

Science and Mathematics Education Centre

**Early Childhood Educators' Attitudes to Science and
Science Education**

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ABSTRACT

It has long been acknowledged that pre-service Early Childhood teachers enter university with a notable lack of confidence, high levels of anxiety and an aversion to science and mathematics. Unless redressed during their time spent at university, such negative attitudes may ultimately influence the quality of science education these teachers offer to young children. This study considers the affective attitudes to science and science education of those people considered to be central to the education of young children.

Specifically the study investigates the attitudes and backgrounds in science/ science education, of academics, pre-service and in-service teachers together with their attitudes towards teaching science to young children. The attitudes to science of a group of young children, aged between 4 and 8 years, were also investigated in the study. The potential links between the attitudes held by each group was of great interest to the researcher who considered the ways that academics promoted the teaching of science to young children, the factors influencing the willingness of pre-service and in-service teachers to present science to young children and the effect that teachers have on the responses of young children to science.

The findings suggest that in contrast to the attitudes towards science of pre-service and in-service teacher groups in the study, the young children and academics displayed attitudes such as interest, curiosity, confidence and enjoyment towards their experiences in science. There was a strong link between the memory of prior experiences in science and the present attitudes to science of the adult participants. The implications of the study are that science education in the early years will be enhanced if ways can be found to provide more positive science related experiences for pre-service and in-service teachers.

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CHAPTER 1

INTRODUCTION TO THE STUDY

Over the past 90 years Early Childhood Education in one Australian state has centred around a specific teacher training Institute, which has placed a heavy emphasis on the social, physical, emotional and cognitive development of the child. The majority of pre-service teachers enter the Institute, recently incorporated into a large education faculty within an even larger University, on the completion of their secondary high school education. The pre-service teachers take a series of subjects as well as extended periods of teaching practicum in order to qualify for a teaching award. The length and composition of the award are reviewed periodically and presently, after a course of four years, allows pre-service teachers to qualify as educators of children between 0-8 years of age. The data collection for the following study took place between 1992, and 1995, when tertiary pre-service education in mathematics and science was receiving considerable attention from science educators due the release of several well published, Commonwealth funded reports (The Discipline Review into Mathematics and Science Teacher Education, 1989; Women and Science Teacher Education, 1990). At the time of data collection, pre-service teachers in Early Childhood Education completed a three year course in order to obtain their teaching qualification.

Teachers in Early Childhood Education work under the directive of a specific office or division of the State's education department. The State government is responsible for setting and maintaining codes of practice and curriculum guidelines. Teachers may work in areas of child-care, Preschool/Kindergarten and Junior Primary Education. Some Junior Primary teachers may also have trained in part with Primary teachers and, although their training in respect to curriculum subjects is similar to those of Early Childhood Education, they are restricted solely to teaching in the Junior Primary school, that is, from the commencement of formal schooling until the child's fourth year at school, or year levels Reception, one, two and three (usually referred to as R-3).

The teachers (pre-service and in-service) of Early Childhood Education come from many different socio-cultural backgrounds and experiences. On a surface level at least,

most seem to be highly interested in the language and skill development of young children but reluctant to provide them with problems based on science. Young children, however, do not display the same inhibitions to science as their teachers and seem prepared to explore their environment and undertake investigations with interest and confidence.

As an academic member of staff, the researcher has often participated in discussions about the possibility that the reluctance towards science exhibited by teachers (pre-service and in-service) in Early Childhood Education is linked with their attitudes to science. Discussions raise many questions, and in particular, questions about how teachers' attitudes might influence children, and how the attitudes of teachers (pre-service and in-service) might also be influenced. The answers to such questions should ultimately provide information which can assist in improving the quality of science education in the area of Early Childhood.

The present study has developed from a desire to seek information about attitudes to science from educators in Early Childhood Education with the view to finding ways of improving the delivery of science education to young children. The purpose of this study is to investigate the attitudes about science and science education of those who are involved in Early Childhood Education. The study attempts to trace how the attitudes of one group, such as academics, might influence those of another group, such as pre-service teachers. The emphasis on attitudes towards science and science education permits exploration of the ways that attitudes impact on others as well as investigation of how attitudes may be influenced. The groups that are examined in the study include academics, pre-service and in-service teachers (including principals, directors and project officers) and children. It is also acknowledged that the wider community, including parents, influences attitudes and in particular the attitudes of young children, however, the study will confine its parameters to groups involved in the formal education of young children as they are the ones more directly involved in science education.

The study is guided by several research questions: What are the affective factors which influence the teaching of science to young children? What kinds of attitudes to presenting science to young children are held and modelled by academics to pre-service teachers? What kinds of attitudes do in-service teachers and pre-service teachers hold? Some possible attitudes and attitude components may include the perceived usefulness of learning about science, confidence in learning, application of a knowledge of science, perceived interest in the subject and the emotion of liking or enjoying it. The study further asks, what kinds of attitudes to science do teachers model to children?

