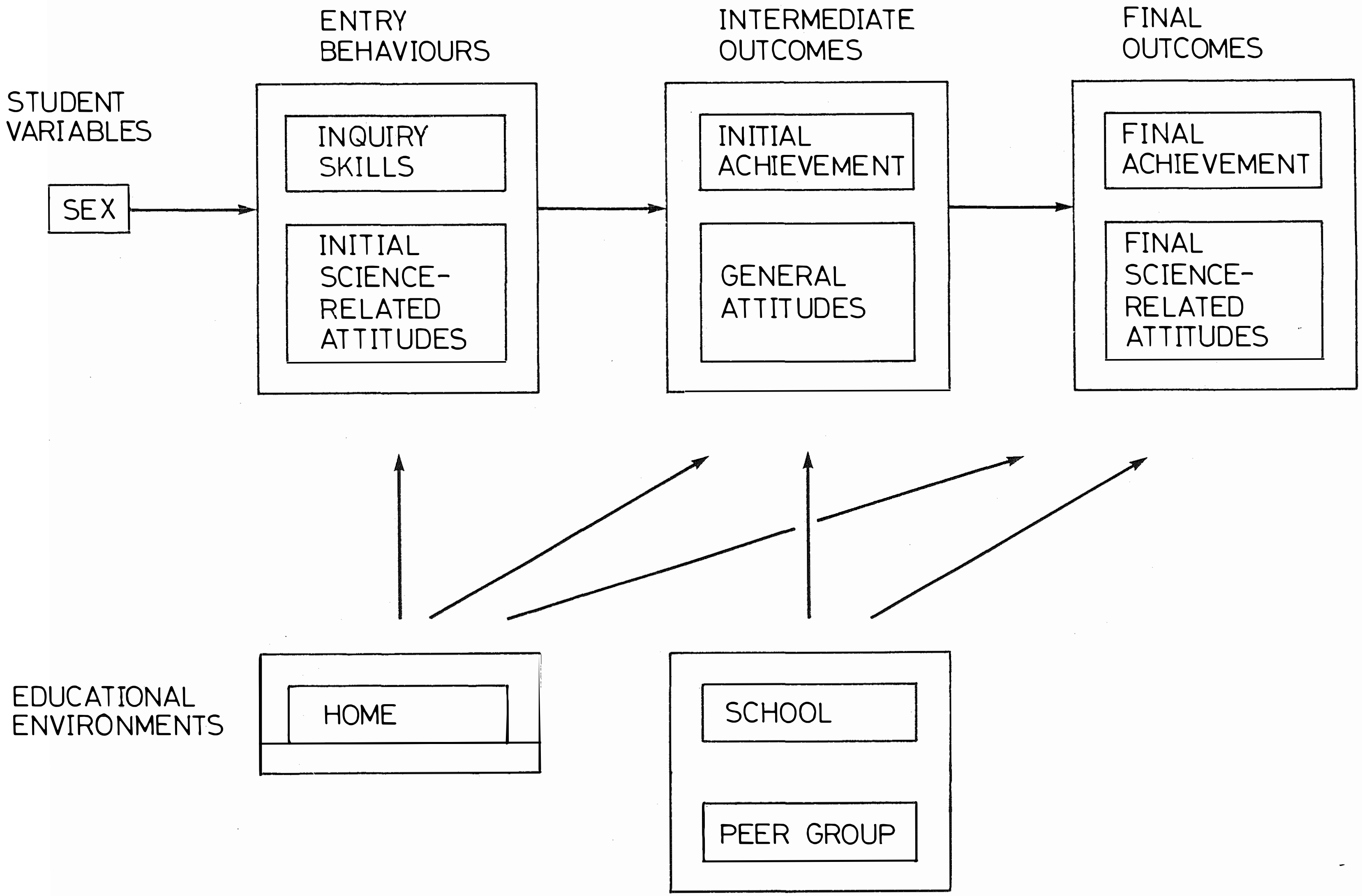


FIGURE 2. A MODEL FOR THE PRESENT STUDY

The model thus shows that the three educational environments may have <u>direct</u> as well as <u>indirect</u> influences on final outcomes (attitudes and achievement). That is, the environments may influence final outcomes directly, or may influence final outcomes indirectly through a causal chain. It also should be observed that the student variables are shown in a temporal sequence. Thus, initial attitudes may influence final attitudes, but, obviously, not vice-versa.

The most significant departure from Keeves' strategy is the use in the present study of all of the Year 8 students in two schools, rather than a small number of students drawn randomly from several different schools. The use of two schools, rather than a large number of schools (as Keeves had done) was done to enable a much fuller understanding to be developed of both the school and, to a lesser extent, the non-school environment of the children. The price paid was that the school process and structural dimensions examined by Keeves (1972) could not be included in the causal models developed in this study as there were fewer cases (17 classes in all) than variables.

A detailed knowledge of the school in which the students studied was considered important for the present study as it would provide background data against which the causal relationships revealed in the study could be examined. Such a detailed knowledge could not be gained for a large number of schools within the resources available for the present study. The methods used in obtaining this contextual information were largely qualitative.

Since 1972, when Keeves reported his findings, there has been much discussion relating to educational research methodology as evidenced by the work of Power (1977) and Welch (1983). Much of the debate has revolved around the merits (or otherwise) of both 'quantitative' and 'qualitative' research. In the present study, quantitative research methods were used as the main strategy; however, an important message of the many qualitative researchers related to the context of a study was <u>not</u> ignored. In this case the context of the study was judged to be important, suggesting that a multivariate study of the relevant quantitative variables needed to be supplemented with contextual information obtained through non-quantitative methods. Interviews, formal discussions and observations, and the inspection of relevant documents were all seen as being of help in painting a more complete picture of the educational context of the study.

The intensive study of the two school communities, rather than the study of a random sample of a larger set of schools, had the attraction of making the study more manageable. In addition, recognition would be given to the views of qualitative researchers who stressed that no particular perspective on educational phenomena could be ignored in our search for understanding.

Specific Features of the Model for the Study

Some of the features of the model depicted in Figure 2 should be highlighted. Thus, the home environment is separated from the other two educational environments. This is because it is hypothesised that the home environment influences entry characteristics, as well as the intermediate and final outcomes. On the other hand, the school and peer group variables cannot influence students' entry characteristics, as they are taken to begin operating later in the school year (after the initial testing). Obviously, previous school and peer group influences (from the student's primary school) could have an influence on entry behaviours, but these were not assessed in the present study.

The model in Figure 2 could be stated verbally in the following way. First, sex influences a student's entry behaviour, which in turn influences intermediate outcomes which (in turn) influence final outcomes. Second, the educational environment of the home influences entry behaviours, intermediate outcomes and final outcomes directly (in addition, there is the indirect influence of the home on final outcomes through entry behavours and intermediate outcomes). Third, the school and peer group educational environment directly influence both intermediate outcomes and final outcomes.

It is useful also, given the use of particular schools in the present study, to draw attention to the notion of 'local theories'. Snow (1977) considered the possibility of a general instructional theory, but wrote "there would never be a general, top-down instructional theory, created in academia and applicable, or inapplicable, in particular schools" (p.12).

Rather, he advocated the development of a "local instructional theory" which would apply in specific locations, for specific parts of the curriculum and for specific sub-groups of the population. Further, he added that "such theories would be intended to generalize more across time in one place than across places" (p.12). Cronbach (1975) also wrote of the value of not making generalization "the ruling consideration in our research". Instead, he urged the researcher to "look within his data for local effects" (p.124).

These proposals of Cronbach (1975) and Snow (1977) are interesting in the context of the present study. One could wonder whether, in fact, the two schools were sufficiently similar so that one sample could be used to develop a causal model which could be subsequently cross-validated using the data from the student sample from the second school. Presumably, the notion of a "local theory" would tend to work against this, that is, local specific theories may make cross-validation less likely. Thus, while the investigation of influences on student attitudes was the central concern of the present study, the study also provided an opportunity to investigate in a limited way the 'local theory' notion with respect to the science-related attitudes and achievement of Year 8 students.

In summarizing, then, the strategy developed for this inquiry was designed to overcome the major weaknesses of many studies of science-related attitudes. A summary of the preliminary investigations to the main inquiry and the details of the procedures followed in the main study are given in the next chapter.

CHAPTER 3

METHODS AND PROCEDURES

This chapter describes briefly some of the investigations which were preliminary to the main study. As well, it provides a summary of the procedures, the characteristics of the sample and the data analysis methods used in the main study.

A number of preliminary investigations were conducted before the main study was carried out. The first investigation was designed to gather teachers' perceptions of curriculum objectives for Lower School Science in Western Australia. The second investigation, which compared the use of Likert scales and semantic differential instruments for measuring science-related attitudes, showed that Likert scales were the more appropriate for this study. The third investigation was designed to validate empirically the conceptual structure of the Likert scale finally used to assess science-related attitudes. Reports of this preliminary work have been published, so brief summaries only will be presented here. Copies of these published reports are given in Appendix 1.

3.1 SUMMARY OF PRELIMINARY INVESTIGATIONS

Teachers' Perceptions of Lower School Science

Few studies have investigated science teachers' perceptions of curriculum objectives in general, and attitudinal objectives in particular. In one investigation, Taylor and Maguire (1967) studied the congruence of perceptions of science curriculum objectives of teachers, subject-matter experts and curriculum writers. In another investigation Carey (1977) compared the perceptions of students and teachers. In both cases, however, the objectives were those proposed by the researchers and were not necessarily objectives of the science curricula actually being implemented by the teachers. In the initial preliminary investigation conducted by the present author, science teachers in Western Australia were asked to give their views of the objectives of the curriculum (for years 8 to 10) they were implementing on a daily basis, that is, on what should have been a set of familiar objectives. It was expected that the science teachers' views would provide important information for use in planning the main study.

The teachers' perceptions of science curriculum objectives were gathered by survey and interview procedures. Summaries of the methods and results of this preliminary investigation are included in the first two published papers given in Appendix 1 (Schibeci, 1981a, 1981b). Both questionnaire and interview data supported the research hypothesis that science teachers regard the cognitive objectives of the science curriculum for years 8 to 10 as more important than the affective objectives. The interviews, in addition, provided many valuable insights into science teachers' perceptions of attitude objectives which could not have been gained from the questionnaires alone. Teachers interviewed indicated quite clearly that they made no systematic attempts to teach towards affective objectives. Professional and biographical characteristics of interviewed teachers suggest that they are a representative sample of their colleagues. This implies that little attempt is made to implement all aspects of the science program specified in the curriculum guide. A further conclusion from this study of perceptions of science-related attitudes is that science teachers are confused and can articulate their views in a poor fashion only. The teachers' lack of clear thinking on the issues is a reflection (at least in part) of the confusion shown by writers in this area as revealed, for example, by Brown (1979) and Gauld and Hukins (1980).

The Measurement of Science-related Attitudes

The central concern of the main study reported in this thesis was to identify the influence of several home, school and peer group variables on student outcomes in science, particularly student attitudes. The first problem which had to be addressed was the procedure to be adopted in assessing students' attitudes. A number of suitable methods is available to the researcher. Gardner (1975a), in his review of the research on attitudes to science, described the following methods: differential (Thurstone) scales, summated rating scales, semantic differential scales, interest inventories, preference rankings, projective techniques, the use of subject enrolment data and anthropological observation.

It was determined that the procedure chosen should meet two criteria. The first important criterion was that the instrument should be of adequate reliability and validity. The second criterion was that it should be possible to administer the instrument economically to a group of students (an intact class). Both the semantic differential and Likert scales have been used in science education research previously and each procedure was judged likely to meet the two required criteria.

A preliminary study (Schibeci, 1982a) compared these two methods for assessing attitudes to science, and it is described in detail in the third paper provided in Appendix 1. The Likert scale which was used was the Test of Science-Related Attitudes (TOSRA) developed by Fraser (1978). The semantic differential (SD) was based on an earlier study (Schibeci, 1977), using scales chosen from a pool including some reported by Yamomoto, Thomas and Karns (1969) and by McCallon and Brown (1971).

Discussions with students who responded to each instrument indicated that the SD allows an assessment of general attitudes to concepts such as "school" and "science". The Likert format used in TOSRA, on the other hand, allows a more fine-grained assessment of specific attitudes. For example, the "Social implications of science" scale in the TOSRA instrument requires students to respond to a set of ten statements, the meanings of which are quite clear. The SD concept "Science in society", on the other hand, allows a wide diversity of interpretations among students. The highest correlation coefficient for the corresponding scales, 'Science lessons'/'Enjoyment of science lessons', may be explained (in part at least) by the unambiguous nature of the concept for the students in the sample.

It seems that the semantic differential and Likert scales may not be used interchangeably, as has been suggested by some authors. Heise (1977), in a review of the use of the semantic differential procedure in attitude research concluded

> Most studies provide confirmation that the SD [semantic differential] can be used to measure attitudes. Too little methodological research is available to decide whether SD ratings always provide as sensitive a measure of attitude as is given by traditional scales (p.247).

The data gathered in this preliminary investigation indicates that semantic differential scales may not be as sensitive as Likert scales, and that it is unlikely that the two methods can be used interchangeably with high school students.

Researchers who look to the literature for guidance in choosing a particular technique for attitude assessment need to be particularly aware that much educational research (especially in the U.S.A.) tends to be conducted with post-secondary students. For example, West and Robinson (1980) found that of the eighty-eight empirical articles they selected at random from three widely-read journals (American Educational Research Journal, Journal of Educational Psychology and Journal of Educational Research), seventy-four involved college students. Similarly, the study by McCallon and Brown (1971) which compared the semantic differential and a Likert scale used a sample of college students. The researcher needs to apply caution in generalizing such results to high school student samples, particularly at the junior high school level.

The results of this preliminary investigation, which compared semantic differential and Likert scales, suggested that a Likert scale would be the more appropriate of the two procedures. Likert scales appear to be suitable in the assessment of specific science-related attitudes, whereas the semantic differential is suitable when global attitudes are to be assessed. For this reason, TOSRA was chosen as the measure of science-related attitudes in the present study. (It should be mentioned that the TOSRA subscales, each of which has ten items, gave satisfactory values for Cronbach's alpha in this preliminary investigation. The values ranged from 0.68 to 0.88, as shown in Table A2.3 in Appendix 2).

Conceptual Structure of TOSRA

The conceptual structure of TOSRA was investigated empirically (Schibeci and McGaw, 1981). This involved separate analyses of student responses to TOSRA and of teacher categorisations of the TOSRA items. Fraser (1978) developed TOSRA to have seven distinct sub-scales, but the analysis of the student responses did not support this contention. However, an analysis of teacher categorisations of the TOSRA items by latent partition analysis (Hartke, 1979; Wiley, 1967) did provide support for it.

The 70 items of the Test of Science Related Attitudes (TOSRA) were given to 1041 students who responded directly to them as attitude test items and to 39 teachers who were asked to assign the items to categories, without directions about either the number of categories to be used or the criteria to be employed in establishing them.

Direct tests of the subscale structure of the total test were obtained through confirmatory factor analyses of the 70 x 70 inter-item correlation matrix of the student response data by using LISREL IV (Jöreskog and Sörbom, 1978). In the first analysis a seven-factor solution was imposed with each item loading only on the factor corresponding to its subscale. All other factor loadings were fixed at zero, and the factor correlation matrix was fixed as an identity matrix to produce an orthogonal solution. Starting values for the non-zero factor loadings were obtained from an exploratory principal axis factor analysis with varimax rotation using the SPSS programme (Nie, Hull, Jenkins, Steinbrenner and Bent, 1975). This seven-factor model did not fit the data (χ^2 = 19695, df = 2345, p < .001). A five-factor model, in which subscales 5, 6 and 7 were collapsed into a single subscale, was then tried, but it also did not fit the data (χ^2 = 17411, df = 2345, p < .001). The subscale structure of the test clearly cannot be recognized in the response patterns of students taking the items. The evidence that the true intercorrelations among the subscales were less than unity clearly does not justify any assertion that seven distinct subscales could be identified in responses to the test.

The teachers' categorizations of the items were analysed by latent partition analysis. For each teacher, a manifest partition was obtained as a category X items matrix with ones and zeros indicating item inclusion in a category or exclusion. For the judges in this study, the number of categories used varied from three to fourteen with a median of six. A joint occurrence matrix was then obtained for each judge by premultiplying the manifest partition matrix by its transpose. Each judge thus had a 70 x 70 joint occurrence matrix of ones and zeros with each one indicating that the items heading the row and column corresponding to the cell were classified in the same category by that judge.

A mean joint proportion matrix was then formed as the mean of the 39 joint occurrence matrices. This 70 x 70 matrix thus contained elements which could have values between zero and one. Its dimensionality could be explored by factor analysis in the same manner as that of a correlation matrix. A seven-factor solution was imposed using LISREL IV with each item permitted to load only on the factor corresponding to the subscale of which it was a member.

This seven factor model fitted the data well (χ^2 = 2355, df = 2345, p < 0.44) A five factor model, in which subscales 5, 6 and 7 were collapsed into a single subscale, was also tried but did not fit the data (χ^2 = 2920, df = 2345, p < .001). The original structure of the test, with its seven subscales, could clearly be recognized in the teachers' categorizations of the items.

These separate analyses of student responses and teachers' categorisations make it clear that, although the developer's factor structure is not evident in the response patterns of students, it is present in the conceptual framework of the teachers. The case for maintaining the separate subscales can thus be more strongly based on their conceptual distinctiveness than on their operational distinctiveness in the measurement of student attitudes.

Values of Cronbach's alpha for the TOSRA subscales were also computed in this investigation. These values ranged from 0.68 to 0.91. As a result of these analyses, it was clear that TOSRA could be used with some confidence. (A copy of the paper describing this preliminary inquiry is provided in Appendix 1.)

3.2 THE STRATEGY FOR THE MAIN STUDY

The preliminary investigations described above provided a number of important guidelines for the conduct of the main study in which the influence of home, school and peer group variables on student outcomes (especially attitudes) in science was investigated. The remainder of this chapter describes the salient aspects of the research strategy, the sample used and the procedures for data analysis. Details of the variables used in the study are given in Chapter 4, including appropriate data on reliability and validity.

The conceptual framework developed by Keeves (1972), outlined in Chapter 2, provided a model for the investigation. It will be remembered that Keeves postulated that environmental factors were crucial in student learning. In particular, his review of the relevant literature led him to the conclusion that three environments were worthy of careful investigation: the home, the school and the peer group. Each of these settings was believed to provide a distinctive environment. Further, it was postulated that each of these environments was characterised by a structural, a process and an attitudinal dimension. An important task for this study was to identify variables which would provide reliable and valid indices for each dimension of each environment. The procedures used in gathering data on variables reflecting each of the three environments will be described in turn.

Students in their first year of secondary education in Western Australia (generally referred to as Year 8) formed the sample for the study. The students attended one of two Perth metropolitan high schools. These schools will be referred to as Acacia Senior High School and Boronia Senior High School, respectively. There were nine Year 8 classes at Acacia and eight Year 8 classes at Boronia. Intact classes were used. Furthermore, there was no external treatment applied to any of the classes. The study was "naturalistic", longitudinal and non-experimental, and was conducted over a period of one school year.

The first year of secondary schooling was chosen for this study since it was hypothesised that the distinct change of educational environment experienced by students in their transition from primary to secondary school would result in a distinct change in learning outcomes during this year. The procedures used to assess the variables which provided indices of the dimensions of the educational environments will be outlined in turn. Information related to the reliability and validity of the data are provided in the next chapter. A summary of the data gathering occasions during the 1980 school year is given in Table 1. Copies of the instruments used in the study are provided in Appendix 2.

The Home

Data on the three dimensions of the home environment of each child were gathered by survey methods. A questionnaire based on Keeves' (1972) interview schedule was developed and was sent by mail with an explanatory letter early in July, 1980 directly to the house of each child. The questionnaire was to be completed by the child's mother and returned in a stamped, self-addressed envelope.

The initial response rate was 38.6 per cent. After making follow-up contact on two occasions, using either telephone or mail, the response rate rose to 71.6 per cent. These response rates are expressed as a proportion of the total possible responses.