Background and Context

This study draws attention to the importance of Early Childhood, an area of education that has received less notice than other areas of science education (Bearlin, Annice & Elvin, 1990; Browne, 1991). It has been postulated that the area of Early Childhood Science Education has received less attention because it has traditionally been perceived to be the domain of women (Jackson, 1993). In addition, women have been traditionally overlooked in the domain of science and there is still much to be done to remedy the situation (Haggerty, 1996). There is considerable justification for selecting the area of early childhood on which to base a study about attitudes to science and science education. Research about attitudes held by children indicates that their attitudes to science are forming by the age of three years (Browne, 1991) and their attitudes to science are influenced by such external variables as parents, the media and experiences at school (Harlen, 1985b). In fact, it is through experiences in science during the early years of schooling that children's attitudes to science may be influenced considerably (Harlen, 1992). It is also likely that attitudes to science develop along with acquisition of knowledge about science, thus attitude development in science requires exploration within an educational setting (Johnstone & Reid, 1981), a point which guided the parameters of the study.

It is worth noting that children enjoy learning about science at school (Parker, Rennie & Hutchinson, 1985), perhaps partly because they also bring a curiosity towards their environment to school (Biddulph & Osborne, 1984) and curiosity is an attitude that is fundamental to learning in science (Harlen, 1992). It is important for all children to learn about science as "society requires citizens able to make informed decisions about scientific issues affecting their world" (Ministry of Education, Victoria, 1987, p.10). Moreover, it is

Through science education, all students' understanding of science and its importance in society should help them make decisions about further education and careers and other life options. This appreciation of scientific and technical knowledge, processes and attitudes has the potential to make them contributors to a more productive, ecologically sustainable and prosperous economy. (Curriculum Corporation, 1994a, pp. 4-5)

However, with some notable exceptions, little effort in science education has been directed to developing teaching methodology that is especially suited to preschool-aged children (Fleer, 1993b). Since attitudes are closely linked with behaviour (Shrigley, 1990), it is essential to investigate the influences on children's attitudes to learning science and to science itself, in order to eventually produce scientifically literate

individuals. Carr (1994) argues that an appropriate teaching strategy in presenting science to young children requires discovering their prior knowledge and interests, and assisting the children to develop them through stimulating resources and tasks. In addition to science, Flear (1993b) also notes that aspects of the technology profile can readily be incorporated into technology programmes with children as young as three years of age.

Given that attitudes are integral to the process of learning science (Gardner, 1975a; Fraser, 1977; Shrigley, 1983a) and that experiences in the early years of childhood are vital for attitude development (Robertson & Rennie, 1991) it is important to consider the attitudes of the providers of science education. Hence, the study will examine attitudes to science held by pre-service and in-service teachers to determine their attitudes to science which might influence children.

Unfortunately, research also shows that many in-service and pre-service Primary and Junior Primary teachers have negative attitudes to teaching science which are manifested by an expressed lack of confidence, fear of failure and expression of dislike for the subject (Yates & Goodrum, 1990; Klindworth, Martin & Tytler, 1991; Goodrum, Cousins & Kinnear, 1992). Fensham (1991) notes that the community of Early Childhood teachers is predominantly female and that as science is masculine in image and construct it is not surprising to find science lacking in the Preschool. Observation of lack of confidence of pre-service and in-service teachers in Early Childhood Education is not confined to Australian researchers. Browne (1991) has reported similar findings in England and emphasises the importance of breaking the perceived cycle of lack of confidence in science from female Early Childhood Education teachers to the girls they will teach.

The literature available on in-service teacher attitudes suggests that they parallel those of pre-service teachers. Fensham (1991) presents a somewhat dismal picture of the status of science among Early Childhood educators. In addition, a study by Westerback (1984) shows that the level of anxiety held by teachers towards science affects the amount of time that they will spend teaching it, which may also help to explain why Science does not feature strongly in the Early Childhood curricula. If teachers feel uncomfortable with science it is a cause for concern as they can transmit attitudes in science to young children (Harlen, 1985b). It seems unfortunate that the attitudes of in-service teachers to science are not influenced by curriculum developers who have long recognised that a complete education in science requires attention to attitudes as well. Such attitudes include, "joy, excitement, satisfaction, wonder, delight" (Gardner, 1975a, p.1).

The three volume Discipline Review of Teacher Education in Mathematics and Science (DEET, 1989a; 1989b; 1989c hereafter referred to as *The Discipline Review*) expressed concern about the negative attitudes to science held by pre-service teachers in Early Childhood Education. These attitudes included a dislike and avoidance of learning mathematics and science, lack of confidence that has already been cited, low level of self esteem, and anxiety towards assessment (DEET, 1989a).

The above finding is somewhat disturbing as pre-service teachers in Early Childhood Education enter university with tertiary admittance scores that are higher than those of pre-service teachers undertaking courses in primary teaching (DEET, 1989a). These pre-service teachers have a secondary school background showing that, with the exception of Biology, they have taken few subjects in science and mathematics (DEET, 1989a). Consequently they often commence Early Childhood Education degrees displaying anxiety towards science and mathematics (DEET, 1989a). This is understandable, as Bearlin, et al. (1990) suggest that attitudes resulting from experiences in secondary school science are responsible for the way in which science is perceived by pre-service teachers taking degrees in Early Childhood Education.