In order to assess the consistency of the information from the questionnaire, a mother who had replied was chosen at random from each class. Each of these seventeen mothers was interviewed by one of two female graduate research assistants. It was considered that the mothers would feel

Table 1

Data-gathering Occasions, 1980

Testing Occasion	Information Gathered
February	TOSRA, Test of Science-related Attitudes
March	TOES, Test of Science Enquiry Skills
April	Formal Interview with each Science Teacher
May	Initial Achievement Data
June	Peer Group Data
July	Home Background Data
August	OPINIONS, Test of General Opinions
October	TOSRA (post-test)
November	Formal observation of Science Classes Final Achievement Data

more willing to discuss the relevant issues with a person of the same sex. The responses given by the mothers during the interviews were then compared with the corresponding responses on the questionnaire. A small number of discrepancies (less than five per cent) occurred on those items which were open-ended. Although the proportion of the mothers who were interviewed was small, the results did provide a degree of confidence in the questionnaire responses.

The School

Since the student was to be the unit of analysis, the indices of the structural and process dimensions of the classroom used by Keeves (1972) could not be employed in this study. These data would have been the same for all the students within any one classroom, that is, there would have been seventeen data points only. Keeves, on the other hand, had eighty of these data points, one for each of the eighty classes studied. Nevertheless, data were collected which related to these two dimensions of the classroom. The methods used to collect these data were the following: one formal and many informal interviews with each teacher; observation of the materials in the classroom or laboratory; and informal observation of classroom behaviour. Although these data were not included in the causal models generated in the study, they did provide a much wider perspective from which to interpret these causal models.

The attitudinal dimension of each environment may relate to the expectations of the relevant respondents. Keeves (1972) did not attempt to assess the attitudinal dimension of the classroom because he had decided that "there was no clear lead as to which aspects of the attitudinal dimension were relevant to the present investigation" (p.83). In the present study, however, it was considered reasonable to use students' own asssessments of their educational and occupational expectations as relevant indicators of the attitudinal dimension. These attitudinal data (unlike the structural and process data) were available for individual students and could therefore be included in the generation of causal models.

The Peer Group

Peer group data were collected in June, 1980. The students had had more than a full school term in which to establish friendships. Every student was asked to complete a questionnaire that sought information which would allow the structural, process, and attitudinal dimensions of the peer group environment to be assessed, as suggested by Keeves (1972). The questionnaires were administered by the author to each class.

The students were also asked in the questionnaire to nominate their three best friends in Year 8 at that school. Since every Year 8 student was included in the study, data for nominated friends was readily available.

3.3 THE SAMPLE

As indicated previously, the Year 8 cohort at two high schools in the Perth metropolitan area formed the sample for the main study. The schools chosen were in two quite different socio-economic areas of Perth (Sanders, 1973) so that a diverse range of home and peer group environments related to the students' educational experiences could be considered in the study. In addition to this main sample there were two adult groups, the teachers who taught Year 8 science classes and the parents of the students.

The use of two schools provided the possibility for investigating the notion of "local theories" as suggested by Cronbach (1975) and Snow (1977). A causal model generated and tested in one school was cross-validated in the second school. The extent to which it was difficult to cross-validate the causal model on the second school could be an indication of some support for "local theories".

The Schools and Their Communities

Recent demographic data, based on the 1976 census, were obtained from the Australian Bureau of Statistics, an agency of the Australian Government. The Bureau was asked to provide data on the "catchment" area of each school. Boronia had a well defined catchment area, but Acacia did not. However, boundaries were drawn up based on the location of Acacia's "feeder" primary schools. In each case, the Bureau was able to abstract data collected during the 1976 census to provide a profile of the area. The profiles are not exact because the Bureau's collection districts did not coincide precisely with the catchment areas of the two schools. In addition, the Bureau data are some years out of date. Nevertheless, it is possible to obtain a perspective from this information on some of the differences between the two areas.

A number of differences between the two areas, based on the Bureau's data, are highlighted in Table 2. The data suggest the classification of Acacia as a middle class/working class area and of Boronia as an upper socio-economic class area. The Boronia area had a larger proportion of people in the professional and technical occupations (doctors, teachers, nurses, medical technologists) than did the Acacia area. A majority of workers in the

Acacia area, on the other hand, are labourers or process workers. It can also be seen from Table 2 that the proportion of people for whom English is the only language is larger in the Boronia area than in the Acacia area. This is reflected in the much higher proportion of students at Acacia who report that a language other than English is spoken at home.

In both schools, the different groups of students studied science topics in different orders. This was done in an attempt to reduce the demand at any one time for the particular sets of equipment required for a topic. The students at Boronia studied one biological science topic each term. On the other hand, the students at Acacia studied a biological science topic during one of the three school terms only, while physical science topics were studied during the remaining two terms. Since there is some evidence that the biological and physical sciences are perceived differently particularly by girls, this may have had some influence on the students' attitudes. This effect could not be quantified in this study because student attitudes were measured on two occasions only, at the beginning and at the end of the year and not after each topic.

3.4 DATA ANALYSIS

It is now widely recognised that simple input-output or pretest-posttest models are inadequate for the analysis of data gathered in a study of complex phenomena in social and behavioural research. Several multivariate analysis strategies, as indicated in Chapter 2, have been directed to the elucidation of these complex phenomena. These include multiple regression, canonical

Table 2

Socio-Economic Characteristics of the Acacia and Boronia School Catchment Areas

		Percentage of the Population	
	Socio-economic Characteristic	Acacia	Boronia
1.	English is only Language	80.5	92.6
2.	Attend University or CAE	24.3	60.7
3.	Hold a Bachelor's Degree or Higher Qualification	0.5	5.5
4.	Personal Annual Income of $12,000 or more	2.3	11.7
5.	Self-employed or Employers	3.6	6.3
6.	Are Employees	36.6	37.5
7.	Have Professional or Technical Occupation	5.4	22.8
8.	Are Process Workers or Labourers	43.1	15.8

correlation and path analysis. Keeves (1972) used canonical correlation analysis to construct causal models from his data. However, recent developments in multivariate analysis have provided more elegant routes to causal models.

Causal Modeling

One strategy for drawing causal interferences from correlations among observed variables is path analysis. It was developed by the geneticist Sewall Wright in the 1920s and subsequently introduced into the social sciences by the sociologist O.D. Duncan in the 1960s (Kenny, 1979). This procedure is "a method for explicitly formulating theory, and attaching quantitative estimates to causal effects thought to exist on a priori grounds" (Wolfle, 1980, p. 183).

The notion of "causality" needs to be examined briefly in this context. Blalock (1964) offered a working definition of "cause" which is useful in causal modeling procedures:

> If X is a cause of Y, we have in mind that a change in X produces a change in Y and not merely that a change in X is followed by or associated with a change in Y (p.9).

The notion of producing a change was seen as crucial; mere juxtaposition of X and Y was insufficient. Thus, night follows day, but it could not be said that day "causes" night. On the other hand, a change in rainfall (within certain constraints) results in a change in wheat yields, but not vice versa. This latter example illustrates the importance of a temporal sequence; it helps to resolve the direction of influence (does X influence Y or does Y influence X?).

Blalock (1964) also discussed the notion of direct and indirect causes. Thus a variable X could have a direct effect on a variable Y, or it could have an indirect influence by influencing a mediating variable, which in turn could influence the criterion variable. He noted that this formulation was not completely satisfactory, but that it provided a guiding framework for researchers. "Cause" is thus used in a restricted sense. Asher (1976) summarised it in this way, "Causal modeling attempts to resolve questions about possible causes - providing explanations of phenomena (effects) as a result of previous phenomena (causes)" (p.5).

In path analysis, a set of structural equations is proposed as a model to explain causal links among the variables which characterise the phenomenon. In early sociological studies, the inter-relationships among observed variables was commonly studied. More recently, however, it has become possible to construct models in which the causal relationships are taken to be among latent or hypothesised variables of which the various observed variables are manifestations. This procedure has been labelled "causal modeling with latent variables" (Bentler, 1980). The statistical methods required in structural equation models of this kind go well beyond conventional regression analysis and the the analysis of variance (Jöreskog and Sörbom, 1978). The methods are generally referred to as the analysis of convariance structures.

In a structural equation model, unknown parameters are estimated so that the variances and covariances of the variables in the model match the data. Model parameters cannot be estimated without a computer program because no algebraic solution is available. Rather, the researcher provides initial estimates ("starting values") which are refined through interative approximations by the program. Two criteria are available for the iterative procedures, least squares and maximum likelihood.

<u>The LISREL Model</u>

The maximum likelihood method is used to estimate the parameters in the computer program LISREL IV (Jöreskog and Sörbom, 1978). The theory on which the program is based was initially proposed by Jöreskog (1973), and then developed in Jöreskog, (1977). The model underlying this program can be used to estimate a variety of causal models, including those containing errors in latent variables (errors of measurement). Errors in equations (residuals) must also be allowed for. The LISREL model can be used to investigate path analysis (including recursive) models, and factor analytic models.

The LISREL model thus enables the researcher to analyse causal networks with latent variables, measurement errors and reciprocal causation. It assumes that there is a causal structure among a set of latent variables and sets of observed variables are manifestations of these latent variables of "hypothetical constructs". The model is described by the model which specifies the structural relationships among the latent variables <u>(the structural equation model)</u> and the model which specifies the relationships among the latent and observed variables <u>(the measurement model).</u>

In the LISREL model there may be any number of measured and unmeasured variables and these are expressed in the parameter matrices. These matrices are presented in Table 3, which is adapted from Carmines and McIver (1981). The structural equation and measurement models in LISREL can be summarised succinctly in terms of these parameter matrices. The relationships among the matrices are given in Figure 3.

Several assumptions underlie the LISREL model, and these have been highlighted by Munck (1979) as follows: the residuals are uncorrelated with the latent dependent variables; the errors of measurement are uncorrelated with the latent variables and with the residuals; the means for the latent variables and for the residuals are zero (that is, the variables are measured as deviations from their means); and the coefficient matrix Beta is non-singular. The three equations given in Figure 3, together with the five assumptions above, constitute the LISREL model.

The latest version of the computer program for the LISREL model available to the author was LISREL IV (Jöreskog and Sörbom, 1978). The authors of LISREL claim that, in principle, the program can analyse data and models of any size; the only limitation is the total memory space in the computer.

Estimating Goodness-of-Fit

LISREL IV estimates unknown parameters in the model by maximising the likelihood ratio. That is, the program calculates the likelihood

Table 3

Variables and Matrices in LISREL
(adapted from Carmines and MacIver, 1981, p74)

	Symbol	Definition
I. Observed Variables	y	observed dependent variable/indicators of latent dependent variable
	x	observed independent variable/indicators of latent independent variable
II. Latent Variables	η (eta)	latent dependent variable
	ξ (xi)	latent independent variable
	ζ (zeta)	errors in structural equation
	ε (epsilon)	errors in measurement of dependent variable
	δ (delta)	errors in measurement of independent variable
III. Matrices	$\utilde{B}$ (beta)	coefficient matrix of latent dependent variables
	$\utilde{\Gamma}$ (gamma)	coefficient matrix of latent independent variables
	$\utilde{\Lambda}$ (lambda y)	factor matrix of y on η
	$\utilde{\Lambda}$ (lambda x)	factor matrix of x on ξ
	$\utilde{\Phi}$ (phi)	variance-covariance matrix of latent independent variables
	$\utilde{\Psi}$ (psi)	variance-covariance matrix of structural errors (variance-covariance matrix of factors in factor analytic models)
	$\utilde{\Theta}_{\varepsilon}$ (theta epsilon)	variance-covariance matrix observed dependent variables
	$\utilde{\Theta}_{\delta}$ (theta delta)	variance-covariance matrix of errors of measurement of observed independent variables

Structural equation model

$$\underset{\sim}{B}\underset{\sim}{\eta} = \underset{\sim}{\Gamma}\underset{\sim}{\xi} + \underset{\sim}{\zeta} \qquad (1)$$

where $\underset{\sim}{B}$ and $\underset{\sim}{\Gamma}$ are coefficient matrices of direct causal effects, and $\underset{\sim}{\zeta}$ is a random vector of residuals.

Measurement model

$$\underset{\sim}{y} = \underset{\sim}{\Lambda}_y\underset{\sim}{\eta} + \underset{\sim}{\varepsilon} \qquad (2)$$

$$\underset{\sim}{x} = \underset{\sim}{\Lambda}_x\underset{\sim}{\xi} + \underset{\sim}{\delta} \qquad (3)$$

where the parameter matrices $\underset{\sim}{\Lambda}_y$ and $\underset{\sim}{\Lambda}_x$ are the regression matrices of $\underset{\sim}{y}$ on $\underset{\sim}{\eta}$ and $\underset{\sim}{x}$ on $\underset{\sim}{\xi}$, respectively.

Note. The covariance matrices of $\underset{\sim}{\xi}$, $\underset{\sim}{\delta}$, $\underset{\sim}{\varepsilon}$ and $\underset{\sim}{\delta}$ are, respectively, $\underset{\sim}{\Phi}$, $\underset{\sim}{\Psi}$, $\underset{\sim}{\Theta}_\varepsilon$, $\underset{\sim}{\Theta}_\delta$.

Figure 3

The LISREL Model

that the observed correlation matrix would actually be obtained from a sample of observations if the population values were those currently estimated. The parameter values ultimately produced by the program are those which make this likelihood a maximum.

In the program, it is actually the logarithm of the likelihood which is maximised which minimises a fitting function, F. The minimum value of this function (F_o) provides a value for chi-square which is used by the program to assess the goodness-of-fit of the model to the data as follows:

$$\chi^2 = \frac{N}{2} F_o$$

Where N = sample size; and

F_o = minimum value of fitting function.

The number of degrees of freedom is given by:

$$d = \tfrac{1}{2} \quad (p + q) \quad (p + q - 1) - t$$

where p and q are the numbers of y- and x-variables respectively, and t is the number of independent parameters in the model.

It should be emphasised that relatively small χ^2 values indicate a model which fits the data well, while relatively large χ^2 values indicate poorly-fitting models. This is, of course, precisely the opposite of the usual situation. Normally, the researcher seeks a large value of χ^2 to indicate that a model which specifies a particular relationship differs from the null model (no relationship). In the present case, two variance-covariance matrices are compared, the matrix implied by the theoretical model and the observed matrix. Small χ^2 values indicate good fit of model and data (Carmines and McIver, 1981).

A large value of chi-square, compared to the number of degrees of freedom, reveals that the model does not fit well and suggests a relaxation of the model is required. That is, paths which are fixed may be relaxed, provided this is substantively meaningful. The results of the initial analysis will suggest ways in which this can be achieved. Large first order derivatives of the fitting function with respect to fixed parameters reveal those fixed parameters which can be relaxed, with greatest gain in the estimated likelihood. The overriding consideration must at all times be that such relaxations of the model are substantively meaningful.

Relaxation of the model results in a new model with a smaller value for chi-square. "A large drop in the value of chi-square, compared to the difference in degrees of freedom, represents a real improvement" (Jöreskog and Sörbom, 1978, p.15).

Examples are provided in the LISREL IV manual of both model and ways in which models can be improved. In each case, the final value for chi-square is close to the number of degrees of freedom in the model. The unwary user may conclude that in cases where the ratio of the value for chi-square to the number of degrees of freedom is not close to unity, the model is not particularly well-fitting. However, Carmines and McIver (1981) have claimed that a ratio of 2:1 or 3:1 is quite acceptable. Indeed Wolfle (1981) has proposed that a model which yields a ratio of chi-square to the number of degrees of freedom of less than 5:1 is adequate. He provided examples which showed how this rule-of-thumb provided confirmation of substantively meaningful models.

In LISREL, the chi-square statistic provides an index of goodness-of-fit, that is, an indication of how well the correlation matrix generated by the parameter estimates ($\underset{\sim}{\Sigma}$) reproduces the observed correlation matrix ($\underset{\sim}{S}$). Thus we have an index for the test of a specific model compared with the alternative that the variables are correlated in an arbitrary way. As is well known, however, the chi-square statistic is very sensitive to sample size. As a consequence, with a large sample small differences between the observed $\underset{\sim}{S}$ and reproduced $\underset{\sim}{\Sigma}$ matrices will be statistically significant.

Recently, alternative procedures for assessing goodness-of-fit have been proposed. For example, Tucker and Lewis (1973) had proposed a statistic for factor models, ρ, which is less sensitive to sample size. Bentler and Bonett (1980) generalised this procedure and proposed the index $\rho_{k\ell}$:

$$\rho_{k\ell} = \frac{M_k - M_\ell}{M_k - 1} \quad \text{where} \quad M_i = \frac{\chi_i^2}{df_i} \; (i = k, \ell)$$

This index, however, does not necessarily take values between zero and unity, and is therefore referred to as a non-normed fit index. A second, more general normed index, $\Delta_{k\ell}$, was therefore proposed (Bentler and Bonett, 1980):

$$\Delta_{k\ell} = \frac{\chi^2_k - \chi^2_\ell}{\chi^2_o} \quad .$$

These two indices, $\rho_{k\ell}$ and $\Delta_{k\ell}$, were used in this study to compare a hypothesised model M_k with the null model M_o, obtained by fitting a zero-factor model to the observed matrix $\underset{\sim}{S}$. (In LISREL terms, this null model is generated by setting the $\underset{\sim}{B}$ and $\underset{\sim}{\Lambda}_y$ matrices equal to the identity matrix, $\underset{\sim}{\Theta}_\varepsilon$ equal to the null matrix, and $\underset{\sim}{\Psi}$ to be a diagonal matrix with free elements.)

The Bentler-Bonett goodness-of-fit indices are attempts to reflect the proportion of variance accounted for by the model. Bentler and Bonett suggest that "models with overall fit indices of less than .9 can usually be improved substantially" (1980, p.66). The strategy used in this study was to improve fit using all three indices, the χ^2/df value and the two Bentler-Bonnett indices. Models were relaxed in ways which were judged to be substantively meaningful.

Models which are generated may, of course, capitalise on chance associations in the data. Bentler (1980) urged cross-validation as a way of establishing the validity of a causal model. He said

> Cross-validation provides an appropriate way of establishing whether empirically based model modifications represent genuinely valuable information about a model. For example, a sample may be split in two halves and one half used to develop

> a model and the second to provide a clean test of the developed model. It is possible to use tight, moderate, and loose replication strategies ... In tight replication, one would attempt to fit the model to the second sample using the first sample's exact parameter estimates. In loose replication, the identical model and fitting procedures are used in both samples. In moderate replication, critical theoretical parameters (such as factor loadings) are held constant but others (such as error variances) can be estimated in the new sample. Research is required to differentiate these methods, but factor invariance theory ... would favor the moderate strategy (p.429).

Cross-validation was accordingly incorporated into the analysis in the present study. This was done by applying a model developed with data from the first school sample to data from the second school sample.

Review

The main study reported in this thesis is a non-experimental, longitudinal investigation of the home, school and peer group influences on student attitudes to science. This chapter has summarised some of the preliminary investigations, especially those relating to the establishment of the reliability and validity of the instruments used to assess student attitudes in the main study. The particular methods and procedures used to assess the home, school and peer group environments of the students are provided in the next chapter.

CHAPTER 4

ASSESSMENT OF THE EDUCATIONAL ENVIRONMENTS

The general methods and procedures used in the present study were summarised in the previous chapter. The assessment of the three educational environments, namely the home, the school and the peer group, are described in this chapter. It will be remembered that each of these environments was assumed to have three dimensions, a structural, a process and an attitudinal dimension.

Kremer and Walberg (1981) have noted the paucity of studies of the influence of home and peer group environments on learning in science. However, many investigations have been conducted in other curriculum areas, some of which were outlined in Chapter 2. In these inquiries, many indices have been used for assessing the home and peer group environments in different cultural settings. In the present study, it was judged that those variables (and their operationalisation) which Keeves (1972) had used should be used where possible since they had been developed and applied in an Australian social context.