Although it can be argued that students who are training to teach very young children do not need a high level of science, it is not possible to dismiss the marked lack of confidence towards science displayed by Early Childhood Education pre-service teachers (DEET, 1989a). The collection of data on attitudes and attitude influences in Early Childhood Science Education will allow the exploration of the reasons for the lack of confidence in science of pre-service teachers (DEET, 1989a). Science is not a prerequisite for entrance to a degree in Early Childhood Education and students with negative attitudes towards science may be biased towards selecting the course. This notion is supported by Fensham (1991), who claims that the characteristics that produce Early Childhood teachers include an aversion to science. It has been recommended (DEET, 1989a) that changing the method of determining university entrance in Early Childhood Education may alter the status quo.

In its third volume, *The Discipline Review* (DEET, 1989c) recommends that in an endeavour to remedy noted deficiencies in the teaching of science, specific tertiary institutions make adjustments to their courses. In Early Childhood Education the recommended alterations range from minor attention to the resources used, to major revisions of science education courses with special attention being given to knowledge-based subjects. The latter point is of interest to the present study, because a combination of background and curriculum science featured in the science education course at the Institute involved in this research. The study may find that it is the way in which the

combination of background and curriculum science is presented to student teachers that affects attitude change, rather than the length of time devoted to it. It is also plausible that the way in which resources and materials are used (Kirkwood, Bearlin and Hardy 1989) may influence attitudes and that they, along with course content, should also be examined.

The findings of *The Discipline Review* further suggested that the academics who provide the courses in science/science education are concerned, capable educators, yet they have conducted little research into the negative attitudes to Science Education held by their student teachers. Since the publication of *The Discipline Review* much of the Australian research in attitudes to science education has been continued by academics who have established specific research programs in the area, including Kirkwood, et al. (1989), Bearlin (1990), Bearlin, et al. (1990), Hardy, Bearlin and Kirkwood (1990), Kirkwood, Bearlin and Hardy (1996). A number of individuals including Skamp (1989), Klindworth, et al. (1991), Grinrod, Klindworth, Martin and Tytler (1991), Kirkwood (1991), Coulson (1992) and Rennie, Parker and Kahle (1996), have investigated attitudes held by pre-service or in-service teachers. Apart from the research provided by Bearlin, et al. it is also hard to find Australian documentation of the attitudes to Early Childhood Science Education held by the academics. However, Blosser (1984) highlighted numerous articles written about science education, suggesting that academics in science education have considerable influence on the attitudes to science education held by pre-service and in-service teachers. For example, a study by Adler and Byrd (1976) indicated that attitudes held by academics to certain science courses are transmitted to pre-service teachers. The research of Shrigley (1976, 1978, 1983b), Rennie, Parker and Hutchinson (1985), Young and Kellog (1993) and Crawley and Koballa (1994) also indicate linkage between pre-service and in-service teacher attitudes and their perceptions of course presenters. It therefore seems reasonable to include academics in the study along with pre-service, in-service teachers and children. This inclusion is additionally justified as academics accept the notion that attitudes held by pre-service and in-service teachers influence the way in which they regard science and the way in which they present science to children (Gardner, 1975a; Schibeci, 1984; Shrigley, Koballa & Simpson, 1988).

There have been many studies about attitudes to science education, and the need for a model has been perceived by some researchers in order to unite, process and explain the complex information available about attitudes (Johnstone & Reid, 1981; Wildt, Bruno & Ginter, 1981). According to Bruno and Wildt (1975) there is no single definitive model about attitudes, and a number of models have been found which are of relevance to the study. The model that is possibly most closely related to the study has developed

from a project referred to as the *Primary and Early Childhood Science and Technology Project* (PECSTEP) (Kirkwood, et al. 1996). The project emphasises improving the effectiveness of teaching and learning science for Primary and Early Childhood in-service and pre-service teachers. The outcomes of the project indicate that teachers' negative attitudes to science can be changed, especially in the area of confidence (Hardy, 1993). It uses materials from the Learning in Science Project (University of Waikato) to change the attitudes of women to science education (Bearlin, 1990). In a series of steps (acceptance, exploration and sharing), knowledge about science is linked with pedagogy associated with gender sensitivity in order to improve the quality of science presented to children. The PECSTEP project appears to acknowledge the influence of attitudes to science held by in-service teachers in the way in which they present science to children.