Some of the variables which Keeves had chosen were not suitable for inclusion in the present study. In some cases, this was a consequence of the difference in procedures between his investigation and the present inquiry. For example, Keeves' home data was based on interviews, while the present study utilised written responses to a mail survey. Thus, a variable used in Keeves' study, "Abnormality of the home" (based on the extent to which the child's parents were living at home continuously with the child), was not included in the present study, since this information was of a sensitive nature, and unlikely to be revealed adequately through written questionnaire responses. For the same reason, data on family income and religious affiliation were not sought in the present investigation. In other cases, variables were excluded because they had been shown in Keeves' inquiry subsequently not to yield additional useful information. For example, the variables "bedroom index" and "birth order" correlated highly with family size. As a consequence, they were not included in the present inquiry as family size was included.

The variables included in the present study, then, are based on those used in the earlier Australian inquiry. These variables were judged to be appropriate for inclusion on both theoretical and practical grounds. Variables used to assess each of the environments will be discussed in turn. Summary statistics for each of the variables were compiled using SPSS (Nie, Hull, Jenkins, Steinbrenner and Bent, 1975), and are presented in Appendix 2 while the intecorrelation matrices are given in Appendix 3.

4.1 THE HOME

Information on the home environment was gathered through survey procedures and validated through interviews with a randomly chosen sub-sample of mothers who had replied to the questionnaire, as described in the previous chapter. The information about the home environment which was sought included background characteristics, parents' expectations for the child and reported practices of the home.

The home environment was assessed in July, 1980. It was assumed that this environment was stable, and that no significant changes would occur during the school year. This assumption was likely be violated in a very small number of cases only, for example, through dramatic changes in the personal circumstances of either parent. Such changes for a small number of cases was unlikely to influence the results in any substantial manner and so no attempt was made to determine if such changes had taken place during the year.

It should also be noted that some of the measures were made on interval or ratio scales (such as age of father) while others were made only on ordinal scales (such as the level of education of the parents), but they all were analysed as though they had interval scale properties. The justification for this practice provided by Keeves was that earlier researchers had employed similar procedures, with meaningful results, for example, Hüsen (1967) and Peaker (1967). Further support for this practice has been provided more recently by Gardner (1975d), who carefully reviewed the use of different scales in social science research and concluded that the "distinction between ordinal and interval scales was not sharp" (p.55). Gardner's analysis indicated that the scales on which the variables were measured in the present study could be analysed with confidence with methods developed for interval scales.

Variables Used to Assess the Structural Dimension of the Home

The structural dimension of the home is assessed typically by demographic or sociological variables, or both. 'Socio-economic status' is commonly used to refer to some aspects of this dimension of the home environment. In the present study six groups of variables were used to assess the structural dimension of the home environment and they are described in turn below.

1. Family Size. The index used for this was the number of children in the family. Since there were very few cases where this number exceeded nine, this was set as the upper limit. As can be seen from Appendix 2 (Tables A2.4 and A2.5), three was the most common value for this variable.

2. Age of Parents. The father's age was given in number of years. Because it was felt that some mothers would be more likely to provide an age range, rather than an exact age, a five-point scale was provided for them: less than 30 years of age, 30 to 40, 41 to 50, 51 to 60 and 61 years or over.

3. Language Background. A three point scale was devised: 1. both parents of English origin; 2. one parent of English origin; 3. neither parent of English origin.

4. Hours per day Mother Employed Outside the Home. This was coded on a five-point scale, in two-hour steps.

5. Occupation. A five-point scale for occupation of the father (or stepfather or guardian), as given in Currie (1980), was used for coding purposes. In addition, mothers who had paid employment outside the home were coded "1" and the remaining mothers were coded "2".

6. Education. The level of education of the mother and the father were both assessed on a seven-point scale. The categories were as follows: some years of primary schooling; full primary schooling; some years of secondary schooling; full secondary schooling; achieved a high school leaving certificate; hold a technical college diploma; and hold a college or university degrees.

Summary statistics for each variable are reported separately for the Acacia and Boronia high school samples in Appendix 2 (Tables A2.4 and A2.5). In addition, the correlations among these variables are given in Appendix 3 (Tables A3.4 and A3.5). Some variables, such as age of mother and age of father were modestly correlated (values were 0.65 and 0.50 for Acacia and Boronia, respectively). Other variables, such as father's occupation and the number of hours worked by the mother displayed lower correlation coefficients (values were 0.34 and 0.31 for Acacia and Boronia, respectively). Still other variables gave values of correlation coefficients which were, statistically, not significantly different from zero.

Variables Used to Assess the Attitudinal Dimension of the Home.

In this study the attitudinal dimension of the home is taken to be related to the expectations and hopes of the parents as these relate to the child and to the parents themselves. Many studies have reported the importance of this dimension for the child's education and these have been reviewed by Keeves (1972) and Bryant *et al* (1974). Four groups of variables were used to assess this dimension of the home:

1. Mother's Attitudes Towards the Child's Present Education. Two variables were assessed. The first variable was the level of expectation for the child's educational accomplishments. The mother was asked to predict the child's place in the class on a five-point scale: 'top'; 'near the top'; 'about the middle'; 'middle'; and 'if' depends on him/her'. The second variable was the mother's perception of whether the child had problems settling in at high school: 'yes'; 'no'; or 'don't know'.

2. Ambitions for the Child's Future Education. These were assessed using two variables: age (in years) to which the mother expected the child to continue full-time education; and the mother's expectation for the child's final educational level were the child to continue beyond secondary school to university, college of advanced education, or technical college.

3. Mother's Expectations for the Child's Secondary Schooling. The mother was asked to predict the level of secondary schooling which the child would attain. Three items sought this information: "Do you expect your child to leave at 15?"; "Would you like your child to take the T.A.E. exam at the end of the year?" and, "Do you expect your child to leave at the end of Year 10?" The scale comprising these three items for both school samples taken together gave a value for Cronbach's alpha of 0.77, which was judged to be satisfactory.

4. Parents' Hopes and Aspirations for Themselves. These were assessed by two variables. The first asked the mother for a prediction about the level of advancement of her husband in the future: 'advance a lot'; 'advance a little'; 'get automatic

promotion'; or 'remain the same'. The second asked whether education was seen as an important means of accomplishment for the mother: 'very important, further education essential'; 'important, further education useful'; 'education of some value'; or 'education of no value'.

Summary statistics for the variables of the attitudinal dimension of the home are provided in Appendix 2 (Tables A2.4 and A2.5). The intecorrelations among these variables, which are given in Appendix 3 (Tables A3.4 and A3.5), are of the order of 0.20 which is quite low.

Variables Used to Assess the Process Dimension of the Home

It is reasonable to expect that the process dimension of the home, which relates to home practices, would influence student learning. Four scales provided indices of this process dimension. Two of these were Likert scales while the remaining two were based on reported frequencies of events.

1. Relations between Home and School. The mother's views on the child's present school were sought, in particular her views of teachers' relationships with students and the child's interest and enjoyment of schooling. There were six items on this scale, for which Cronbach's alpha was 0.48, which was not as high as one would expect.

2. Use of Books and Library Facilities. The quality and quantity of books in the home, the extent of the child's reading, the use of library facilities and the encouragement given to the child to read from an early age were assessed. Again, there were six items on this scale for which Cronbach's alpha was 0.74. This value was judged to be satisfactory since only six items formed the scale.

3. Provision of Help with Formal Schoolwork. The help given to the child with schoolwork in the home was assessed, together with the time spent by the child on homework. There were eleven items on this scale for which Cronbach's alpha was 0.71, a value judged to be satisfactory.

4. Science-related Activities. The frequency with which the student engaged in science-related activities, such as doing home experiments, was assessed. There were three items on this scale, for which Cronbach's alpha was 0.54. Although this value is rather low, it is not unexpected since there were three items only in the scale.

Summary statistics for the aggregated variables of the process dimension of the home are given in Appendix 2 (Tables A2.4 and A2.5). Intecorrelations among the variables, which are given in Appendix 3 (Tables A3.4 and A3.5), generally yield low to moderate values. For example, the correlation coefficient for "reading practices" and "help at home" was 0.31 at Acacia and 0.26 at Boronia. The correlations between home/school relations as perceived by the mother and the other process variables were not statistically significantly different from zero.

4.2 THE SCHOOL

Both quantitative and qualitative data were gathered related to the school environment. Among the quantitative data were variables associated with students' inquiry skills, science-related attitudes, general attitudes and achievement. The attitudinal dimension of the classroom as indicated by students' expectations for their full-time education and their occupation was also assessed. In addition to these quantitative data, much qualitative data was sought regarding the schools and, specifically, the science teachers and their classrooms. These qualitative data will be presented first.

The Schools and the Science Teachers

Each science teacher was interviewed formally in April, 1980. In addition, numerous informal discussions were held during the year. Informal observations of students during science lessons also occurred throughout the year. At Acacia Senior High School, seven different teachers taught the nine Year 8 science classes in the school. Five teachers took one class each, and two took two classes each. All seven teachers regarded themselves as science subject specialists, although their backgrounds in the various science disciplines differed quite markedly.

All nine Year 8 classes were heterogeneous, according to the head of the school's science department. Six of the classes had six periods of science a week, while the other three classes had seven periods. The difference in the number of science periods resulted from the foreign language subject choices of the students. This difference in the amount of formal time spent in science may have had some influence on the students' attitudes. Again, this effect could not be quantified in this study because the number of teachers was too small.

Small group practical work in science was intermittent in all the classes. Demonstrations were used more frequently, but those observed by the author appeared not to have been prepared particularly well, nor were they well presented. The assessment procedures used in science relied mainly on short answer or multiple-choice questions. There was infrequent opportunity given to students to engage in project work, or to undertake substantial exercises based on more open-ended questions.

At Boronia Senior High School seven teachers taught the eight Year 8 classes at the school. Six of the teachers taught one class each while the remaining teacher took two classes. All seven teachers regarded themselves as science subject specialists. The science classes were all heterogeneous. Five of the classes had six periods a week of science while the remainder had seven periods each. The difference in the number of periods devoted to science was the consequence of the choice of music by some of the students.

The teachers at Boronia Senior High School, like their Acacia colleagues, emphasised the use of short answer or multiple-choice formats in the assessment procedures. The students had little opportunity to complete more extended answers or project work. The students had their own textbook which was supplemented by a variety of other methods and materials such as duplicated worksheets, use of educational television programmes, programmed instruction and, very occasionally, field trips. Small group practical work was conducted intermittently in most cases. Demonstrations were also given intermittently by the teacher.

The interviews and informal observations conducted at the two schools indicated that there were a number of important differences between the teaching practices at the two schools. At Acacia, the orientation was markedly less academic than it was at Boronia. There was virtually no homework set at Acacia and, generally, less appeared to be expected of the students.

On the other hand, there were remarkably few differences among the practices of the seventeen science classrooms. The emphasis was on the remembering and recall of facts and principles. Few opportunities appeared to be provided for students either to work independently or to investigate topics in depth. Whole class instruction was the norm, with the teacher dominating and directing lessons. Occasional small-group practical work was undertaken which broke this pattern.

The overall impression, then, was of two school science programs which were remarkably similar. The quite different communities served by the two schools did not produce two very different science programs.

Inquiry Skills, Attitudes and Achievement

In addition to the qualitative data presented above, quantitative data was gathered on a number of school-related variables, including science inquiry skills, general attitudes and achievement in science.

Science Inquiry Skills. It was considered desirable to assess students' general scientific abilities early in the school year, as student entry characteristics are frequently judged to be important. However, as the students in the two high schools had arrived from fifty different primary schools, it was likely that their knowledge of science and the science content which they had studied would vary greatly. Thus, a content-specific test was unlikely to provide particularly useful data because the students came from such different backgrounds. A measure of the students' science inquiry skills was considered to be more suitable.

The Test of Enquiry Skills (TOES), published by the Australian Council for Educational Research (Fraser, 1979b) attempts to measure a number of general inquiry skills, some of which are science-specific. In particular, two skills labelled "critical-thinking-in-science" were considered suitable and were chosen for use in this study. The scales which measure these abilities are called "Design of Experimental Procedures" and "Conclusions and Generalisations". Each question in TOES has a multiple-choice format. The number of options varies from two to four. Each response was scored '1' if correct and '0' if incorrect. A total score was computed for each student for each of the two scales by summing the item scores of their responses on that scale.

The first nine questions related to the scale "Conclusions and Generalisations" and were designed to assess the students' ability to draw valid conclusions and generalisations from data presented to them. The mean score for this scale was 5.4, with a standard deviation of 2.2 (n = 476). The next ten questions related to the scale "Design of Experimental Procedures". These questions were designed to assess the students' ability to design experiments to test hypotheses. The mean score for this scale was 5.9, with a standard deviation of 1.8 (n = 488). The reliability coefficients (KR-20) for the two scales were, respectively, 0.65 and 0.53 for both school samples taken together. Fraser (1979b) reported in the TOES manual KR-20 values of 0.57 and 0.75, respectively, for a Year 8 sample.

General Attitudes. In addition to the science-related attitudes, three general attitudes were assessed by methods developed by Keeves (1974). Three scales "Attitudes Towards School and School Learning", "Motivation to Achieve in School Learning" and "Respect and Confidence in Self" were judged to be appropriate for the present study as they constitute general attitudes which may influence science-related attitudes. All three were Likert scales. Other attitude scales developed by Keeves and not used in the present investigation related to attitudes to mathematics, which were not relevant to the present study, and to attitudes to science, which were assessed in the present inquiry by TOSRA, for which detailed psychometric data were available.

An instrument was assembled which contained the items in these three scales. In addition, a number of items were devised which would enable students to report their attentiveness in science classes since attentiveness is regarded by teachers as an important indicator of student learning (Haladyna, Olsen & Shaughnessy, 1982). The values for Cronbach's alpha for the three Keeves' scales and the attentiveness scale were, respectively, 0.82, 0.77, 0.92 and 0.84. These values were considered to be quite satisfactory, particularly for the scale "Attentiveness in Science Lessons" (0.82) which had six items only. Summary statistics for the scales are provided in Appendix 2 (Table A2.2).

The validation of such scales poses considerable difficulty. Often teacher ratings are used, but the author (Schibeci, 1981b) has found that teachers generally assess global attitudes rather than specific science-related attitudes. A number of other researchers have reported a similar difficulty (Black and Dockrell, 1979; Gardner, 1981; Keeves, 1972; Wood and Naphali, 1975). Keeves (1972) concluded from his study that there was "some agreement" between students and teachers, but that this agreement was "not strong". He believed that the lack of a strong relationship could be "ascribed either to the inability of teachers to assess accurately the students or to inadequacies in the attitude scales" (p. 30), but he could not determine which from his data.

The author (Schibeci, 1984b), as part of the present inquiry, examined the utility of validating student self-responses by comparing them with teachers' ratings of students on the same behaviours. The results confirm the findings of many earlier researchers. That is, the use of teacher ratings to establish the validity of attitude scales appears not to be a useful general approach. However, it may be that the use of very specific criteria may be shown in future studies to improve the usefulness of teacher ratings as a means of validating student attitude data. In the meantime, it is clear that researchers must proceed with caution if they wish to validate student responses by means of teacher ratings.

Student Achievement. It was decided to use data from the schools' own achievement tests in this study rather than an externally-prepared instrument, on two grounds. The first was educational. It was anticipated that the students' early achievement was more likely to influence their later performance if these early achievement scores were known to them. School achievement data were constantly being fed back to students and hence were likely to influence their attitudes and subsequent achievement. An externally prepared and administered examination may not have been regarded by the students as being part of their normal testing programme and may, therefore, not have been treated seriously. The science teachers at the two schools reported that this phenomenon had occurred with the statewide comparability tests the students had taken. These were tests administered throughout the whole State and were used to provide a basis for comparing schools. That is, they were not used to assess individuals. Students (quite correctly) believed that these tests did not contribute to their individual achievement grades and therefore did not deserve their full attention and effort.

The second reason was a practical one. It was not possible to impose two further tests on the Year 8 cohorts at the two schools. Each student in this study took part in four separate testing occasions. In addition, they were subject to a variety of questionnaires from other research studies during the year which had no connection with the present study. It would not have been possible to impose a further two testing occasions without jeopardising the goodwill built up in the two schools.

In each school, two achievement measures were included in the performance cycle. In each case, the the school's regular end of year test was chosen as the final achievement measure since the result on this test determined the student's science class placement in the following year. The initial achievement measure in both cases was the student's result at the end of first term. The students had had an opportunity by the end of the first term to study science for about twelve weeks. It provided some indication of the student's ability as seen by the teachers and the results were communicated to the students. Also, the collection of first term attitude data (in February) was separated from this test by a substantial time period. This avoided any immediate, direct interaction between the students' achievement and attitude responses.

For Acacia, the mean and standard deviation for the initial (end of term) achievement scores and the final (end of year) achievement scores were, respectively, 55.1 (17.6) and 45.5 (19.6). The corresponding data for Boronia were 61.1 (15.2) and 47.6 (24.7). In each case the scores were on a scale of 0 to 100. It should be emphasised that these were data supplied by the schools, based on the schools' normal assessment program. Data on science achievement were gathered by the schools chiefly through the use of written end-of-topic tests administered during the year, with a final end-of-year test also being given in each school. The tests, designed by the teachers, employed a mix of multiple choice, short answer and, less frequently, extended response types of items. While the tests were different in each school, the same end-of-topic test and end-of-year test was given to each student within each school. The initial (end of first term) achievement scores were based on an average of the end-of-topic test scores from Term 1. The final (end of year) achievement scores were based on the end-of-year test.

Although the tests used at the schools were of unknown reliability and validity, they were used for within-school grading, and hence were of direct relevance to the students. It was judged that these results, because of their immediate relevance to the students, were likely to influence student attitudes.

Classroom Attitudes. In addition to the quantitative data described in this section, the attitudinal dimension of the classroom was assessed. The indicators of this dimension were taken to be the expectations of the students regarding their educational and occupational futures.

1. Educational expectations. A seven point scale was used: 'Leave school at fifteen'; 'Leave school at end of Year 10'; 'Leave school at end of Year 11'; 'Go to a teachers' college'; 'Go to the Institute of Technology'; and 'Go to a university' (scored one to seven, respectively).

2. Occupational expectations. A five-point occupational scale was used (Currie, 1980). These data proved to be of limited utility. It became clear, in the course of discussions with students, that their occupational expectations were, in general, very imprecise.

4.3 THE PEER GROUP

Peer group data were collected in June, 1980. The students had had more than a full school term at high school in which to establish friendships. Every student was given a questionnaire to fill in which sought information which would allow the structural, attitudinal and process dimensions of the peer group environment to be assessed.

The students were asked to nominate friends in this way: "Name your three best friends in Year 8 at this school. Please give their names and class". Since every student in the Year 8 cohort filled in the questionnaire, ready access to the background data on these friends was available.

The questionnaire sought four groups of data: (a) frequency of visits to a number of organisations and institutions (such as the zoo, industries and museums); (b) general personal background data (such as the child's language background, the occupations of their parents and the educational aspirations of the child); (c) frequency of certain specified activities (such as home chemistry experiments, watching T.V. and playing chess); and (d) information on hobbies and other activities shared with friends. The data provided were used to assess the different dimensions of the peer group environment as described below.

The Structural Dimension of the Peer Group

The structural dimension of the peer environment relates to aspects of the background of a students' nominated three best friends. Three variables were suggested by Keeves (1972), based on earlier research, as useful indices of this dimension.

1. Occupational Status of Three Friends. The five-point occupation scale used to classify the occupation of the father (Currie, 1980) was used. The aggregate score of the occupational status of the three friends' fathers was computed.

2. Language of Three Friends. A home in which English was the language was assigned a score of "1"; otherwise, a score of "2" was assigned. The aggregate score for the language spoken in the three friends' homes was computed.

3. Star Rating of a Student. This was the number of students in the Year 8 cohort who had named that student as a friend. The range which resulted was zero to nine.

Attitudinal Dimension of the Peer Group

The attitudinal dimension relates to educational and occupational expectations of the students' nominated three best friends. As noted earlier, each individual student's expectations had been sought. Since the whole Year 8 cohort was included in the study, it was a simple task to seek out the information for those students who had been nominated as "best friends".

1. Occupational Expectations of Three Friends. The five-point occupational scale mentioned earlier (Currie, 1980) was used. The combined score for the occupation expected by the friends after they had finished their schooling was computed. As noted earlier, occupational expectation appeared, from discussions with students, to be imprecise for many students.

2. Educational Expectations of Three Friends. A seven-point scale was provided in the questionnaire as explained on page 86. From these data, a combined score for the three friends was computed.

The Process Dimension of the Peer Group.

The process dimension of the peer group relates to general and educational practices of students nominated as "best friends." Again, since information had been gathered for each individual student in the Year 8 cohort at each school, it was a simple matter to seek out data relevant to their nominated best friends. Three variables were used to assess the process dimension of the peer group. These related to homework practices, science-related activities and general activities of three friends.

1. Hours of Homework per Week done by Three Friends. This was the aggregate score of the nominated number of hours of homework for all subjects done by the three friends.

2. Science Activities of Three Friends. Students were asked to nominate the frequency (on a three-point scale) with which they engaged in activities likely to promote learning in science. A three-point scale for frequency was provided for each item. This scale gave a value for Cronbach's alpha of 0.71, a value judged to be satisfactory.

3. General Activities of Three Friends. Students were asked to nominate the frequency (on a three-point scale) with which they engaged in five different sorts of activities which were not directly relevant to school learning (such as "go to the pictures" and "watch television"). A combined score for the thirteen items was computed. This scale gave a Cronbach's alpha of 0.67. This value is not high given that there were thirteen items on the scale.

Summary statistics for the variables of the structural, process and attitudinal dimensions of the peer group are provided in Appendix 2 (Table A2.6 and Table A2.7 for Acacia and Boronia, respectively). The intercorrelations among the peer group variables are given in Appendix 3 (Table A3.8 and Table A3.9 for Acacia and Boronia, respectively). The values for these correlation coefficients were generally low, but some yielded moderate values. For example, the values of 0.44 and 0.33, respectively for Acacia and Boronia resulted for the occupational and educational expectations of the nominated "three best friends". Values of 0.30 and 0.43, respectively, were reported for educational expectations and the number of hours of homework for the nominated three best friends. The highest values were, respectively, 0.97 and 0.98, for the science activities and general activities of the nominated friends. This may be because these two sets of activities were not sufficiently distinguished, that is, there is substantial overlap between these two sets of activities, as perceived by the students.

Review

In this chapter, the variables used to assess the structural, process and attitudinal dimensions of the home and peer group environments of the students have been presented. In addition, variables related to the attitudinal dimension of the class, students' inquiry skills, attitudes and achievement have been summarised. As noted earlier, summary statistics and intecorrelations for these variables are given in Appendix 2 and Appendix 3, respectively.

This chapter and the previous chapter together have outlined the methods and procedures used in the main phase of the present study, as well as giving a description of the variables. We now turn to the analysis and results of this study.

CHAPTER 5

INFLUENCE OF THE EDUCATIONAL ENVIRONMENTS

The study reported in this thesis was specifically concerned with the identification of variables which influence students' science-related attitudes. Procedures using path analysis methods are especially suitable for identifying such influences. The LISREL model was chosen as the most appropriate method for undertaking the path analysis for this study and the salient features of the LISREL model, which underlies the LISREL IV computer program (Jöreskog and Sörbom, 1978) were summarised in Chapter 3.

5.1 PRELIMINARY ANALYSES USING LISREL

In principle, any number of variables can be analysed using the LISREL IV program. In practice, the amount of memory available in the computer limits the number of variables which can be included in any model. For this reason, the data collected in the present study, which included a large number of background variables suggested by Keeves'(1972) conceptual framework, were initially decomposed into three data sets. These three data sets comprised the variables of the home, the school and the peer group environments respectively. The model which guided the study (Figure 2) was described in Chapter 2. This was used to generate all the initial causal models, including those in the preliminary analyses.

The strategy thus used to analyse each of the three data sets was the same. A model (M_1) was initially proposed to explain the interrelationships among the variables of the data from one sample. In the causal model, various paths were postulated among relevant variables, consistent with the model developed for the study. Inspection of the LISREL IV output suggested ways in which the model could be relaxed. Specifically, a path was freed if the first order derivative of the fitting function with respect to the matrix element corresponding to that path was substantially different from zero, provided that freeing this path was substantively meaningful. The result of this model building process was, finally, a model (M_2) which appeared to fit the data best.

In this refinement of a hypothesised model, the drop in the value of chi-square, compared with the drop in the number of degrees of freedom, was used to determine whether the change represented a real improvement, as suggested by Jöreskog and Sörbom (1978).

In judging how well the final model fitted the data, two criteria were used. The first criterion was the value of the ratio χ^2/df. Carmines and McIver (1981) have suggested that a ratio of 2:1 or less is appropriate, while Wolfle (1981) has suggested that values of 5:1 or less are acceptable. (In fact, all the final models of this study met the more stringent criterion for χ^2/df values). The second criterion was that models were required to have Bentler-Bonett indices of 0.9 or better. These indices and their recommended criterion values are described in Chapter 3.

In selecting the variables to be included in the final analysis, 'T values' provided by the LISREL IV program were examined. The 'T value' is the ratio of a parameter estimate to its standard error. This ratio has an approximate z distribution. Thus, the normal curve provides a means for deciding between large and small values (Bentler, 1980). Paths for which $|T|>2$ were judged to be significant, following the suggestion of Munck (1979).

A common group of variables was included in each of the three data sets. These variables were: (a) sex; (b) the two science inquiry skills assessed at the beginning of the year, Design of Experimental Procedures (DESIGN) and Conclusions and Generalisations (GENERAL); (c) the four general attitudes assessed by the OPINIONS instrument: Attentiveness in Science Lessons (ATTEN), Respect and Confidence in Self (SREGARD), Motivation to Achieve in School Learning (ACADMOT); and Attitudes Toward School and School Learning (ATSCHL); and, (d) two TOSRA subscales, one assessing a scientific attitude (Adoption of Scientific Attitudes, ADOPT), and the other assessing an attitude to science (Enjoyment of Science Lessons, ENJSC). There were two values for each of the two TOSRA subscales, a value for the beginning of the year and one for the end of the year. In addition to the common set of variables, those variables specifically used to assess the structural, attitudinal and process dimensions of the home and peer group environments were included in the corresponding analyses. The school data set included two variables which were used to assess the attitudinal dimension of the classroom, which were taken to be related to the occupational and educational expectations of students. The intercorrelation matrices for the various data sets are given in Appendix 3.

The preliminary analyses were conducted as follows. First, a causal model for the home data was developed and refined using the 'home' data obtained about students at Acacia school. The final home causal model yielded $\chi^2_{108} = 152.05$ and this model, applied to Boronia home data set, yielded $\chi^2_{108} = 164.5$. Next, a school causal model was developed and refined using the school data set from the Acacia school. This resulted in $\chi^2_{59} = 132.40$ and this model, applied to the Boronia school data set, gave $\chi^2_{59} = 173.04$. Finally, a causal model was developed and refined using the Acacia peer data set, and it also proved to be well-fitting, with $\chi^2_{84} = 176.3$. This model, applied to the Boronia peer data, also fitted giving $\chi^2_{84} = 146.0$. The final models, then, in each case were cross-validated by being tested against the data from the second school student sample. It can be seen that the obtained values of χ^2 were similar for both samples.

These separate analyses revealed a number of features. In each case, there was a strong causal chain among the cognitive variables in the study and another (less strong) causal claim among the affective variables. In addition, a number of background variables appeared to have substantial paths to the latent dependent variables. (Substantial paths were those for which $|T|>2$). These background variables, which were then included in the combined final analysis of the home, school and peer group influences, were sex of the student (SEX), the mother's age

(MUMAGE), the mother's expectations for child's place in class (PLACECL), the mother's expectations for the length of her child's secondary schooling (HOMEX), the reading practices of the home (HREAD), the child's expectation for full-time education (CHILDED), the hours of homework reported by the child's nominated three best friends (HWK) and the educational expectations of these three friends (ED).

5.2 FINAL ANALYSIS OF THE HOME, SCHOOL AND PEER GROUP DATA

The variables included in the final analysis were those which were judged to be important as a result of the separate analyses described earlier. The intercorrelation matrices for these variables are given for Acacia and Boronia in Tables 4 and 5, respectively.

LISREL Specifications for the Final Model

In the final causal models tested, the sex of the student and those home, school and peer group variables which appeared to be the most important from the preliminary analyses were designated independent variables. All other variables were designated dependent variables. For reference, all the dependent and independent variables described below, together with their corresponding descriptors, have been presented with the final causal model in Figure 4 on page 106. This section, then, describes the LISREL specifications for both the measurement model and the structural equation model.

Table 4

Intercorrelation Matrix for Acacia

Home, School and Peer Group Variables

(n = 190)

	DESIGN	GENERAL	ADOPT1	ENJSC1	ACH1	ATTEN
DESIGN	1.000					
GENERAL	0.517	1.000				
ADOPT1	0.125	0.190	1.000			
ENJSC1	0.047	0.147	0.576	1.000		
ACH1	0.346	0.416	0.145	0.131	1.000	
ATTEN	0.140	0.133	0.154	0.327	0.328	1.000
SREGARD	0.232	0.216	0.191	0.117	0.295	0.349
ATSCHL	0.162	0.116	0.191	0.201	0.307	0.481
ACADMOT	0.132	0.080	0.296	0.208	0.251	0.591
ACH2	0.427	0.338	0.284	0.207	0.598	0.290
ADOPT2	0.251	0.222	0.488	0.300	0.205	0.283
ENJSC2	0.149	0.099	0.335	0.441	0.165	0.479
SEX	-0.089	-0.066	-0.136	-0.224	0.045	-0.020
MUMAGE	-0.138	-0.099	0.051	0.076	-0.005	-0.083
PLACECL	0.268	0.269	0.073	0.016	0.286	0.006
HOMEX	0.157	0.145	0.090	0.091	0.394	0.181
HREAD	-0.023	-0.133	-0.108	-0.153	-0.293	-0.159
CHILDED	0.249	0.337	0.132	0.072	0.370	0.269
HWK	0.019	0.093	-0.018	-0.005	0.189	0.094
ED	0.146	0.220	0.146	0.092	0.142	0.054

	SREGARD	ATSCHL	ACADMOT	ACH2	ADOPT2	ENJSC2
SREGARD	1.000					
ATSCHL	0.272	1.000				
ACADMOT	0.324	0.688	1.000			
ACH2	0.321	0.250	0.239	1.000		
ADOPT2	0.258	0.388	0.492	0.371	1.000	
ENJSC2	0.164	0.421	0.486	0.248	0.586	1.000
SEX	0.072	0.223	0.113	-0.155	0.092	-0.001
MUMAGE	0.034	-0.069	-0.139	0.025	0.020	-0.067
PLACECL	0.098	0.114	0.100	0.156	0.110	0.018
HOMEX	0.274	0.231	0.220	0.356	0.144	0.148
HREAD	-0.013	-0.154	-0.136	-0.252	-0.162	-0.164
CHILDED	0.322	0.292	0.212	0.367	0.200	0.187
HWK	0.119	0.198	0.245	0.133	0.193	0.120
ED	0.107	0.206	0.202	0.247	0.291	0.181

	SEX	MUMAGE	PLACECL	HOMEX	HREAD	CHILDED
SEX	1.000					
MUMAGE	-0.055	1.000				
PLACECL	-0.020	0.020	1.000			
HOMEX	-0.035	0.074	0.116	1.000		
HREAD	-0.154	0.134	-0.065	-0.100	1.000	
CHILDED	-0.029	-0.003	0.106	0.418	-0.136	1.000
HWK	0.165	-0.041	0.026	0.077	-0.180	0.134
ED	0.071	-0.004	0.024	0.138	-0.226	0.343

	HWK	ED
HWK	1.000	
ED	0.302	1.000

Table 5

Intercorrelation Matrix for Boronia
Home, School and Peer Group Variables
(n = 200)

	DESIGN	GENERAL	ADOPT1	ENJSC1	ACH1	ATTEN
DESIGN	1.000					
GENERAL	0.516	1.000				
ADOPT1	0.209	0.195	1.000			
ENJSC1	0.036	0.111	0.467	1.000		
ACH1	0.411	0.435	0.215	0.206	1.000	
ATTEN	0.112	0.077	0.343	0.402	0.330	1.000
SREGARD	0.142	0.152	0.298	0.204	0.266	0.318
ATSCHL	0.049	0.027	0.367	0.392	0.298	0.611
ACADMOT	-0.001	0.045	0.375	0.408	0.299	0.678
ACH2	0.179	0.280	0.222	0.338	0.553	0.317
ADOPT2	0.112	0.026	0.504	0.423	0.194	0.395
ENJSC2	0.155	0.062	0.388	0.539	0.235	0.568
SEX	-0.042	0.020	0.049	-0.109	-0.092	-0.127
MUMAGE	0.012	-0.012	0.037	0.121	0.035	0.085
PLACECL	0.138	0.095	0.067	0.049	0.190	0.110
HOMEX	0.224	0.144	0.133	0.084	0.279	0.223
HREAD	-0.013	-0.035	-0.055	-0.120	-0.135	-0.116
CHILDED	0.036	0.002	0.196	0.088	0.228	0.192
HWK	-0.002	0.160	0.052	0.207	0.173	0.165
ED	0.094	0.127	0.030	0.215	0.284	0.206

	SREGARD	ATSCHL	ACADMOT	ACH2	ADOPT2	ENJSC2
SREGARD	1.000					
ATSCHL	0.292	1.000				
ACADMOT	0.400	0.720	1.000			
ACH2	0.204	0.366	0.377	1.000		
ADOPT2	0.263	0.453	0.463	0.184	1.000	
ENJSC2	0.197	0.490	0.470	0.179	0.634	1.000
SEX	-0.062	0.196	0.034	-0.058	0.082	-0.027
MUMAGE	-0.035	0.067	0.100	0.038	0.067	0.115
PLACECL	0.186	0.110	0.202	0.116	0.051	0.039
HOMEX	0.191	0.316	0.133	0.161	0.057	0.126
HREAD	-0.100	-0.302	-0.194	-0.100	-0.083	-0.105
CHILDED	0.193	0.336	0.286	0.107	0.129	0.170
HWK	0.168	0.297	0.248	0.405	0.029	0.016
ED	0.109	0.238	0.249	0.385	0.125	0.182

	SEX	MUMAGE	PLACECL	HOMEX	HREAD	CHILDED
SEX	1.000					
MUMAGE	-0.002	1.000				
PLACECL	0.014	0.003	1.000			
HOMEX	-0.035	-0.001	0.147	1.000		
HREAD	-0.196	-0.004	-0.157	-0.202	1.000	
CHILDED	0.000	0.033	0.092	0.227	-0.150	1.000
HWK	0.112	-0.032	0.094	0.037	-0.081	0.074
ED	-0.120	0.028	0.116	0.190	-0.162	0.136

	HWK	ED
HWK	1.000	
ED	0.431	1.000

Measurement Model The observed independent variables (x_1 to x_8) were defined in the LISREL measurement model to be equivalent to the latent independent variables ξ_1 to ξ_8 since there was one observed variable for each latent variable and consequently, the measurement error for the latent variables was set to zero. Since the latent independent variables were simply taken as equivalent to the corresponding observed independent variables, the regression of the observed variables on the latent variables, defined as (Λ_x), becomes $x = \xi$, with $\Lambda_x = I$ (the identity matrix) and $\delta = 0$. Also, the correlation matrix for the ξ-variables, ϕ, is fixed and equal to the observed correlation matrix between the x-variables. The measurement model for the dependent variables specifies the relationships between the six latent dependent variables η_1 to η_6 and the twelve observed dependent variables y_1 to y_{12}. The relationships required by the model can be specified by defining Λ_y as following:

$$\Lambda_y = \begin{array}{c} \\ y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \\ y_6 \\ y_7 \\ y_8 \\ y_9 \\ y_{10} \\ y_{11} \\ y_{12} \end{array} \begin{array}{c} \begin{array}{cccccc} \eta_1 & \eta_2 & \eta_3 & \eta_4 & \eta_5 & \eta_6 \end{array} \\ \left[\begin{array}{cccccc} 1.0 & 0 & 0 & 0 & 0 & 0 \\ \lambda^y_{21} & 0 & 0 & 0 & 0 & 0 \\ 0 & 1.0 & 0 & 0 & 0 & 0 \\ 0 & \lambda^y_{42} & 0 & 0 & 0 & 0 \\ 0 & 0 & 1.0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1.0 & 0 & 0 \\ 0 & 0 & 0 & \lambda^y_{74} & 0 & 0 \\ 0 & 0 & 0 & \lambda^y_{84} & 0 & 0 \\ 0 & 0 & 0 & \lambda^y_{94} & 0 & 0 \\ 0 & 0 & 0 & 0 & 1.0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1.0 \\ 0 & 0 & 0 & 0 & 0 & \lambda^y_{12,6} \end{array}\right] \end{array}$$

Some non-zero paths have to be fixed to specify the scales of $\eta_1, \eta_2, \ldots$ and η_6. For η_1, η_2, η_4 and η_6, one of the path coefficients is set at unity. The two latent achievement variables (η_3, η_5) are identified with the observed variables and in this case, the path coefficients are fixed at unity.

The latent dependent variables η_1 to η_6 were identified as, respectively, the latent variables 'general ability', 'initial science-related attitude', 'initial achievement', 'general attitude', 'final achievement' and 'final science-related attitude'. The latent achievement variables (η_3 and η_5) were defined by the measurement model to be equivalent to their corresponding observed variables y_3 and y_5, the observed initial and final achievement scores.

<u>The Structural Model</u> The relationship among the latent dependent variables is defined in LISREL by $\underset{\sim}{B}$ in which the diagonal elements are fixed at one, all the elements shown as zero are fixed at zero (this corresponds to an absence of a path in the model) and all the elements β_{ij} are the free parameters for those paths which are in the model. (In fact, as a consequence of the algebra of the LISREL equations, the β_{ij} elements are negative. To avoid confusion, however, the negative signs for β_{ij} are omitted.) Thus β_{31} is the coefficient of the path from η_1 to η_3 . In the present case, $\underset{\sim}{B}$ is defined as follows:

$$
\underset{\sim}{B} = \begin{array}{c} \\ \eta_1 \\ \eta_2 \\ \eta_3 \\ \eta_4 \\ \eta_5 \\ \eta_6 \end{array}
\begin{array}{c}
\begin{array}{cccccc} \eta_1 & \eta_2 & \eta_3 & \eta_4 & \eta_5 & \eta_6 \end{array} \\
\left[\begin{array}{cccccc}
1 & 0 & 0 & 0 & 0 & 0 \\
\beta_{21} & 1 & 0 & 0 & 0 & 0 \\
\beta_{31} & \beta_{32} & 1 & 0 & 0 & 0 \\
\beta_{41} & \beta_{42} & \beta_{43} & 1 & 0 & 0 \\
\beta_{51} & \beta_{52} & \beta_{53} & \beta_{54} & 1 & 0 \\
0 & \beta_{62} & \beta_{63} & \beta_{64} & \beta_{65} & 1
\end{array}\right]
\end{array}
$$

The relationship between the latent independent variables $\xi_1, \ldots, \xi_8$ (which correspond to the eight observed variables, x_1 to x_8, described above) and the latent dependent variables $\eta_1, \ldots, \eta_6$ is defined by $\underset{\sim}{\Gamma}$. In the present case, where γ_{ij} specify paths which are non-zero, we have the following:

$$
\underset{\sim}{\Gamma} = \begin{array}{c} \\ \eta_1 \\ \eta_2 \\ \eta_3 \\ \eta_4 \\ \eta_5 \\ \eta_6 \end{array}
\begin{array}{c}
\begin{array}{cccccccc} \xi_1 & \xi_2 & \xi_3 & \xi_4 & \xi_5 & \xi_6 & \xi_7 & \xi_8 \end{array} \\
\left[\begin{array}{cccccccc}
\gamma_{11} & 0 & \gamma_{13} & \gamma_{14} & 0 & 0 & 0 & 0 \\
\gamma_{21} & \gamma_{22} & 0 & 0 & \gamma_{25} & 0 & \gamma_{27} & 0 \\
0 & 0 & \gamma_{33} & \gamma_{34} & \gamma_{35} & \gamma_{36} & \gamma_{37} & \gamma_{38} \\
\gamma_{41} & 0 & \gamma_{43} & \gamma_{44} & \gamma_{45} & \gamma_{46} & \gamma_{47} & \gamma_{48} \\
\gamma_{51} & 0 & 0 & \gamma_{54} & 0 & \gamma_{56} & \gamma_{57} & 0 \\
\gamma_{61} & 0 & 0 & \gamma_{64} & 0 & 0 & \gamma_{67} & \gamma_{68}
\end{array}\right]
\end{array}
$$

The remainder of the LISREL model is specified by doing the following: fixing $\underset{\sim}{\Phi}$ as the correlations among the observed independent variables; setting $\underset{\sim}{\Psi}$ as a diagonal matrix with the free parameters in the diagonal to give the variances of the uncorrelated residuals ζ_1 to ζ_6; setting all the diagonal elements of $\underset{\sim}{\Theta}_\varepsilon$ except

$\underset{\sim}{\Theta}_{\varepsilon 55}$ and $\underset{\sim}{\Theta}_{\varepsilon\, 10,10}$ to be free, as well as $\underset{\sim}{\Theta}_{\varepsilon 11,3}$ and $\Theta_{\varepsilon 12,4}$ (in the case of the last two elements, to allow correlated errors between the first and final administrations of the same TOSRA subscale), and all others elements fixed at zero; and setting $\underset{\sim}{\Theta}_{\delta}$ to be a null matrix. The zero residual variances for all δ and for ε_5 and ε_{10} reflect the one to one relationships within pairs of latent and observed variables.