PECSTEP is based on the "gender-sensitive model" as described in the Women and Science Teacher Education Project (WASTE) presented by Bearlin, et al. (1990). Three models on attitude change have been described from information collected through the WASTE project: all three models are based on models of curriculum design (Bearlin, 1990). The first model proposes that women gain positive attitudes to science by developing their body of knowledge about it, hence the term "subject-centred model". The second model referred to by the authors as "learner-centred" builds women's confidence by emphasising how to present science to young children. The third model, known as a "gender-sensitive model", encourages women to understand their attitudes to both science and themselves. It subsequently encourages women to put their science experiences into practice (Bearlin, et al. 1990). It is interesting to note that although Bearlin, et al. (1990) consider the third model to be most appropriate in influencing attitudes to science, according to data collected, few academics presenting courses in science education share this opinion or use the model (Bearlin, et al. 1990). The information collected by these authors highlights the need to examine course structure and attitudes held by all groups concerned with science education. In fact, the processes involved in developing a model on attitudes can determine if any attitude change occurs in pre-service and in-service training (Bearlin, et al. 1990).

The models described above refer specifically to women and reflect the gender composition of teachers of young children, as 98% of early childhood teachers are female (Fensham, 1991). Thus, there will be an inherent gender "issue" to the study. Kahle, Parker, Rennie and Riley (1993) drew attention to the relationship between gender and science when they designed a model which portrayed how the constructs of gender held by students and teachers affected students' attitudes in science. The models mentioned in this section of the chapter are important to the study as they

make three suggestions. First, teachers influence the attitudes of the students that they teach, second, there is an influence between gender and attitudes towards science, and third, the attitudes of teachers to science can be influenced in carefully designed programs.

Other models used in science education appear to have been based predominantly on models derived from the field of social psychology. For instance, in 1953, Hovland, Janis and Kelley researched the effect of persuasive messages on attitude change. Hovland's model, based on the assumption that human beings are rational, proposed that a persuasive message would have effect to the degree that it could be attended to, understood and accepted, by the recipient. Briefly summarised, Hovland's model comprises a source, message and recipient (Crawley & Koballa, 1994). Shrigley (1976, 1978) and Shrigley and Koballa (1992) formulated models in science education based on Hovland's (1953) model of persuasive communication. Shrigley's (1976) model contains a science educator who sends information on the importance of science to the child to pre-service teachers in order to change their attitude towards teaching science. Although this early study of Shrigley (1976) reports effective results, Hovland's original model is not without criticism (Crawley & Koballa, 1994) and Shrigley's results are confined to pre-service teachers in the area of elementary education. Another model, that builds on information generated from Hovland's work and Shrigley's (1976) model, has been developed by Shrigley, Johnstone, Wolfinger and Maria (1979). Their leadership model is designed for in-service teachers and aids the implementation of changing curricula.

More recently, Crawley and Koballa (1994) claimed that the outcomes that promote positive attitudes in specific groups in science education can be derived from attitude models of Ajzen and Fishbein (1980), Ajzen and Madden (1986), Petty and Cacioppo (1986) and Sutman and Newell (1984). Each model focuses on persuading a targeted group to change their attitude and resulting behaviour. These models allow examination of the attitudes held by one group at a time, for example, pre-service teacher's attitudes to chemistry.

The models described in the two preceding paragraphs provide some information about attitudes in science education and in particular attitude change in science education. All the models imply that attitudes can be influenced by the efforts of one group to persuade another, by inferring that the result of the change will be passed on elsewhere. These models do not relate specifically to Early Childhood Education and can therefore only serve as guides to what may develop when considering attitudes and the influence of attitudes in Early Childhood Science Education.

Attitude Defined

Augoustinos and Walker (1995) suggest that attitudes are hypothetical constructs that allow an individual to make evaluations about objects or events in the environment. An emotional reaction occurs when the attitude referent is of importance to individuals, and their attitudes are expressed in affective language such as like, dislike, enjoyable (Augoustinos & Walker, 1995). Attitudes are important in that they communicate an individual's position in respect to how they classify affective responses and behave towards the world. In other words, attitudes reveal an individual's orientation towards attitude objects such as politicians, young children, aspects of teaching and science. Attitudes can also serve to define groups and therefore have certain social and behavioural ramifications (Augoustinos & Walker, 1995).

Attitudes have complexity in depth and composition and are also able to be influenced by others (Triandis, 1971). According to Katz (1960), attitudes serve four functions; the first assists individuals to make sense of the surrounding world. The second allows individuals to display attitudes which are congruent with the social situation in which they are placed. The third allows individual expression and the fourth, enables the projection of an individual's self-image. In addition, attitudes also have social functions (Augoustinos & Walker, 1995) which involve the display of attitudes within a group or social setting. The social function of attitudes allows groups to openly state their shared attitudes and operate the mechanism of attitude transmission. Attitude transmission refers to the way in which attitudes are passed or transferred from one person to another (Reynolds & Skilbeck, 1976). Reaction to a stated attitude results in discussion in which different opinions, stances, uncertainties are expressed and attitude positions are clarified and reviewed (Augoustinos & Walker, 1995).