Simultaneous Analyses of the Two School Data Sets

Because the number of variables had been reduced in the preliminary analyses, a specific feature of the LISREL IV program could be used in the final analysis. This feature allows a causal model to be tested simultaneously on two or more different groups, in the present case, samples from the two different schools. The simultaneous analysis in LISREL of two or more data sets allows the researcher to specify that none, some or all parameters will be constrained to be equal across groups. One may choose how many and which parameters will be so constrained.

In the present case, a hypothesis was specified as follows:

H_1 : All parameters are invariant between the groups; that is, each free parameter must be equal in both data sets.

This hypothesis states, in effect, that the causal model generated from the conceptual framework for the study should fit the two data sets in precisely the same way.

However, a secondary concern of this study was the examination of the notion of 'local theories' proposed by Cronbach (1975) and Snow

(1977). A second hypothesis may be proposed, consistent with this notion, which specifies that the only difference in the two school data sets will be the way that the independent background variables (and the variable sex which has often been shown to be an important determinant of student learning outcomes) influence the latent dependent variables, that is, the entry characteristics and the intermediate and final outcomes. These parameters are elements of the matrix $\underset{\sim}{\Gamma}$. An alternative hypothesis, then, was proposed as follows:

> H_2: The parameters of the causal model when applied to the two school data sets will be invariant, except for the elements of $\underset{\sim}{\Gamma}$, the matrix of coefficients for the paths from the latent independent to the latent dependent variables.

The hypothesis H_1 (precisely the same influences in the two schools) yielded $\chi^2_{281} = 447.05$. Thus, the ratio for χ^2/df is 1.6 (less than the 2.0 recommended by Carmines and McIver, 1981). The Bentler-Bonnett indices for H_1 were 0.92 and 0.90, respectively and thus, they reached the recommended value of 0.90. The hypothesis H_2 yielded $\chi^2_{254} = 380.08$ and this gives a value of 1.50 for the ratio χ^2/df. The values for the Bentler-Bonett indices were 0.94 and 0.90, respectively. These values indicate that the hypothesis H_2 also fits the data. In deciding whether one hypothesis fits the data better, one can examine the drop in the value of χ^2 compared to the drop in the degrees of freedom. In going from H_1 to H_2, there is a drop in the value of χ^2 of 66.97, and a reduction of 27 in the number of degrees of freedom, indicating that hypothesis H_2 is one which can be significantly better supported than hypothesis H_1.

The matrix $\underset{\sim}{\Gamma}$ (which gives values for paths from independent to latent dependent variables) for hypothesis H_2 was, for Acacia

$\underset{\sim}{\Gamma}_A$ =

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
η_1	-0.02	a	0.08	**0.16**	a	a	a	a
η_2	-0.07	0.09	a	a	-0.08	a	**0.13**	a
η_3	a	a	0.06	0.08	-0.03	**0.15**	0.03	**0.16**
η_4	0.06	a	0.06	0.08	-0.06	**0.13**	**0.10**	a
η_5	-0.03	a	a	-0.03	a	-0.07	**0.23**	**0.12**
η_6	0.04	a	a	a	a	a	**-0.19**	0.08

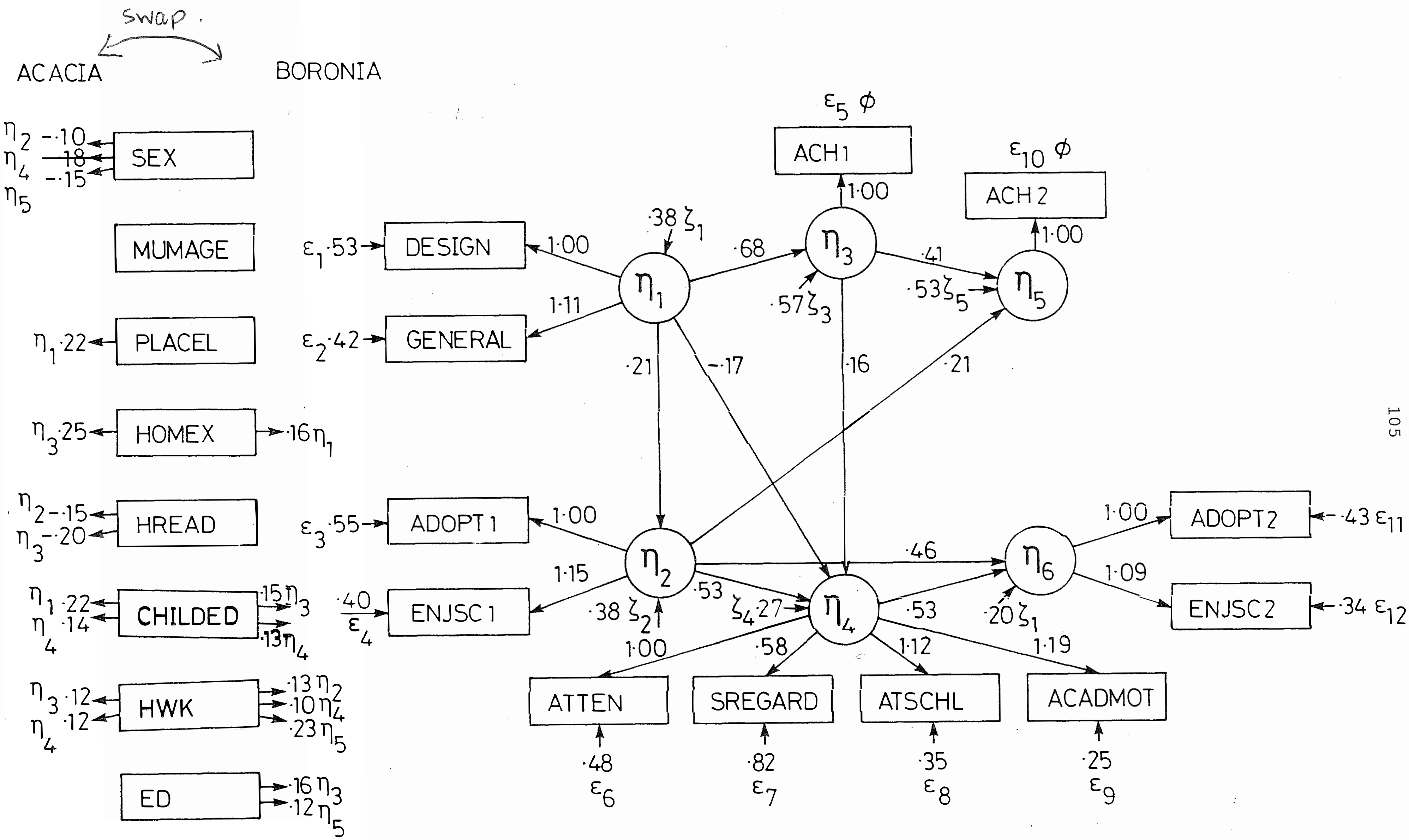
where "a" indicates a path fixed at zero and the values in bold type are those for which $|T|>2$. For Boronia, the corresponding $\underset{\sim}{\Gamma}$ matrix was

$\underset{\sim}{\Gamma}_B$ =

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
η_1	-0.05	a	**0.22**	0.01	a	**0.22**	a	0.10
η_2	**-0.18**	0.05	a	a	**-0.15**	a	-0.02	a
η_3	a	a	0.07	**0.25**	**-0.20**	0.06	**0.12**	-0.13
η_4	**0.18**	a	0.03	0.06	0.05	**0.14**	**0.12**	a
η_5	**-0.15**	a	a	0.10	a	0.06	0.01	0.11
η_6	0.05	a	a	a	a	a	0.03	0.08

Thus, for example, the value of γ_{41} for Boronia indicates a path value of 0.18 from SEX (x_1) to "General attitude" (η_4).

The model embodied by hypothesis H_2 is presented in Figure 4. Since the measurement model and the relationships among the latent dependent variables (the latter expressed by the matrix $\underset{\sim}{B}$) were


swap
ACACIA
BORONIA
SEX
MUMAGE
PLACEL
HOMEX
HREAD
CHILDED
HWK
ED
DESIGN
GENERAL
ADOPT 1
ENJSC 1
ACH 1
ACH 2
ADOPT 2
ENJSC 2
ATTEN
SREGARD
ATSCHL
ACADMOT
η1
η2
η3
η4
η5
η6
ε5 ϕ
ε10 ϕ
·38 ζ1
·57 ζ3
·53 ζ5
·38 ζ2
ζ4 ·27
·20 ζ1
ε1 ·53
ε2 ·42
ε3 ·55
·40 ε4
·43 ε11
·34 ε12
·48 ε6
·82 ε7
·35 ε8
·25 ε9
1·00
1·11
1·15
·68
·41
·21
−·17
·16
·46
·53
·58
1·12
1·19
1·09

INDEPENDENT VARIABLES

SEX	Sex of student (x_1)
MUMAGE	Mother's Age (x_2)
PLACECL	Expected Place in Class: mother's expectations for child's place in class (x_3)
HOMEX	Educational Expectations: mother's expectations for length of child's secondary schooling (x_4)
HREAD	Reading Practices: use of books and library facilities (x_5)
CHILDED	Child's expectation for full-time education (x_6)
HWK	Hours of Homework: hours per week reported by nominated three best friends (x_7)
ED	Educational Expectations: nominated three best friends (x_8)

DEPENDENT VARIABLES

η_1 = "General ability"

DESIGN	Design of Experimental Procedures (y_1)
GENERAL	Ability to Draw Valid Conclusions and Generalisations (y_2)

η_2 = "Initial science-related attitude"

ADOPT1	Adoption of Scientific Attitudes (y_3)
ENJSC1	Enjoyment of Science Lessons (y_4)

η_3 = "Initial achievement"

ACH1	Achievement score in first term (y_5)

η_4 = "General attitude"

ATTEN	Attentiveness in Science Classes (y_6)
SREGARD	Respect and Confidence in Self (y_7)
ATSCHL	Attitudes Towards School and School Learning (y_8)
ACADMOT	Motivation to Achieve in School Learning (y_9)

η_5 = "Final achievement"

ACH2	End-of-year achievement score (y_{10})

η_6 = "Final science-related attitude"

ADOPT2	Adoption of Scientific Attitudes (y_{11})
ENJSC2	Enjoyment of Science Lessons (y_{12})

Figure 4

Causal Model for Home, School and Peer Group Influences assumed to be invariant across the schools in hypothesis H_2, values for the corresponding parameters are equal. However, the relationships among the observed independent (background) variables and the latent dependent variables were hypothesised to vary between the schools, that is, $\underset{\sim}{\Gamma}$ was not invariant. Values (given by γ_{ij}) for substantial paths from the independent to the dependent variables are shown on the left-hand side of the independent variables (in rectangles) in Figure 4 for Acacia, and on the right-hand side of the same variables for Boronia. It should be noted that only values for which $|T|>2$, as suggested by Munck (1979), are included in Figure 4. It will be remembered that the "T" value is the ratio for the parameter estimate to the standard error for that parameter.

The substantive interpretation of this final causal model will be discussed next.

5.3 CAUSAL RELATIONSHIPS AMONG THE ENVIRONMENTAL VARIABLES AND STUDENT OUTCOMES

There are several striking features of the causal model represented in Figure 4. The relationships among the latent dependent variables ($\eta_1, \eta_2, \ldots, \eta_6$) will be considered first.

Relationships Among the Latent Dependent Variables

There is a strong causal link from 'general ability' to 'initial achievement' (η_3), with the value for this path being 0.68. There is also a strong link from initial achievement (η_3) to final achievement (η_5) with a path value of 0.41. There is thus a strong causal chain for these three cognitive student variables. There is also a strong causal chain among the attitude variables. Thus, for example, there is a substantial path from 'initial science-related attitude' (η_2) to 'general attitude' (η_4) and from 'general attitude' (η_4) to 'final science-related attitude' (η_6) with the value for each of these two paths being 0.53. Finally there is a substantial path (0.46) directly from 'initial science-related attitude' (η_2) to 'final science-related attitude' (η_6).

There are thus two strong causal chains, one for the cognitive variables and a second for the attitude variables. Between these two sets of variables there are links which are not nearly as strong as those within each causal chain. For example, there is a path (value, 0.16) from 'initial achievement' (η_3)to 'general attitude' (η_4).

There are also paths from 'general ability' (η_1) to 'initial science-related attitude' (η_2), and from 'initial science-related attitude' (η_2) to 'final achievement' (η_5).

One path between the two causal chains which is unexpected is that from 'general ability' (η_1) to 'general attitude' (η_4). The value for this path is - 0.17. The negative value suggests that higher ability students have a tendency to develop a somewhat negative general attitude. This may be explained, in part, by the failure of the high school experience in general (and science experiences in particular) to match the expectations of these high ability students. This explanation is based on the qualitative data gathered during the study, which includes discussions with each science teacher on a number of occasions, together with informal discussions with the students.

The strong relationships within the cognitive and within the affective variable sets are consistent with the findings of other researchers. The weaker relationships between the cognitive and the affective variables are also supported by numerous findings, such as those reported in the meta-analyses conducted by Willson (1981). Unlike many other studies, however, it is possible here to examine these relationships in the context of the two schools studied. That is, these relationships appear to hold for students from two quite different geographic communities within the Perth metropolitan area. Despite the differing socio-economic backgrounds of the students, these relationships are similar. This suggests that similar relationships may hold over a wide range of schools, at least within the Perth metropolitan area.

Influence of Background Variables

The influence of sex and the home, school and peer group background variables on the latent dependent variables may now be examined. It will be recalled that the hypothesis tested was that these particular influences (given in LISREL by the elements of the matrix $\underset{\sim}{\Gamma}$) differed between the two schools. The relevant values of γ_{ij} are given in Figure 4, on the left-hand side of the observed independent variables for Acacia and on the right-hand side of the same variable for Boronia in order to allow a direct comparison of the influences between the two schools.

Of the home background variables, mother's expectation of the length of her child's secondary schooling (HOMEX) appears to be an important influence on the cognitive variables in both schools. Mother's age (MUMAGE), on the other hand, appears to be important in neither school, possibly because of the very small standard deviation of this variable. Mother's expectation of the child's place in class (PLACECL) appears to be an important influence on general ability at Boronia. There is a plausible explanation for this. That is, mothers' perceptions are influenced by children's prior performance in primary school. In other words, we are observing part of a causal chain which may be represented as follows: child's performance in primary school influences mother's perception of child's place in class, which in turn influences child's general ability. This causal chain, although also present at Acacia is much weaker. In fact, it does not appear in Figure 4 because its value did not meet the criterion $|T|>2$. It is not clear why mothers' expectations at Acacia do not appear to have the same influence as at Boronia.

The use of books and library facilities (HREAD) appears to exert a negative influence (path value, - 0.15) on 'initial science-related attitude', η_2, and 'initial achievement', η_3 (path value, - 0.20). One could speculate that students from homes in which these reading practices were common had expectations which did not match the realities of their science classroom experiences in the first part of the year, and that subsequently they had to adjust their expectations accordingly. However, this explanation cannot be supported directly from any of the data gathered.

It should also be remembered that a host of home background variables gathered in the study and described in Chapter 4 appear not to be important influences. Many of these variables (as indicated by studies cited in the next section) have been reported to have significant influences on academic achievement by some researchers. These include the occupational and educational background of the parents and the parents' expectations for the child's occupation. None of these variables appear to be important direct influences in the present study. Home variables, in general then, appear not to be significant direct influences on either achievement or attitudes.

Of the two peer group variables, the amount of homework reported by the nominated three best friends (HWK) appears to be an important, positive influence on 'general attitude' (η_3) at Acacia and on final achievement (η_5) at Boronia. This influence on final achievement is not surprising at Boronia, given the academic emphasis at the school.

The other peer group variable, educational expectations of the three best friends (ED) appears to influence both initial and final achievement at Boronia (path values are, respectively, 0.16 and 0.12). It appears not to be a (statistically) significant influence at Acacia however. This may partly be explained by the lower educational expectations of the students at Acacia the median value for this variable was 11.8 at Acacia, compared with a value of 13.6 at Boronia. (The standard deviations were, respectively, 3.6 and 3.2). This is consistent with the more distinctly academic emphasis of the Boronia curriculum.

Again, it should be noted that the other peer group variables gathered in the study, and described in Chapter 4, appeared not to be important direct influences at either school. These included the occupation of the fathers of the three best friends, the language background of the three best friends, and the science and general activities of the three best friends. It appears, then, that the peer group variables in this study generally were not important direct influences on academic achievement or attitudes.

The child's own educational expectations (CHILDED) appear to be a positive influence on 'general attitude' (η_4) at both schools. The path values for Acacia and Boronia are very similar (0.14 and 0.13, respectively). This finding suggests that the student's expectation for future schooling influences his or her motivation and self-concept, which is hardly surprising. CHILDED appears to exert a moderate influence on initial achievement (η_3) at Boronia (path value, 0.15) and 'general ability' (η_1) at Acacia (path value, 0.22). Again, these findings are not surprising, as one would expect students with higher educational expectations in general to achieve more highly than those with lower expectations. This, of course, may not always be the case and, presumably, this is reflected in the moderate values for these path coefficients.

Finally, the influence of sex may be examined. There are no paths from SEX to any of the latent dependent variables in Figure 4 for Boronia, since no parameter gave values such that $|T|>2$. On the other hand, there are substantial paths from SEX to three dependent variables for Acacia. At Acacia, it is also interesting to observe the negative influence of sex on 'initial science-related attitude'

(η_2) and 'final science achievement' (η_5), but a positive influence on 'general attitude' (η_4). This suggests that there is support for the finding that boys are more positive (initially at least) to science than girls. It also suggests that boys generally achieve higher scores.

The corresponding parameter values for Boronia are not shown in the causal model because (as explained earlier) for no path did $|T|$ reach the value of 2. Nevertheless, the same pattern (negative influence on η_2 and η_5, but positive influence on η_4) is present. Thus, sex appears to be a more important variable at Acacia than at Boronia. This is consistent with the known backgrounds of the two schools. Boronia has a higher proportion of parents of high socio-economic status. One could hypothesise that these parents might try to encourage boys and girls more equally than do parents at Acacia, and hence sex differences would not be as marked This suggestion is based on qualitative data gathered during the study.

5.4 DISCUSSION

There are a number of patterns which emerge from this study which can be summarised as follows:

(1) There is a strong causal chain among the cognitive latent variables, 'general ability', 'initial achievement' and 'final achievement' ;

(2) There is a strong causal chain for the affective latent variables 'initial science-related attitude', 'general attitude' and 'final science-related attitude' ;

(3) There are links between these two sets of variables (cognitive and affective), but they are not as strong as those within each set; and

(4) There are some moderate links between the background (independent) variables and the dependent variables.