Within the context of this study, attitudes are considered to be a "learned disposition to evaluate in certain ways objects, people, actions, situations or propositions involved in the learning of science" (Gardner, 1975a, p. 2). This definition reflects the notion that attitudes in science education are learnt in different ways, by different individuals and involve cognition (Shrigley, 1983a). Also implicit in Gardner's (1975a) reference to evaluation is the idea that attitudes are active and emotional responses to given situations (Triandis, 1971). For instance, a teacher in Early Childhood Education may not assign the same status to teaching science as to teaching mathematics, because science is not perceived to be as important as mathematics for young children to learn (Browne, 1991). Gardner's (1975a) definition is not implying that attitudes can be deliberately taught, in fact Harlen (1992) claims that attitudes are "caught" rather than "taught". For instance, children could develop a specific attitude to science lessons, and eventually science per se, by participating in science activities that they perceive as motivating and absorbing.

Research Questions

The purpose of the study is to investigate how attitudes to science and science education in the early childhood years are linked between academics, pre-service and in-service teachers and children. The general research question refers to the affective factors that influence the teaching of science to young children.

Specifically the study will investigate the following questions.

1. How do academics promote the teaching of science to young children?
2. What factors influence the willingness of pre-service teachers to present science to young children?
3. What are the factors that influence in-service teachers to teach science to young children?
4. How does the classroom teacher (pre-service and in-service) influence young children's responses to science at school? This question was addressed by asking how children respond to science and what effect the teacher has on the children's responses to science.

The study is designed to obtain information about attitudes from all groups in the study and examine how these are linked between groups. Particular emphasis is placed on deriving information that will ultimately benefit the child. For instance, investigation of how children respond to science will provide data on the type and style of science that can be presented to promote positive attitudes in children. It is also important to know what motivates teachers (pre-service and in-service) to present science to children in order to develop improved strategies for teaching science. The science presented at university can also be improved from knowledge about academic and pre-service teacher attitudes towards science.

Method

Information for the study will be collected from academics, pre-service, in-service teachers and children in Early Childhood Science Education in a metropolitan area. Quantitative data from a questionnaire, and qualitative data from interviews, observation and examination of written work and video tapes of children participating in science learning activities will be collected. The advantage of using several techniques in data gathering is that while a broad spectrum of information about attitudes towards science can be collected, a deeper understanding of the attitudes held can also be obtained (Lindlof, 1995).

Data will be collected from four groups central to the study, including academics teaching in the area of science education; pre-service teachers taking subjects in science

education; in-service teachers working in the field of Early Childhood Education; and children aged between 4 and 8 years of age. It is anticipated, on the basis of the reviewed literature, that children in this upper range of early Childhood Education may have already formed some attitudes to science.

A questionnaire that has been designed specifically to assess the affective components of Early Childhood educators towards science will be administered to cohorts of pre-service teachers in their first, second and third year of Early Childhood Science Education and to in-service teachers in randomly selected Junior Primary Schools and Preschools.

Interviews will be conducted with seven academic staff at the university who have an interest in Science Education, with volunteer pre-service teachers from each cohort who filled out questionnaires, and with in-service teachers who indicated a willingness to be interviewed. The interviews with teachers were unstructured (Lindlof, 1995) and intended to ascertain the participants' backgrounds in, and attitudes to, science education as well as their attitudes to teaching science. A small sample of commencing teachers (n=6) who completed their award during the time of the study and commenced work, will also be interviewed about their attitudes to teaching science. Due to the erratic teacher employment conditions of the time, unfortunately it was not possible to follow the longitudinal transition of many pre-service teachers into in-service teaching. A sub-group of exemplary teachers who were readily identifiable as having a long and sustained interest in science were also interviewed in order to note any possible differences in attitudes between them and other in-service teachers.

Information about children's attitudes to science were collected from Preschool children through the analyses of video-taped sessions of them involved in science activities. However, information about Junior Primary children's attitudes to science were inferred from their written material about science as well as classroom observations of children participating in science lessons.

Limitations of the Study

The study is confined to a relatively small population in a limited geographical location, and therefore cannot claim to represent all individuals in Early Childhood Science Education. Consequently, the generalisation of results is limited. Also, because the researcher is employed as an academic in Early Childhood Science Education, the study has been described from the viewpoint of a participant observer (Lindlof, 1995) and this may unconsciously include inherent biases, in that the attitudes of the observer towards the University may influence the interpretation of results, for example the

researcher may be overly critical of academic staff mentioned in the study. Although it is considered unlikely in the present study, the administration of an instrument to measure attitudes may in itself influence the attitudes of the subjects. Other limitations are concerned with the non random sample, as there were volunteers for interviews and classroom data were collected from people who were willing to cooperate and the sample therefore is not likely to be representative. Also, as previously noted, the study was not longitudinal and could not follow one group over a long period.

Significance of the Study

The study is significant in four ways. Firstly, it emphasises the need to ensure that children have the best opportunity to develop positive attitudes to science at a very early age as their attitudes to science, and to themselves as learners, begin to form (Ayres & Price, 1975; Bloom, 1976; Chambers, 1983; Hardy, 1993). This aspect of the study is in keeping with the notion of the Institute, that all aspects of child development should be encouraged in early childhood.