The influence of the background variables appears to vary between the two schools. This provides limited support for the notion that local influences should be investigated more frequently than is the case. The home influences appeared, in general, not to influence either attitudes or achievement in any direct, substantial way. Keeves (1972) arrived at a similar conclusion. However, one variable which appeared to be important was the mother's expectations for the length the child's secondary schooling; this appeared to be an important influence on cognitive variables in both samples. (However, as pointed out earlier, a mother's perceptions will almost certainly be influenced by a child's prior performance in primary school. Thus, the cognitive variables are being influenced, indirectly at least, by the child's prior performance). Of the peer group variables, the amount of homework reported by the three best friends appeared to be an important influence on attitudes and achievement at both schools.

Related Studies

It is useful to compare the results presented in this chapter with the findings reported by others. Table 6 summarises some salient aspects of a number of related studies. Unfortunately, direct comparison is difficult for many reasons. Firstly, there is

Table 6

Student Variables Reported to Have a Substantial Influence on Academic Achievement and Attitudes

Variable(s)	Author(s) of Study	Description of Sample
Parents' Educational Achievement	Sewell & Shah (1968)	Random sample of 9,007 high school seniors
Intelligence	Hauser (1971)	Population of white students grades 7-12) in Tenessee.
Social Background	Peschar (1975)	Primary school children (112 matched pairs) in the Netherlands.
Socio-economic Level, Mental Ability, Academic Performance	Portes & Wilson (1976)	Random sample of approx. 1,140 white high school students in 87 schools in the U.S.A.
Self-esteem, Educational Aspirations	Portes & Wilson (1976)	Random sample of approx. 180 black high school students in 87 schools in the U.S.A.
School-related Attitudes	Marjoribanks (1978a)	Primary school children from five groups: middle-status Anglo-Australian (140); lower social status Anglo-Australian (250); English (120); Greek (170); Southern Italian (120) in Australia.
Interaction Between Social Environment Intelligence and Teacher Perceptions of Student Behaviour	Marjoribanks (1978b)	Primary school children in England who were involved in a follow-up study to the Plowden (1967) investigation (n = 3,000 approx.)
Parental Influence	Biddle, Bank & Marlin (1980)	Public high school students (n = 149)
Home Environment	Cuttance (1980a)	Random sample of students on whom data was collected in Australia as part of the study by the International Association for the Evaluation of Educational Achievement (IEA).

the obvious difference in the location of the communities from which the samples are drawn. Thus, Peschar (1975) conducted a study in the Netherlands, Sewell and Shah (1968) in the U.S.A. and Marjoribanks (1978b) in the U.K. Secondly, the focus of the studies in many cases has varied. Many sociologists, for example, have been interested primarily in students' educational and occupational aspirations (see Cuttance, 1980b). Thirdly, the data analysis procedures used do not always allow direct comparison with the present study. For example, Marjoribanks (1978a, 1978b) used complex regression models to generate regression surfaces and his findings are not easy to summarise succinctly. Studies in which path analysis procedures have been used (such as that by Biddle, Bank & Marlin, 1980) allow a more ready comparison of findings with the present study. Also, the year level of the students in many studies varies. Sewell and Shah (1968), for example, used high school seniors in their inquiry. The various educational environments may have influenced those students in ways which are different from influences on students in their first year of high school. Finally, most studies have used random samples of students. Cronbach (1975) and Snow (1977), as discussed in earlier chapters, have indicated the possible importance of local influences and these influences are likely to be masked in studies of random samples drawn from many schools.

This last point is illustrated to some extent by Porter and Wilson's (1976) study of black-white differences in educational attainment. The authors showed clearly that there were important differences between the two samples and summarised the findings in this way, "the substantial influence of self-esteem on black educational attainment is absent among whites, while the key role of academic performance in white attainment is absent among blacks" (p.428). Just as there are demonstrable differences among races, it is likely that important differences may be expected among communities.

In addition to the studies in Table 6, comparisons may be made with Kremer and Walberg's (1981) synthesis of social and psychological influences on science learning, together with a recently-reported study of the relations of student, teacher and learning environment variables to attitudes to science (Haladyna, Olsen and Shaughnessy, 1982).

The home appears generally not to be an important direct influence on students' academic achievement, but particular home variables are exceptions. This appears to be generally true in the present study and is consistent with the findings of both Keeves (1972) and Biddle, Bank and Marlin (1980). Bridge, Judd and Moock (1979), in a review of research studies of the influence of educational environments on student outcomes, wrote "In all of the studies reviewed, parental educational expectations for the child ...seem to make a positive difference in achievement" (p. 227). It will be remembered that the mother's expectation for the length of the child's secondary schooling was found to be an important influence on cognitive variables in the present study. It will also be remembered that the mother's perceptions, however, may have been influenced by the child's prior performance.

Unlike the findings of Keeves (1972) and Bridge et al (1979), parents' occupation did not appear to be an important influence on attitudes or achievement in the present study. Kremer and Walberg (1981) reported varying associations between measures of parents' socio-economic status and science learning. Many of them were positive associations while others showed as significant relationships.

Haladyna, Olsen and Shaghnessy (1982) examined the correlation between a number of exogenous student variables such as parental involvement, parental concern about schooling and parental perceptions about the importance of school. They concluded that "there is no apparent link between these exogenous student variables and attitudes to science" (p.678). These authors cautioned, however, against generalising their conclusions to the U.S. population as a whole because of the restricted range of family backgrounds in their study.

Gardner (1975a) had concluded in his review of the literature on science-related attitudes that structural variables (including home background variables) were unlikely to affect student attitudes in any direct way. This general conclusion is supported by the findings of the present study.

Kremer and Walberg (1981) were able to locate only five studies of the influence of peer environment on science learning and one of these was Keeves' (1972) study. The emphasis in these studies, they noted, was on cognitive achievement.

In addition to the study of background variables, the influence of a student's sex has been investigated. This influence on general attitudes to school has not been shown to be important in all cases in the present investigation, a finding which differs from the findings of Cuttance (1980b). The particular backgrounds of the samples of students used may contribute to the discrepancy in these findings. Keeves (1972) had also found that the sex of a student was not a direct, significant influence on science achievement, but that sex was important in determining a student's attitudes to self and school.

Thus, some findings from the present inquiry (such as the importance of mothers' expectations) are consistent with those of other published research reports. Other findings (such as the role of parental occupation) are different from those previously reported. Direct comparisons with previously-reported research are not always easy for the reasons given earlier.

Local Theories

An important contribution of the present study is the finding that it is profitable to examine local communities and the influence of background variables on student learning in science. That is, the study has provided support for the concept of 'local theories' suggested by Cronbach (1975) and Snow (1977). It has also supported the value of gathering qualitative data as part of a quantitative study. It was possible to suggest explanations for various findings by an appeal to these qualitative data. Such explanations would otherwise have been much more tentative.

The results presented here must, of course, be treated with some caution. Kremer and Walberg (1981) noted that construct measures with high reliabilities yield higher correlations with learning outcomes than measures with lower reliabilities. This may explain, in part, the generally lower path values from independent variables to dependent variables in this study. Also, it must be emphasised that the causal relationships examined here are derived from non-experimental data, and caution must therefore be exercised in drawing inferences from these results. Ideally, causal relationships are demonstrated, as Cliff (1983) has pointed out, by "active control of variables" (p. 119).

The implications of these findings for educational theory and practice are examined next.

CHAPTER 6

REVIEW

The purpose of this chapter is to draw together the various elements of the present study. First, the overall strategy for the study is reviewed. This is followed by a summary of the main features of the inquiry, together with a summary of the main findings. Finally, some implications of the findings are considered.

A Strategy for the Present Study

Curriculum developers and science educators generally believe the affective domain in science education to be an important area of concern to the school. This can be seen from an inspection of curriculum development materials, such as those developed as part of the Australian Science Education Project (ASEP), and in science curriculum documents, such as those adopted in New South Wales and Western Australia. Examples of objectives in the affective domain taken from these various sources were provided in earlier chapters.

The wealth of literature related to attempts to identify variables with a significant influence on attitudinal outcomes in science education provides an indication of the importance assigned to the affective domain. Unfortunately, many of these studies have been confined to the study of a limited number of variables. It is difficult to judge whether the particular variables chosen for the investigation are important. Moreover, the researcher does not have an indication of how the influences of the variables which are investigated may change in the presence of other variables (which are not simultaneously investigated).

Two developments in the past decade have suggested methods for increasing our understanding of how attitudinal outcomes are influenced and how these influences may be investigated. The first development has been the refinement of multivariate statistical methods and, in particular, those for the analysis of covariance structures. The second development has been the growing interest in 'alternative' strategies of educational inquiry, which have been labelled 'case study' or 'anthropological' and in other ways, depending on the particular style of inquiry. These two developments have been regarded by some scholars as competing while others regard them as complementary. The stance adopted in this thesis is the latter, that is, each of these developments is considered to have much to offer in aiding an understanding of educational phenomena. Educational research cannot afford to ignore any approach which, potentially, may offer us greater understanding of the process of education. In addition, the notion of local theories has been recently suggested and was considered to be worthy of investigation.

Main Features of the Present Study

The study reported in this thesis reflects the exploitation of both of the developments mentioned above. The study was essentially longitudinal and naturalistic: it was conducted over a school year and there was no overt, external intervention by the investigator. The basic strategy reflects the 'scientific' paradigm which characterises much educational research. The model-building strategy used causal modeling procedures; in particular, the theory proposed in the LISREL model formed the basis for the analyses.

This basic strategy was complemented by informal observation of science classrooms and frequent discussions with the science teachers. In addition, curriculum documents, tests, timetables and many other sources of data were investigated. The causal model derived from the path analysis was thus complemented by data collected through a less formal, non-quantitative study of the two schools.

The Year 8 samples were chosen because these students had recently progressed from primary to secondary school. This transition involved a substantial change in their educational environment which, it was hypothesised, would result in a significant change in student outcomes during the course of the year. A total of 600 students entered the two schools during the school year, 335 at Acacia and 265 at Boronia. Complete information on the school and peer group variables was available, however, for only 190 students at Acacia and 200 at Boronia. The remainder of the students were not present for the whole school year and some left before the end of the year; others arrived during the year. Also, as mentioned in Chapter 3, there was a proportion of mothers who did not reply to the home questionnaire. This proportion was greater at Acacia than at

Boronia. The difference in response rates for the two schools partly reflects the demographic and sociological differences in the regions which formed the 'catchment' areas for the two schools. Acacia had a large proportion of homes in which English was not the only language spoken. The corresponding proportion at Boronia was much smaller. Data provided in Chapter 3 indicated that Acacia was, in general, lower in socio-economic status than Boronia.

Student science-related attitudes were assessed at the beginning and at the end of the school year. Peer group data were collected in the middle of the year, since it was assumed that relatively stable peer group friendships would have emerged by that time. Data on home background were also collected at this time. In addition, a test of science inquiry skills was administered at the beginning of the year. This was used to assess general inquiry skills, rather than any particular science content. There were two reasons for this: first, science normally has a low priority in the primary school curriculum and many of the schools from which the children came would have taught little science; second, in those schools where science was taught, the emphasis would have been on the development of process skills, not on the acquisition of factual material. The achievement data used in this study was collected by the schools as part of their normal assessment programme in science. Since these achievement data were made known to the students, they were presumed to influence their final learning outcomes in science.

The schools in the study were in quite different socio-economic areas of the Perth metropolitan area. This provided a range of different home environments, while simultaneously allowing an intensive study of the individual schools. The underlying assumption in the present study was that student outcomes are influenced primarily by three educational environments those of the home, the school and the peer group and each of these environments has a structural, a process and an attitudinal dimension. The use of two schools (rather than a randomly-selected set of schools enabled the utility of the notion of 'local theories' to be examined. In each school, the complete Year 8 cohort comprised the target population, and all the students were to be used, if possible.

Main Findings of the Present Study

The results of the present study support the findings of other researchers which indicate that the background home and peer group variables generally do not influence student outcomes in science in any direct, substantial way. There are particular variables which are exceptions to this general rule. In the present study, the mother's expectation for the length of her child's secondary schooling and the amount of homework reported by three best friends in the same year at the school appeared to be important influences on student attainment. The first influenced the cognitive dependent variables and the second both the cognitive dependent and the affective dependent variables.

Another important finding was the confirmation of the existence of two strong causal chains, one for the cognitive student variables and one for the affective student variables. Further, there were links between these two causal chains, but these were weaker than those within the causal chains, and of the same order of magnitude as the links between the background variables and the dependent student variables.

These findings are in general agreement with the findings of many other studies. It appears, then, that these general results apply in many different countries. In addition, it was found in the present study that local theories may usefully be developed as a means of understanding the particular influence of background variables on student learning in science in particular schools.

The results reported here are clearly restricted to the subject area of science and to the two schools involved, with some further cautious generalisation being possible to schools similar to those used in the study. The general cautions given in the previous chapter must also be remembered. For example, it must be remembered that the causal relationships examined in this study were based on non-experimental data and would need to be tested in experimental situations. Despite these limitations, there are a number of implications which deserve further consideration.

Considerations for the Future

The model which guided the present study appears to provide a firm basis for developing soundly-conceived research studies for the investigation of patterns of relationships among background variables, achievement and attitudes. It acknowledges the complex network of influences on student learning outcomes.

There were many important differences in the influence of the environmental variables between the two samples. This finding suggests that future studies may fruitfully emphasise the intensive study of a small number of school cases. Simple random samples of the type used by Keeves (1972) suffer from the very real problem that the important differential interrelationships may be masked. That is, variables important in one context (but not in another) are hidden in studies based on random samples which range across several discrete school contexts. In addition, random samples provide enormous practical difficulties if the quantitative data are to be supplemented by qualitative data. A possible compromise would be a study based on a small number of schools, perhaps one school from each of four or five widely differing categories, which might differ in geographic location, socio-economic status, type of curriculum, or in some other significant way. A sample of the Year 8 students in the schools could then be selected for study. This could provide a sufficiently large and diverse sample, while enabling the intensive study of each of the separate educational milieux. This approach would also allow the further testing of the utility of local theories.

Another important area of investigation for a future study is the 'learning environment' of the classroom. There is now a large body of evidence in this area and it suggests strongly that future research ought to include this construct as an important element. Yet another consideration is the subject matter area to be studied. The choice of science in the present study reflected the author's interest. The simultaneous study of other subject areas would have posed very great practical difficulties in terms of time and resources. Nevertheless, a future study should perhaps include other curriculum areas, such as mathematics, English and social studies. Focus on one subject area may disguise important differences and interrelations among the subject areas. For example, a student may do well in some of the subjects but not in others. The reasons for this are worth pursuing. Still another consideration is the sequence of activities in the research strategy. It would be very beneficial if the preliminary study of teachers' perceptions reported here were supplemented by a preliminary study of a small number of homes and peer groups. These case studies would provide a much more valuable guide in the choice of variables to investigate in a subsequent study. Future studies, too, could test the notion of 'local theories' more extensively than was possible in the current study. This could be done, for example, by conducting similar investigations with the Year 8 cohorts in the same schools in the following year. This would provide some indication of the stability and importance of local influences. Another general concern to be addressed in the future is the development of more valid and reliable scales for assessing the home and peer group environments. These constructs are not as readily measured as student cognitive and affective variables, but deserve more effort.

In addition to suggestions for future research, it is important to indicate possible implications of the investigation for educational practice. It is clear that, for this study, cognitive variables and, separately, the affective variables are strongly related to each other. The links between the two sets are not as strong. To some extent, this may be a function of the attention paid to the cognitive domain by science teachers. It is clear from the data gathered in preliminary investigations that no systematic attempts are made to develop science-related attitudes.

The present study has shown that influences on students' science-related attitudes are many and varied. Some influences (such as general attitudes) are strong while others (such as environmental variables) are weaker. It is clear, however, that there is a complex web of inter-relationships among the school and non-school variables. Science education researchers could profitably work closely with students, parents and teachers. A specific intervention program in which positive science-related attitudes were actively promoted among students would provide a useful follow-up to the kind of inquiry reported in this thesis. Such a program would need the involvement of parents as well as teachers and school administrators. It would be interesting to examine the network of relationships during a school year and compare them with the relationships revealed in the non-interventionist study reported in this thesis.

The complexity of educational practice cautions against simplistic solutions for many of the problems that exist in our schools. Nevertheless, some of the suggestions described above represent some tentative steps in a potentially fruitful direction.

The development of a number of science-related attitudes in high school science remains an important goal of science education. Among these science-related attitudes is the development in students of a sense of wonder and excitement which is felt by professional scientists such as Carl Sagan (1979, p.14):

> To penetrate into the heart of the thing - even a little thing, a blade of grass,... - is to experience a kind of exhilaration that, it may be, only human beings of all the beings on this planet can feel.

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APPENDIX 1

PUBLISHED REPORTS OF PRELIMINARY INVESTIGATIONS IN THIS STUDY

Pages 148-189 have been removed due to copyright restrictions. Published reports can be found here:

Schibeci, R. A. (1981) Do teachers rate science attitude objectives as highly as cognitive objectives? *Journal of Research in Science Teaching*, *18*(1), 69-72.

Schibeci, R. A. (1982) Science teachers and science-related attitudes. *European Journal of Science Education*, 3(4), 451-459.

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APPENDIX 2

INSTRUMENTS USED TO GATHER DATA ON, AND SUMMARY STATISTICS FOR, VARIABLES DESCRIBED IN CHAPTER 4.

Pages 191-220 have been removed due to copyright restrictions. Instruments be found here:

(a) Keeves, J. P. (1972) *The home, the school and educational achievement*, Melbourne, Victoria: Australian Council for Educational Research.

Instruments: *Home environment survey* and, *Activities and leisure time survey*

(b) Fraser, B. J. (1981) *TOSRA: Test of science-related attitudes,* Melbourne, Victoria: Australian Council for Educational Research.

Instrument: *Test of science-related attitudes*

(c) Fraser, B. J. (1979) *Test of inquiry skills handbook*. Melbourne, Victoria: Australian Council for Educational Research.

Instrument: *Test of inquiry skills*

Table A2.1

Summary Statistics for Student Responses to OPINIONS

(n = 507)

	Subscale	M	SD	Number of Items	Cronbach's α
1.	Attentiveness in Science Lessons	19.0	5.1	6	0.82
2.	Respect and Confidence in Self	57.4	7.7	17	0.77
3.	Attitude Toward School and School Learning	54.8	13.3	17	0.92
4.	Motivation to Achieve in School Learning	67.9	11.3	20	0.84

Table A2.2

Data on OPINIONS Subscales

Subscale	Number of Items	Inter-class correlation coefficient	Reliability (Cronbach's α)	N	M	SD
Attitudes Towards School and School Learning	17	0.80	0.89	2338	21.33	7.96
Motivation to Achieve in School Learning	20	0.84	0.81	2338	23.66	7.62
Respect and Confidence in Self	17	0.78	0.79	2322	20.26	6.22

Note. These data are taken from Keeves (1974).

Table A2.3

Summary Statistics and Reliability for Each TOSRA Subscale

TOSRA Subscale	*M*			*SD*			Reliability (Cronbach's α)
	Year Level			Year Level			
	8	9	10	8	9	10	
Social Implications of Science	36.6	35.7	36.7	5.6	5.9	5.7	0.81
Normality of Scientists	35.5	35.7	35.6	4.8	4.8	4.5	0.73
Attitude Towards Scientific Inquiry	38.3	39.3	37.5	4.5	5.2	5.0	0.69
Adoption of Scientific Attitudes	35.6	35.7	36.7	4.5	5.4	4.6	0.68
Enjoyment of Science Lessons	33.9	31.4	31.9	7.9	8.7	7.8	0.91
Leisure Interest in Science	28.8	27.2	27.7	7.6	8.1	8.0	0.87
Career Interest in Science	29.1	28.4	29.2	7.2	8.3	7.9	0.88

Note. Each scale contains 10 items scored 1 to 5, so that the minimum and maximum score possible on each scale is 10 and 50 respectively.