Secondly, the study helps to clarify an area of education that is often discussed but only partially documented. The area of science and Early Childhood Education has received less attention than other areas of science education, a problem that is compounded by the fact that the majority of educators are female (Browne, 1991). It will also suggest the most effective ways to encourage pre-service and in-service teachers at this level to teach science. Improvements to pre-service courses and ideas for teaching can build from the information provided. In addition the study will be able to provide information on the recommendations of *The Discipline Review* (DEET, 1989a) related to the length and composition of pre-service science education courses.

Thirdly, the study contributes to research related to gender sensitive models of science teaching (Bearlin, 1990), by highlighting the attitudes to science and women teachers in Early Childhood Education. Although the study does not explicitly aim to devise a gender sensitive model, or to test one, it provides additional information in an important area related to the teaching of science.

Fourthly, the study has applied the premise that those involved with science education should place a high priority in researching attitudes (Thompson & Shrigley, 1986). The study is unique in that it combines investigation of attitudes of all those involved with the area of Early Childhood Science Education.

Overview of the Study

Chapter Two of the study presents a review and discussion of the literature that forms the background to the study. It will include consideration of the definition of attitudes, summarise other studies of teachers' attitudes to science education and interpretations of children's responses to science. Information about the research into the measurement of attitudes, the effects of gender on attitudes to science education, and strategies and models that are considered pertinent to this study will also be described.

The third chapter of the thesis provides a detailed description of the research design and instruments used, as well as a description of the data collected and an overview of data analyses. Chapters Four and Five of the thesis tabulate and report on the results obtained from data analyses. Analyses of quantitative results are contained in Chapter Four and qualitative results are described in Chapter Five. Chapter Six of the thesis reviews all information obtained and interprets the findings in the context of the research questions. The seventh chapter presents the summary, conclusions and recommendations arising from the study. Future directions in Early Childhood Science Education will be considered in the light of the 1997, Australian Science Technology and Engineering Council's (ASTEC) report into *Science and Technology in Primary Schools*. The chapter will also include a discussion of the potential impact of the National Science Statement (Curriculum Corporation, 1994a) on teacher attitudes.

CHAPTER 2

LITERATURE REVIEW

Attitudes have been described in the literature related to the social sciences and social psychology since the turn of the century. For instance, by 1918, Thomas and Znaniecki defined social psychology as the study of attitudes. In their extensive *Cumulative Author and Subject Indexes for Volumes 1-5 of a Handbook of Social Psychology* (1970), Lindzey and Aronson included many chapters about attitudes. Attitudes are also portrayed in literature by authors such as Eysenck (1944), Sherif and Sherif (1956), McKee (1969), Turner (1978), Grossack and Gardner (1970) and McGuire (1985) in terms of understanding the systems under which society functioned (Rokeach, 1972). The broadness of the term “attitude” allowed a common meeting point for both psychologists and sociologists (Allport 1935), and the attitude literature associated with science education appears to reflect the definitions and theory related to social psychology.

In this chapter, the literature relating to attitudes to science is considered. In keeping with the research questions and rationale for the study, the literature review covers four main sections. First, definitions of attitude and attitudes to science are considered with models for attitude change. Second, studies of attitudes in relation to science education and in particular early childhood are reported. Third, approaches to the measurement of attitudes are addressed and the chapter closes with a brief consideration of attitudes promoted in science-based resources available to teachers.

The Meaning of Attitude and Its Use in Science Education

Definition of Attitude

Derived from the Latin term *aptus* (Shrigley, et al. 1988), "attitude" has had a number of meanings that included the notion of mental alertness towards an object (Allport, 1935). Triandis (1971, p. 2), defined attitude as "an idea charged with emotion which predisposed a class of actions to a particular class of social situations". Other definitions of attitude in the past have noted possible correlations between intention and action (Dawes & Smith, 1985), a degree of affect or evaluation for or against something (Katz, 1960) or a disposition to respond or react in a particular way (Oskamp, 1977; Harlen, 1992). In other words, attitudes represent individual outlooks and inclinations toward action (Hollander & Hunt, 1971).

Ajzen and Fishbein (1980) argued that attitudes had three components, namely cognition, behaviour and affection. These three components were traditionally linked with the term attitude (McGuire, 1985). The affective component of attitude describes the feelings experienced by the individual when thinking about an object. Shrigley, et al. (1988) noted that the literature pointed to the evolution of a complex definition of attitude. Shrigley, et al. (1988) contended that evaluation was an important attribute of an attitude. Their review took into account the traditional view that attitudes comprised "affection, cognition and conation", yet concluded that the evaluative aspect of affection (like-dislike), dominated the other attributes. Similarly, in one of the more recently written definitions of attitude, Augoustinos and Walker (1995) suggested that attitudes were directly equated to the evaluation of an object and were socially communicated.