Table A2.4

Summary Statistics for Home Environment Variables: Acacia

(n = 197)

Variable	M	SD	Median	Mode	Range
Structural dimension					
Family size	3.0	1.2	2.8	3	1-9
Mother's Age	2.3	0.5	2.2	2	1-4
Father's Age	41.5	6.4	40.1	39	31-64
Language Background	2.5	0.8	2.8	3	1-3
Hours Mother Worked	4.2	1.5	4.8	5	1-5
Father's Occupation	1.3	0.9	1.1	1	1-5
Mother's Education	3.4	1.2	3.5	4	1-7
Father's Education	3.6	1.4	3.7	4	1-7
Attitudinal dimension					
Expected Place in class	2.9	1.2	3.1	4	1-5
Problems at School	2.8	0.4	2.9	3	1-3
Age of Full-time Education Expected	17.9	1.9	17.1	17	15-25
Hoped-for Occupation	2.5	1.4	2.0	2	1-5
Educational Expectations	7.4	2.0	8.6	9	3-9
Aspiration for Husband	2.0	1.2	1.4	1	1-4
Value of Education for Mother	2.7	0.8	2.7	3	1-4
Process dimension					
Home/school Relations	10.7	3.9	10.1	6	6-26
Reading Practices	10.1	3.0	10.0	10	4-20
Formal Schoolwork: Help at Home	33.4	6.5	32.9	33	17-51
Science-related Activities	9.6	2.3	9.8	10	3-15

Table A2.5

Summary Statistics for Home Environment Variables:

Boronia

(n = 203)

Variable	M	SD	Median	Mode	Range
Structural dimension					
Family size	3.2	1.2	3.1	3	1-9
Mother's Age	2.5	0.6	2.4	2	1-5
Father's Age	44.9	9.0	43.2	43	30-58
Language Background	2.7	0.6	2.9	3	1-3
Hours Mother worked	4.1	1.6	4.8	5	1-5
Father's Occupation	2.6	1.5	2.1	2	1-5
Mother's Education	4.4	1.5	4.2	4	1-7
Father's Education	5.3	1.6	5.5	7	1-7
Attitudinal dimension					
Expected Place in Class	3.1	1.1	3.3	4	1-5
Problems at School	2.8	0.4	2.9	3	1-3
Age of Full-time Education Expected	19.3	2.2	19.9	17	15-25
Hoped-for Occupation	3.0	1.5	2.2	2	1-5
Educational Expectations	8.3	1.3	8.9	9	3-9
Aspiration for Husband	2.7	1.2	3.0	4	1-4
Value of Education for Mother	3.0	0.7	3.1	3	1-4
Process dimension					
Home/School Relations	10.5	3.2	9.5	9	6-21
Reading Practices	8.8	2.9	8.5	8	4-16
Formal Schoolwork: Help at Home	31.9	5.7	31.8	32	15-50
Science-Related Activities	9.2	2.0	9.2	9	4-15

Table A2.6

Summary Statistics for Peer Group Variables: Acacia

(n = 292)

Variable	M	SD	Median	Mode	Range
Structural dimension					
Occupation (father)*	13.4	1.8	13.8	15	5-15
Language	3.7	0.8	3.5	3	3-6
Star Rating	3.6	2.4	3.1	2	1-9
Attitudinal dimension					
Occupational Expectations*	9.1	2.1	9.0	9	3-15
Educational Expectations*	11.9	3.6	11.8	12	3-21
Process dimension					
Hours of Homework	11.4	6.8	9.8	6	3-45
Science Activities	112.8	38.9	102.8	101	59-351
General Activities	31.7	16.3	26.8	26	14-135

Note. All values (except for Star Rating) are the combined scores for the nominated three best friends.

Table A2.7

Summary Statistics for Peer Group Variables : Boronia

(n=237)

Variable	M	SD	Median	Mode	Range
Structural dimension					
Occupation (father)	10.5	3.0	10.4	15	3-15
Language	3.2	0.4	3.1	3	3-5
Star Rating	3.6	2.5	3.1	1	1-9
Attitudinal dimension					
Occupational Expectations	9.6	2.2	9.2	9	5-16
Educational Expectations	13.6	3.2	13.6	15	6-21
Process dimension					
Hours of Homework	14.6	6.7	13.8	6	4-37
Science Activities	122.7	53.6	102.9	102	72-351
General Activities	36.4	23.3	27.2	26	21-135

Note. All values (except for Star Rating) are the combined scores for the nominated three best friends.

Table A2.8

Summary Statistics for School-Related Data Included in Home Causal Models

Variable	M	SD	Median	Mode	Range
Acacia [a]					
DESIGN	6.0	1.8	6.0	6	2-10
GENERAL	5.2	1.9	5.7	6	0-9
ADOPT1	35.6	4.1	35.2	35	24-50
ENJSC1	36.2	7.6	37.5	38	11-50
ACH1	59.1	16.7	59.0	68	24-93
ATTEN	19.7	4.6	20.1	20	7-30
SREGARD	57.8	7.3	56.9	56	38-79
ATSCHL	56.3	13.1	56.4	56	18-82
ACADMOT	70.3	10.5	71.3	76	38-95
ACH2	52.3	14.6	54.0	58	19-85
ADOPT2	35.6	5.1	35.8	37	21-49
ENJSC2	32.9	8.1	34.2	38	11-49
Boronia [b]					
DESIGN	7.1	1.8	7.4	8	2-10
GENERAL	6.5	1.9	6.8	8	2-9
ADOPT1	35.9	4.3	36.1	37	21-47
ENJSC1	33.3	7.8	34.1	33	14-49
ACH1	61.5	14.1	63.0	70	22-91
ATTEN	18.4	5.2	18.1	16	7-30
SREGARD	57.5	7.4	56.8	54	38-77
ATSCHL	53.8	13.4	55.6	39	23-83
ACADMOT	67.6	11.2	66.4	66	40-94
ACH2	58.5	15.9	57.1	50	17-93
ADOPT2	36.1	5.1	36.1	35	19-50
ENJSC2	31.2	9.4	32.4	38	10-50

[a] n = 197

[b] n = 203

Table A2.9

Summary Statistics for School-related Variables

Variable	M	SD	Median	Mode	Range
Acacia [a]					
LEISURE1	30.0	7.5	29.8	28	11-50
CAREER1	28.8	6.8	29.3	30	10-50
SOCIMP1	36.2	5.2	36.1	37	22-50
NORMSC1	34.7	4.4	34.4	32	23-50
ATTINQ1	37.6	6.3	37.9	33	19-50
CHILDED	2.8	1.7	2.3	5	1-5
CHILDOCC	4.4	1.0	4.8	5	2-5
LEISURE2	28.3	7.9	28.9	33	10-48
CAREER2	27.2	7.0	27.1	27	10-49
SOCIMP2	33.9	6.1	33.7	30	10-48
NORMSC2	34.8	4.9	33.9	33	23-48
ATTINQ2	38.5	6.4	38.3	37	13-50
Boronia [b]					
LEISURE1	28.1	7.6	27.7	24	10-49
CAREER1	29.1	7.2	29.7	32	12-48
SOCIMP1	36.3	5.4	35.6	35	16-50
NORMSC1	35.8	4.4	35.3	34	24-49
ATTINQ1	40.3	5.3	40.3	40	25-50
CHILDED	4.7	1.8	4.4	4	1-7
CHILDOCC	4.4	1.0	4.8	5	2-5
LEISURE2	27.7	8.9	27.9	32	10-50
CAREER2	28.2	8.3	28.0	25	10-50
SOCIMP2	35.2	6.3	35.5	33	10-50
NORMSC2	36.7	5.7	36.2	33	19-50
ATTINQ2	39.6	6.2	40.1	40	19-50

[a] n = 292
[b] n = 237

Table A2.10

Summary Statistics for School-Related Data

Included in Peer Group Causal Models

Variable	M	SD	Median	Mode	Range
Acacia [a]					
DESIGN	5.8	1.8	5.8	6	1-10
GENERAL	4.8	2.0	5.5	6	0-9
ADOPT1	35.2	4.2	35.1	35	24-50
ENJSC1	35.8	7.3	36.6	39	11-50
ACH1	55.8	16.3	55.3	50	10-93
ATTEN	19.4	4.7	19.9	20	6-30
SREGARD	57.1	7.5	57.1	57	36-79
ATSCH2	55.3	12.8	56.2	56	18-82
ACADMOT	69.2	10.4	70.5	76	38-95
ACH2	48.9	15.3	49.7	50	10-94
ADOPT2	34.7	5.0	33.8	33	21-49
ENJSC2	31.3	8.3	30.8	28	11-49
Boronia [b]					
DESIGN	6.9	1.8	7.0	8	2-10
GENERAL	6.3	1.9	6.4	6	1-9
ADOPT1	35.7	4.2	35.6	35	21-47
ENJSC1	33.4	7.9	34.5	33	12-49
ACH1	61.5	14.1	63.0	70	22-91
ATTEN	18.5	5.2	19.1	20	6-30
SREGARD	57.7	7.5	57.3	57	38-77
ATSCHL	54.5	12.8	55.9	56	23-83
ACADMOT	67.8	11.5	68.4	76	40-94
ACH2	58.5	15.9	57.0	50	17-93
ADOPT2	35.9	5.2	36.0	35	19-50
ENJSC2	31.0	9.2	31.9	38	10-50

[a] n = 292

[b] n = 237

APPENDIX 3

INTECORRELATION MATRICES FOR VARIABLES IN PRELIMINARY LISREL ANALYSES.

Table A3.1

Descriptors Used to Identify Variables Included in Causal Models of the School

	Descriptor	Variable to Which Descriptor Refers
1.	ACH1[a]	Achievement score in first term
2.	ATTEN[a]	Attentiveness in science classes
3.	SREGARD[a]	Respect and confidence in self
4.	ATSCHL[a]	Attitudes towards school and school learning
5.	ACADMOT[a]	Motivation to achieve in school learning
6.	ACH2[a]	End-of-year achievement score
7.	ADOPT2[a]	Adoption of Scientific Attitudes
8.	ENJSC2[a]	Enjoyment of Science Lessons
9.	SEX[a]	Sex of student
10.	DESIGN[a]	Design of experimental procedures
11.	GENERAL[a]	Ability to draw valid conclusions and generalisations
12.	ADOPT1[a]	Adoption of Scientific Attitudes
13.	ENJSC1[a]	Enjoyment of science lessons
14.	CHILDED	Child's expectation for full-time education
15.	CHILDOCC	Child's expected occupation

a Variable included in all three (home, school and peer group) causal models

Note: The numerals "1" and "2" at the end of descriptors (e.g. ENJSC1 and ENJSC2) in Tables A3.1 and A3.3 refer to the pre-test (February, 1980) and the post-test (October, 1980) values respectively.

Table A3.2

Descriptors Used to Identify Variables Included in Causal Models of the Peer Group

Descriptor		Variable to Which Descriptor Refers
1.	ACH1[a]	Achievement score in first term
2.	ATTEN[a]	Attentiveness in science classes
3.	SREGARD[a]	Respect and confidence in self
4.	ATSCHL[a]	Attitudes towards school and school learning
5.	ACADMOT[a]	Motivation to achieve in school learning
6.	ACH2[a]	End-of-year achievement score
7.	ADOPT2[a]	Adoption of scientific attitudes
8.	ENJSC2[a]	Enjoyment of science lessons
9.	SEX[a]	Sex of student
10.	DESIGN[a]	Design of experimental procedures
11.	GENERAL[a]	Ability to draw valid conclusions and generalisations
12.	ADOPT1[a]	Adoption of scientific attitudes
13.	ENJSC1[a]	Enjoyment of science lessons
14.	DAD	Occupational Status: occupation of fathers of nominated three best friends
15.	ENG	Language: the commonly spoken language in homes of nominated three best friends
16.	STAR	Star Rating: number of times student was named as a friend by the Year 8 cohort
17.	JOB	Occupational Expectations: nominated three best friends
18.	ED	Educational Expectations: nominated three best friends
19.	HWK	Hours of Homework: hours per week reported by nominated three best friends
20.	SACT	Science Activities: reported by nominated three best friends
21.	GACT	General Activities: reported by nominated three best friends

[a] Variable included in all three (home, school and peer group) causal models

Table A3.3

Descriptors Used to Identify Variables Included in Causal Models of the Home

	Descriptor	Variable to Which Descriptor Refers
1.	ACH1[a]	Initial Achievement Score
2.	ATTEN[a]	Attentiveness in Science Lessons
3.	SREGARD[a]	Respect and Confidence in Self
4.	ATSCHL[a]	Attitudes Toward School and School Learning
5.	ACADMOT[a]	Motivation to Achieve in School Learning
6.	ACH2[a]	Final Achievement Score
7.	ADOPT2[a]	Adoption of Scientific Attitudes
8.	ENJSC2[a]	Enjoyment of Science Lessons
9.	SEX[a]	Sex of Student
10.	DESIGN[a]	Design of Experimental Procedures
11.	GENERAL[a]	Conclusions and Generalisations
12.	ADOPT1[a]	Adoption of Scientific Attitudes
13.	ENJSC1[a]	Enjoyment of Science Lessons
14.	CHILDNO	Number of Children in Family
15.	DADAGE	Father's Age
16.	MUMAGE	Mother's Age
17.	PARENT	Language Background of Parents
18.	MUMHRS	Hours Mother Worked: number of hours mother works away from home
19.	DADOCC	Father's Occupation
20.	MUMOCC	Mother Has Paid Employment
21.	DADED	Husband's Educational Background
22.	MUMED	Mother's Educational Background
23.	SETTLE	Problems At School: mother's perception of extent to which child has settled in at school
24.	PLACECL	Expected Place in Class: mother's expectation for child's place in class
25.	EDAGE	Age of Full-Time Education Expected: mother's prediction of age at which full-time education will end
26.	HOMEX	Educational Expectations: mother's expectations for length of child's secondary schooling
27.	CHILDJOB	Hoped-for Occupation: expected occupation for child
28.	DADEX	Aspiration for Husband: mother's expectation for father's advancement in his occupation
29.	MUMVAL	Value of Education for Mother
30.	HSCHOOL	Home/School Relations: mother's perceptions of home-school relations
31.	HREAD	Reading Practices: use of books and library facilities
32.	HOMEWK	Formal School Work: help at home
33.	HSCIENCE	Science-Related Activities: mother's perception of child's home science-related activities

[a] Variable included in all three (home, school and peer group) causal models

Table A3.4

Intercorrelation Matrix for Acacia Home Variables

	ACH1	ATTEN	SREGARD	ATSCHL	ACADMOT	ACH2	ADOPT2	ENJSC2	SEX	DESIGN
ACH1	1.000									
ATTEN	0.289	1.000								
SREGARD	0.287	0.345	1.000							
ATSCHL	0.292	0.495	0.277	1.000						
ACADMOT	0.238	0.671	0.332	0.688	1.000					
ACH2	0.590	0.286	0.313	0.245	0.237	1.000				
ADOPT2	0.183	0.304	0.270	0.377	0.477	0.372	1.000			
ENJSC2	0.168	0.509	0.162	0.403	0.475	0.252	0.600	1.000		
SEX	0.048	-0.041	0.063	0.206	0.084	-0.148	0.088	-0.008	1.000	
DESIGN	0.337	0.161	0.226	0.152	0.118	0.417	0.249	0.139	-0.077	1.000
GENERAL	0.415	0.115	0.219	0.119	0.095	0.322	0.199	0.105	-0.064	0.496
ADOPT1	0.148	0.173	0.189	0.185	0.297	0.289	0.470	0.336	-0.137	0.138
ENJSC1	0.139	0.301	0.113	0.190	0.206	0.215	0.294	0.440	-0.227	0.049
CHILDNO	-0.093	-0.037	-0.101	-0.041	0.023	-0.038	0.047	-0.062	-0.009	-0.093
DADAGE	0.028	0.021	0.013	-0.031	0.026	-0.055	-0.126	-0.039	-0.023	-0.032
MUMAGE	0.035	0.071	0.038	0.076	0.118	-0.051	-0.110	0.027	-0.041	-0.190
PARENT	-0.012	-0.057	0.118	-0.044	-0.037	0.010	0.063	-0.026	0.090	0.065
MUMHRS	0.127	0.006	0.077	0.079	-0.067	0.188	0.105	0.068	-0.012	0.163
DADOCC	0.162	0.045	0.125	0.073	-0.028	0.113	0.086	0.006	0.110	0.109
MUMOCC	-0.121	-0.029	-0.069	-0.015	0.054	-0.141	-0.013	0.070	-0.052	-0.063
DADED	0.123	0.027	-0.002	0.023	0.014	0.112	0.002	0.021	-0.107	0.132
MUMED	-0.058	0.005	0.006	-0.053	0.015	-0.098	-0.091	0.005	-0.077	-0.068
SETTLE	0.291	0.032	0.152	0.119	0.106	0.297	0.161	-0.002	0.019	0.216
PLACECL	0.334	0.102	0.168	0.122	0.150	0.195	0.113	0.053	-0.046	0.309
EDAGE	0.285	0.188	0.064	0.129	0.195	0.259	0.170	0.171	-0.167	0.153
HOMEX	0.379	0.175	0.277	0.245	0.236	0.344	0.136	0.134	-0.041	0.149
CHILDJOB	0.236	-0.259	0.157	0.063	0.135	0.199	0.095	0.194	-0.194	0.249
DADEX	0.097	0.127	-0.016	0.179	0.141	0.059	0.093	0.028	-0.007	0.110
MUMVAL	-0.022	0.004	-0.036	0.047	0.017	-0.007	0.022	0.044	-0.095	-0.111
HSCHOOL	-0.151	-0.008	-0.067	-0.049	0.017	-0.143	0.018	-0.063	0.038	-0.299
HREAD	-0.277	-0.091	-0.026	-0.149	-0.139	-0.240	-0.147	-0.152	-0.158	-0.035
HOMEWK	-0.108	-0.196	-0.107	-0.216	-0.227	-0.189	-0.137	-0.206	-0.009	-0.004
HSCIENCE	-0.148	-0.124	-0.119	-0.067	-0.044	-0.196	-0.121	-0.112	0.300	-0.028

	GENERAL	ADOPT1	ENJSC1	CHILDNO	DADAGE	MUMAGE	PARENT	MUMHRS	DADOCC	MUMOCC
GENERAL	1.000									
ADOPT1	0.189	1.000								
ENJSC1	0.146	0.577	1.000							
CHILDNO	-0.098	0.096	-0.024	1.000						
DADAGE	0.021	-0.045	0.070	0.088	1.000					
MUMAGE	-0.074	-0.003	0.133	0.119	0.631	1.000				
PARENT	0.083	0.003	-0.049	-0.166	-0.293	-0.201	1.000			
MUMHRS	0.092	0.022	0.003	-0.111	-0.159	-0.100	0.355	1.000		
DADOCC	0.100	-0.036	-0.056	-0.100	-0.238	-0.242	0.428	0.344	1.000	
MUMOCC	0.021	-0.046	0.067	0.026	0.083	0.105	-0.090	-0.029	-0.176	1.000
DADED	0.021	0.011	-0.047	-0.111	-0.106	0.012	0.141	0.316	0.085	0.027
MUMED	-0.092	0.008	0.026	0.053	0.054	0.137	0.126	0.024	-0.005	0.284
SETTLE	0.108	0.150	0.057	0.017	0.029	0.058	0.004	0.047	0.072	-0.140
PLACECL	0.250	0.084	0.028	-0.149	0.094	0.063	-0.161	-0.082	0.024	-0.038
EDAGE	0.204	0.200	0.197	0.048	0.143	0.107	-0.182	-0.064	0.037	0.091
HOMEX	0.141	0.088	0.088	-0.036	0.012	0.015	0.048	0.179	0.076	-0.029
CHILDJOB	0.225	0.164	0.212	-0.077	0.063	0.023	-0.154	-0.021	-0.106	0.070
DADEX	0.048	0.001	-0.112	-0.007	-0.228	-0.152	0.121	0.129	0.156	-0.120
MUMVAL	-0.096	0.032	0.032	-0.081	-0.072	-0.007	-0.053	0.139	0.141	0.030
HSCHOOL	-0.062	-0.072	-0.039	0.171	0.021	0.029	-0.089	-0.112	-0.020	0.098
HREAD	-0.138	-0.114	-0.143	0.017	-0.134	-0.149	-0.028	0.007	-0.070	0.083
HOMEWK	-0.095	-0.062	-0.165	0.188	-0.151	-0.067	-0.086	-0.017	-0.034	-0.021
HSCIENCE	-0.112	-0.234	-0.250	0.066	0.005	0.041	-0.136	-0.260	-0.104	0.046