For the purpose of this study, the term attitude was taken to be a social construct of an individual's evaluation of an object, a process of evaluation, which incorporates an emotional or affective response expressed in terms of like/dislike. In addition, this study accepts the conclusions of Shrigley et al. (1988) that attitudes are relatively enduring and do not change randomly, that attitudes are learned, and that they are related to behaviour. In the following section, attitudes to science are explored.

Attitudes to Science

In 1975, Gardner reviewed the literature on attitudes to science. He distinguished two categories of attitude, namely "attitudes towards science" and "scientific attitudes" (Gardner, 1975a, p. 1). Harlen (1992) also distinguished between attitudes to science

and scientific attitudes. The former category, which Gardner defined as “a person’s attitude to science as a learned disposition to evaluate in certain ways objects, people, actions, situations, or propositions involved in the learning of science” (Gardner, 1975a, p. 2) are the kinds of attitudes which are the focus of this study. In contrast, scientific attitudes refer to styles of thinking, such as open mindedness, and are of less interest because teachers and children were not expected to be trained scientists with scientific attitudes. Research in attitudes to science has extended into a number of different aspects of attitudes. For example, “confidence in doing science, enjoyment of science at school, personal usefulness of science and appropriateness of science for young children” were used by Coulson (1992) when investigating the attitudes of first year pre-service teachers to science.

Harlen (1992) was concerned with attitudes to science held by children at an early age, in particular, their attitudes towards school work, attitudes towards themselves as learners, attitudes towards science as an enterprise and attitudes towards objects or events in the environment. She considered that the development of the attitude of curiosity in children was extremely important in science education. Harlen’s view was in agreement with Gardner (1975a, p. 33) who had suggested that the aim of the educator should be to “stimulate joy, wonder, satisfaction and delight in children as a result of their encounters with science”. However, Gardner did not make it clear how educators could stimulate these positive attitudes in children. The way that positive attitudes might be developed in young children, is an idea which is central to this study.

Although there is a range of research on attitudes, there is little research that is directly relevant to the development of attitudes. Before examining the research literature, it is useful to consider some of the theoretical arguments for attitude change which have been conducted and used in science education.

Models for Attitude Change

The two hierarchical models for attitude change which have been used in science education research are Hovland’s learning theory model of persuasion (Hovland, et al. 1953) and Ajzen and Fishbein’s theory of reasoned action (Fishbein & Ajzen, 1975; 1971; Ajzen & Fishbein, 1980).

Persuasive Communication Model

Shrigley (1976, 1978, 1983b) and his colleagues worked with Hovland's persuasive communication model during the 1970s and 1980s. This model was developed by Hovland, et al. (1953) and was designed to explain the effect of "persuasive messages" on attitude change. It could be summarised by the question: "who says what to whom and with what effect?" The model contained three variables; a source (the who), a message (the what), and a recipient (the whom). The assumption underlying the model was that learning new information via a persuasive message would change the cognitive basis of attitudes. Then, remembering that information would allow attitude change to persist. According to Hovland et al. (1953), it was essential that the persuasive message was attended to, comprehended and accepted by the individual.

Shrigley (1976, 1978) used the model to investigate ways of changing the attitudes of elementary teachers to science teaching. In two studies Shrigley concentrated on the credibility of the source of the message. By 1983b, Shrigley had extended Hovland's model to one that he referred to as "persuade" (based on components of Hovland's model), "mandate" (insistence that science be taught) and "reward" (reinforcement of attempts to teach science). Shrigley's extension of the persuasive communication model was used successfully by Rennie, et al. (1985), who found that teachers' attitudes and behaviours in relation to science and technology were a critical influence on the attitudes of their pupils. Their study included employment of a science superintendent and an advisory teacher as trustworthy experts or sources to "persuade" teachers to teach a particular topic in science. A critical time period of reflection and analysis was included before teachers used the resources provided to teach their year 5 class. The notion of "mandate" and "reward" comprised a built-in process of evaluation, which included visits to classes by the researchers and rewards in terms of the satisfaction gained from the course. Rennie et al. found that both teachers' and students' attitudes became more positive over the period of the study, suggesting that attitude change had taken place, although the effects of teachers' attitudes on their students was not teased out. Similar results were obtained by Kahle, Anderson and Damnjanovic, when, in 1991, they compared attitudes of teachers in the United States with those in the study of Rennie et al.

In a review, Crawley and Koballa (1994) reported that Hovland's original 1953 model was criticised by Fishbein and Ajzen (1981) and Petty and Caccioppo (1981) who perceived weaknesses in Hovland's model, including failure to show any relationship between attitude and behaviour. More importantly, the model paid a minimal amount of attention to the recipient of the message, although Crawley and Koballa (1994) felt that to some extent Shrigley (1978) remedied some of these criticisms by listing the

responses of the recipient that gave credibility to the communicator.

By the mid 1980s research in science education was focussing more on the recipient of the message (often the student or pre-service teacher) rather than the communicator, and the theory of reasoned action was adopted by some science education researchers.