	DADED	MUMED	SETTLE	PLACECL	EDAGE	HOMEX	CHILDJOB	DADEX	MUMVAL	HSCHOOL
DADED	1.000									
MUMED	0.041	1.000								
SETTLE	0.085	-0.004	1.000							
PLACECL	0.044	-0.131	0.165	1.000						
EDAGE	0.166	0.086	0.161	0.312	1.000					
HOMEX	0.045	-0.046	0.176	0.175	0.383	1.000				
CHILDJOB	0.123	0.033	0.083	0.230	0.482	0.227	1.000			
DADEX	0.172	-0.009	0.138	-0.006	0.064	0.131	-0.006	1.000		
MUMVAL	-0.004	-0.008	0.139	0.063	0.215	0.234	0.113	0.160	1.000	
HSCHOOL	-0.026	0.040	-0.233	-0.088	-0.045	-0.075	-0.048	-0.130	-0.038	1.000
HREAD	-0.057	-0.074	-0.183	-0.121	-0.162	-0.118	-0.020	-0.130	-0.138	0.145
HOMEWK	-0.017	-0.052	-0.113	-0.059	-0.144	-0.204	-0.111	-0.053	-0.209	0.056
HSCIENCE	-0.097	-0.069	-0.090	-0.064	-0.265	-0.373	-0.134	-0.168	-0.193	0.079

	HREAD	HOMEWK	HSCIENCE
HREAD	1.000		
HOMEWK	0.310	1.000	
HSCIENCE	0.148	0.352	1.000

Table A3.5

Intercorrelation Matrix for Boronia Home Variables

	ACH1	ATTEN	SREGARD	ATSCHL	ACADMOT	ACH2	ADOPT2	ENJSC2	SEX	DESIGN
ACH1	1.000									
ATTEN	0.329	1.000								
SREGARD	0.266	0.328	1.000							
ATSCHL	0.291	0.613	0.296	1.000						
ACADMOT	0.300	0.680	0.408	0.719	1.000					
ACH2	0.671	0.424	0.192	0.409	0.410	1.000				
ADOPT2	0.192	0.399	0.268	0.450	0.464	0.306	1.000			
ENJSC2	0.234	0.570	0.211	0.491	0.474	0.426	0.632	1.000		
SEX	-0.094	-0.115	-0.047	0.207	0.042	0.110	0.085	-0.016	1.000	
DESIGN	0.414	0.109	0.139	0.036	0.001	0.417	0.113	0.149	-0.052	1.000
GENERAL	0.486	0.122	0.191	0.053	0.094	0.396	0.078	0.104	0.017	0.521
ADOPT1	0.212	0.345	0.300	0.373	0.375	0.323	0.505	0.388	0.057	0.199
ENJSC1	0.202	0.401	0.203	0.395	0.406	0.270	0.419	0.537	-0.104	0.028
CHILDNO	0.002	-0.052	-0.073	0.071	-0.041	-0.012	-0.024	0.002	0.024	0.056
DADAGE	0.038	0.030	-0.194	0.049	0.040	0.137	0.027	0.090	0.026	-0.001
MUMAGE	0.055	0.014	-0.123	0.018	-0.006	0.090	-0.063	0.012	-0.036	0.094
PARENT	-0.063	-0.139	-0.072	-0.159	-0.197	-0.113	-0.072	-0.041	0.103	0.058
MUMHRS	0.231	0.163	0.132	0.131	0.196	0.215	0.105	0.237	-0.099	0.151
DADOCC	0.196	0.256	0.089	0.145	0.207	0.292	0.144	0.233	-0.088	0.260
MUMOCC	0.001	0.063	0.092	0.034	0.010	-0.035	0.102	0.032	-0.055	-0.090
DADED	0.164	0.019	0.157	0.059	0.146	0.171	0.033	0.102	0.049	0.022
MUMED	0.135	0.027	0.015	0.023	0.067	-0.013	-0.062	-0.084	-0.063	-0.085
SETTLE	0.047	0.043	0.167	0.049	0.096	0.007	0.183	0.026	0.038	0.053
PLACECL	0.279	0.120	0.174	0.137	0.210	0.325	0.098	0.077	0.056	0.189
EDAGE	0.264	0.056	0.174	0.272	0.168	0.291	0.154	0.094	0.008	0.243
HOMEX	0.277	0.225	0.194	0.315	0.135	0.283	0.058	0.122	-0.029	0.224
CHILDJOB	0.254	0.147	0.163	0.122	0.122	0.190	0.178	0.101	-0.198	0.180
DADEX	0.005	0.039	0.015	0.066	0.030	0.023	0.008	-0.018	0.042	0.011
MUMVAL	0.164	0.224	0.053	0.206	0.238	0.260	0.191	0.208	-0.109	0.090
HSCHOOL	-0.008	-0.052	-0.059	-0.165	-0.114	-0.069	-0.130	-0.096	-0.074	-0.050
HREAD	-0.135	-0.126	-0.114	-0.307	-0.201	-0.167	-0.094	-0.121	-0.205	-0.008
HOMEWK	0.020	-0.074	-0.053	-0.148	-0.205	-0.111	-0.111	-0.048	-0.156	0.039
HSCIENCE	-0.215	-0.260	-0.015	-0.154	-0.187	-0.201	-0.135	-0.296	0.321	-0.051

	GENERAL	ADOPT1	ENJSC1	CHILDNO	DADAGE	MUMAGE	PARENT	MUMHRS	DADOCC	MUMOCC
GENERAL	1.000									
ADOPT1	0.201	1.000								
ENJSC1	0.112	0.469	1.000							
CHILDNO	0.063	0.079	0.041	1.000						
DADAGE	-0.086	0.016	0.113	0.201	1.000					
MUMAGE	0.023	-0.010	0.066	0.220	0.498	1.000				
PARENT	-0.029	-0.131	-0.057	0.005	0.045	0.063	1.000			
MUMHRS	0.147	-0.099	0.058	-0.046	-0.019	-0.110	-0.081	1.000		
DADOCC	0.071	0.099	0.071	-0.153	-0.004	0.040	0.045	0.305	1.000	
MUMOCC	-0.057	0.049	0.046	0.145	-0.041	0.077	-0.009	0.061	0.045	1.000
DADED	0.029	0.002	-0.041	-0.089	-0.097	-0.062	-0.049	0.370	0.127	0.089
MUMED	-0.157	-0.101	-0.083	0.036	0.030	-0.017	-0.078	0.105	-0.008	0.048
SETTLE	-0.002	0.160	0.056	0.043	0.025	0.099	-0.016	-0.067	-0.081	0.154
PLACECL	0.233	0.136	0.069	-0.024	-0.004	0.000	-0.164	0.027	0.088	-0.055
EDAGE	0.240	0.152	0.073	0.064	0.089	-0.041	-0.185	0.208	0.074	-0.010
HOMEX	0.164	0.132	0.080	0.139	-0.030	0.007	0.002	0.046	0.145	0.152
CHILDJOB	0.191	0.121	0.112	0.003	-0.016	-0.019	-0.110	0.259	0.057	0.066
DADEX	-0.056	0.064	0.024	-0.210	-0.010	0.006	-0.005	0.155	0.106	0.040
MUMVAL	0.120	0.127	0.022	-0.115	-0.026	0.000	-0.045	0.185	0.396	0.029
HSCHOOL	0.066	0.012	-0.047	0.022	-0.141	-0.033	-0.091	0.029	-0.085	-0.134
HREAD	-0.067	-0.061	-0.124	0.004	-0.021	-0.037	0.128	-0.111	-0.079	-0.070
HOMEWK	-0.044	-0.065	-0.050	0.123	-0.004	0.022	-0.029	-0.001	-0.137	0.026
HSCIENCE	0.027	-0.143	-0.192	0.097	-0.099	-0.109	0.074	-0.142	-0.189	-0.022

	DADED	MUMED	SETTLE	PLACECL	EDAGE	HOMEX	CHILDJOB	DADEX	MUMVAL	HSCHOOL
DADED	1.000									
MUMED	0.107	1.000								
SETTLE	-0.042	-0.080	1.000							
PLACECL	0.106	0.015	0.073	1.000						
EDAGE	0.177	-0.018	-0.004	0.266	1.000					
HOMEX	0.090	-0.082	0.087	0.166	0.410	1.000				
CHILDJOB	0.122	0.098	0.116	0.202	0.448	0.210	1.000			
DADEX	-0.032	0.041	-0.001	-0.023	0.012	0.056	-0.014	1.000		
MUMVAL	0.184	-0.035	-0.115	-0.055	0.181	0.121	0.141	-0.001	1.000	
HSCHOOL	0.005	-0.033	-0.257	-0.044	-0.046	-0.076	-0.015	-0.043	0.055	1.000
HREAD	-0.040	0.082	-0.070	-0.163	-0.154	-0.201	-0.061	0.014	-0.105	0.068
HOMEWK	0.077	0.095	0.105	-0.225	-0.085	-0.111	-0.005	-0.157	-0.105	0.077
HSCIENCE	0.007	0.071	0.140	-0.065	-0.051	-0.068	-0.066	-0.049	-0.238	-0.066

	HREAD	HOMEWK	HSCIENCE
HREAD	1.000		
HOMEWK	0.263	1.000	
HSCIENCE	0.104	0.248	1.000

Table A3.6

Intercorrelation Matrix for Acacia School Variables

	ACH1	ATTEN	SREGARD	ATSCHL	ACADMOT	ACH2
ACH1	1.000					
ATTEN	0.302	1.000				
SREGARD	0.332	0.296	1.000			
ATSCHL	0.339	0.408	0.314	1.000		
ACADMOT	0.293	0.586	0.376	0.676	1.000	
ACH2	0.652	0.244	0.356	0.285	0.274	1.000
ADOPT2	0.271	0.325	0.285	0.423	0.462	0.373
ENJSC2	0.164	0.471	0.153	0.356	0.380	0.216
SEX	0.043	-0.024	0.055	0.273	0.132	-0.071
DESIGN	0.409	0.146	0.240	0.159	0.149	0.404
GENERAL	0.432	0.119	0.150	0.144	0.079	0.337
ADOPT1	0.198	0.212	0.216	0.263	0.334	0.256
ENJSC1	0.053	0.297	0.093	0.187	0.208	0.139
CHILDED	0.408	0.238	0.368	0.347	0.273	0.400
CHILDOCC	-0.088	0.012	-0.041	-0.020	0.015	0.015

	ADOPT2	ENJSC2	SEX	DESIGN	GENERAL	ADOPT1
ADOPT2	1.000					
ENJSC2	0.547	1.000				
SEX	0.175	0.040	1.000			
DESIGN	0.243	0.066	-0.065	1.000		
GENERAL	0.214	0.084	-0.009	0.472	1.000	
ADOPT1	0.480	0.283	0.009	0.132	0.150	1.000
ENJSC1	0.283	0.389	-0.135	0.001	0.073	0.499
CHILDED	0.287	0.217	0.074	0.232	0.260	0.202
CHILDOCC	-0.038	0.021	-0.140	-0.026	0.050	-0.029

	ENJSC1	CHILDED	CHILDOCC
ENJSC1	1.000		
CHILDED	0.111	1.000	
CHILDOCC	0.039	-0.004	1.000

Table A3.7

Interrcorrelation Matrix for Boronia School Variables

	ACH1	ATTEN	SREGARD	ATSCHL	ACADMOT	ACH2
ACH1	1.000					
ATTEN	0.268	1.000				
SREGARD	0.261	0.307	1.000			
ATSCHL	0.283	0.634	0.284	1.000		
ACADMOT	0.259	0.690	0.384	0.753	1.000	
ACH2	0.582	0.342	0.223	0.389	0.373	1.000
ADOPT2	0.148	0.355	0.223	0.428	0.410	0.228
ENJSC2	0.179	0.557	0.176	0.504	0.449	0.244
SEX	-0.047	-0.112	-0.039	0.176	0.034	-0.013
DESIGN	0.414	0.132	0.146	0.078	0.038	0.243
GENERAL	0.544	0.102	0.210	0.079	0.096	0.369
ADOPT1	0.239	0.318	0.251	0.367	0.337	0.233
ENJSC1	0.156	0.375	0.133	0.357	0.337	0.299
CHILDED	0.288	0.254	0.187	0.428	0.346	0.389
CHILDOCC	-0.035	0.060	0.002	-0.042	-0.021	-0.101

	ADOPT2	ENJSC2	SEX	DESIGN	GENERAL	ADOPT1
ADOPT2	1.000					
ENJSC2	0.625	1.000				
SEX	0.085	-0.028	1.000			
DESIGN	0.147	0.152	0.020	1.000		
GENERAL	0.100	0.077	0.033	0.498	1.000	
ADOPT1	0.489	0.364	0.064	0.195	0.168	1.000
ENJSC1	0.370	0.493	-0.104	0.038	0.019	0.479
CHILDED	0.172	0.219	-0.051	0.115	0.113	0.198
CHILDOCC	0.041	0.108	-0.205	-0.007	-0.028	0.004

	ENJSC1	CHILDED	CHILDOCC
ENJSC1	1.000		
CHILDED	0.146	1.000	
CHILDOCC	-0.074	0.011	1.000

Table A3.8

Intercorrelation Matrix for Acacia Peer Group Variables

	ACH1	ATTEN	SREGARD	ATSCHL	ACADMOT	ACH2	ADOPT2	ENJSC2	SEX	DESIGN
ACH1	1.000									
ATTEN	0.302	1.000								
SREGARD	0.332	0.296	1.000							
ATSCHL	0.339	0.408	0.314	1.000						
ACADMOT	0.293	0.586	0.376	0.676	1.000					
ACH2	0.652	0.244	0.356	0.285	0.274	1.000				
ADOPT2	0.271	0.325	0.285	0.423	0.462	0.373	1.000			
ENJSC2	0.226	0.483	0.165	0.378	0.405	0.252	0.583	1.000		
SEX	0.043	-0.024	0.055	0.273	0.132	-0.071	0.175	0.039	1.000	
DESIGN	0.409	0.146	0.240	0.159	0.149	0.404	0.243	0.109	-0.065	1.000
GENERAL	0.432	0.119	0.150	0.144	0.079	0.337	0.214	0.144	-0.009	0.472
ADOPT1	0.198	0.212	0.216	0.263	0.334	0.256	0.480	0.315	0.009	0.132
ENJSC1	0.053	0.297	0.093	0.187	0.208	0.139	0.283	0.401	-0.135	0.001
DAD	0.001	0.032	-0.041	0.058	0.013	-0.033	0.006	-0.030	0.081	-0.048
ENG	-0.073	-0.019	-0.183	-0.123	-0.089	-0.185	-0.149	-0.023	-0.045	-0.102
STAR	0.096	0.062	-0.064	-0.107	-0.059	0.029	-0.104	0.017	-0.093	0.002
JOB	0.051	-0.046	0.093	-0.010	0.005	0.166	0.055	-0.020	-0.217	0.164
ED	0.170	-0.018	0.068	0.150	0.127	0.222	0.206	0.087	0.060	0.220
HWK	0.216	0.102	0.114	0.182	0.229	0.146	0.184	0.127	0.163	0.064
SACT	0.016	-0.134	-0.079	-0.040	-0.115	-0.007	-0.113	-0.087	-0.065	0.017
GACT	0.010	-0.116	-0.081	-0.072	-0.130	-0.009	-0.134	-0.086	-0.146	0.020

	GENERAL	ADOPT1	ENJSC1	DAD	ENG	STAR	JOB	ED	HWK	SACT
GENERAL	1.000									
ADOPT1	0.150	1.000								
ENJSC1	0.073	0.499	1.000							
DAD	0.012	-0.116	-0.020	1.000						
ENG	-0.110	-0.095	-0.023	0.101	1.000					
STAR	0.010	-0.140	-0.047	0.077	-0.035	1.000				
JOB	0.109	0.095	0.065	-0.001	-0.002	-0.061	1.000			
ED	0.175	0.103	0.027	-0.064	-0.086	-0.141	0.435	1.000		
HWK	0.083	0.020	0.006	0.051	-0.118	-0.073	0.121	0.295	1.000	
SACT	-0.055	-0.075	-0.041	0.084	-0.160	0.046	-0.068	-0.003	-0.101	1.000
GACT	-0.055	-0.055	-0.013	0.068	-0.073	0.045	-0.034	0.000	-0.135	0.969

	GACT
GACT	1.000

Table A3.9

Intercorrelation Matrix for Boronia Peer Group Variables

	ACH1	ATTEN	SREGARD	ATSCHL	ACADMOT	ACH2	ADOPT2	ENJSC2	SEX	DESIGN
ACH1	1.000									
ATTEN	0.292	1.000								
SREGARD	0.261	0.321	1.000							
ATSCHL	0.295	0.637	0.309	1.000						
ACADMOT	0.277	0.689	0.397	0.735	1.000					
ACH2	0.706	0.405	0.208	0.421	0.409	1.000				
ADOPT2	0.145	0.367	0.228	0.431	0.434	0.308	1.000			
ENJSC2	0.177	0.561	0.178	0.492	0.466	0.419	0.625	1.000		
SEX	-0.051	-0.094	-0.030	0.195	0.053	0.123	0.085	-0.028	1.000	
DESIGN	0.439	0.113	0.151	0.065	0.029	0.377	0.116	0.137	0.009	1.000
GENERAL	0.553	0.080	0.207	0.065	0.073	0.417	0.067	0.058	0.034	0.512
ADOPT1	0.228	0.321	0.252	0.358	0.349	0.297	0.489	0.364	0.064	0.190
ENJSC1	0.154	0.378	0.135	0.349	0.350	0.181	0.370	0.493	-0.104	0.022
DAD	-0.073	-0.081	-0.148	-0.242	-0.132	-0.044	-0.011	-0.010	-0.089	-0.056
ENG	0.018	0.053	-0.074	-0.038	-0.064	0.017	-0.129	-0.052	-0.140	0.008
STAR	-0.031	0.072	0.016	0.044	0.053	0.037	0.051	0.071	0.049	-0.085
JOB	0.034	0.129	0.017	0.039	0.106	0.059	0.069	0.068	-0.130	-0.020
ED	0.204	0.216	0.099	0.256	0.266	0.183	0.147	0.204	-0.078	0.109
HWK	0.136	0.169	0.124	0.272	0.225	0.126	0.091	0.055	0.112	0.023
SACT	-0.040	-0.106	-0.085	-0.115	-0.054	-0.048	-0.022	0.005	-0.071	-0.129
GACT	-0.007	-0.055	-0.080	-0.076	-0.011	-0.020	0.009	0.057	-0.155	-0.112

	GENERAL	ADOPT1	ENJSC1	DAD	ENG	STAR	JOB	ED	HWK	SACT
GENERAL	1.000									
ADOPT1	0.171	1.000								
ENJSC1	0.016	0.479	1.000							
DAD	-0.106	-0.015	-0.109	1.000						
ENG	-0.017	-0.086	-0.033	0.021	1.000					
STAR	0.027	0.055	0.137	0.123	0.073	1.000				
JOB	-0.061	0.006	0.051	-0.125	-0.043	0.030	1.000			
ED	0.088	0.049	0.231	-0.360	0.038	-0.040	0.328	1.000		
HWK	0.130	0.058	0.192	-0.499	-0.113	-0.000	0.214	0.433	1.000	
SACT	-0.054	0.050	-0.028	0.385	-0.167	0.045	-0.083	-0.177	-0.341	1.000
GACT	-0.048	0.073	0.018	0.369	-0.144	0.059	-0.055	-0.102	-0.317	0.984

	GACT
GACT	1.000