The Theory of Reasoned Action

In their book, *Understanding Attitudes and Predicting Social Behaviour*, Ajzen and Fishbein (1980) put forward the theory of reasoned action. The theory was based on a model devised in 1972 and extended in 1975. The model also had similarities with one proposed by Rosenberg (Rosenberg & Hovland, 1960). Fishbein and Ajzen (1975) contended that a person's attitude to any given object was a function of their beliefs about the object as well as the evaluative responses associated with their beliefs. Their model assumed that all human beings were rational and made systematic use of information available to them. The authors argued that people considered the implications of their actions before deciding to engage or not to engage in any given behaviour. Thus, a person's intention to behave in a certain way was determined by their personal nature and the social influence to perform, or not perform the behaviour. Ajzen and Fishbein proposed that individuals would perform a behaviour when they had evaluated it positively and when they believed that it was important for some reason. Their model has been applied to many fields of research ranging from consumer choice (Nakanishi & Bettman, 1974), to a study predicting the behaviour of women who intended to become pregnant (Davidson & Jacard, 1979) and more importantly, for this study, to science education (Koballa, 1986).

Koballa (1986) used Ajzen's and Fishbein's model to examine the relationship between the eventual behaviour of 76 pre-service teachers and their stated intention to teach science for two periods a week during their first year of employment. His findings suggested that the influences on the behaviour of teaching science may not be directly linked with the pre-service teacher's attitudes to science. Koballa concluded that science teaching behaviour could not be predicted or explained adequately by simply measuring the attitudes of pre-service teachers to science.

In 1988, Koballa again used the model to examine the effects of external variables such as science grades and academic ability on the intention of female students to enrol in a high school physics course. He found that the attitudes toward performing behaviour and subjective norm in combination were found to predict behavioural intention with

a high degree of accuracy. Koballa (1988) suggested that the social component of behaviour might be influenced by the expectations of family and peers, teachers or community leaders.

In 1990 Shrigley examined literature related to the correlation between attitude and behaviour which included a revised model by Ajzen and Madden (1986). He investigated the question, "How well can we expect science attitude scores to predict science-related behaviours"? (Shrigley, 1990, p. 97) in a longitudinal study that examined the problem from five perspectives of attitudes and behaviour. Shrigley concluded that Ajzen's and Fishbein's theory of reasoned action explained many aspects of the behaviour of teaching science. He also claimed that measurement of behaviour was a possible alternative to testing attitudes, especially through the research approach of ethnomethodology in which written, verbal and overt behaviour were recorded and appraised. The written, verbal, and overt behaviour of children towards science was considered pertinent to the present study.

A recent review by Koballa (1995) describes the shift in attitude research away from the social psychologist perspective to incorporate cognitive elements in the change of attitudes. He concludes that the theoretical research based on models such as those described helps to understand the relationship between attitude and behaviour. In addition, this research has emphasised the need to collect a range of data to describe more comprehensively the science-related attitudes and behaviour of interest to the researcher.

Other Models of Attitude Change

Few other models of attitude change can be found in the science education literature. Johnstone and Reid (1981) proposed a theoretical model in which attitude change involved various cognitive and affective influences but their model was untested and does not seem to have been taken up by other researchers. More commonly, researchers have developed models on the basis of literature reviews, which include a number of variables that are not always connected by shared theoretical links. For example, Haladyna and Shaughnessy (1982) presented a model suggesting that the teacher and the learning environment work in concert to affect attitudes. Their quantitative review failed to find strong support for the model but pointed to concerns about the quality of attitude measurement and research methodology.

In 1993, Kahle et al. developed a more comprehensive and explanatory model based on a literature review and empirical research carried out in the United States and Australia. Their model focussed specifically on gender and science and three groups of related variables, teachers' beliefs, attitudes and perceptions, and teachers' and students' behaviours in the classroom. Later Rennie, et al. (1996) provided additional empirical support for the model in the context of both mathematics and science. Their model allowed for the effect of the socio-cultural educational context of schooling, including a perceived masculine image of science, on both teacher and student beliefs. It was hypothesised that experiences in the science classroom served either to strengthen or modify the science related attitudes and beliefs that students had already formed. The model has relevance to the present study because it suggests that attitudes to science of both students and teachers can be changed. It also suggests that the variables related to the formatting of attitudes and their change are complex and dependent on the socio-cultural content, with gender as a major factor. It is interesting to note that Browne (1991) stated that programs for the early childhood educator should also address equity issues; thus ensuring that all children developed the confidence to access the processes of science.

In 1989, Goodrum, Kinnear, and Cousins presented a paper discussing ways of improving the confidence of primary school teachers in science. They based their approach on the concerns-based model devised by Hall and Hord (1987) and found that by addressing teachers' concerns they were successful in raising confidence levels of teachers.

Simpson and Oliver (1990) carried out a study of the influences of home, school and individual differences in attitude and achievement in science. On the basis of their longitudinal study they proposed a model summarised by the following steps. First, science experiences in early childhood are a major influence on science achievement. Second, influences of the home and the self worth of the child affect early science experience at school. The feelings of enjoyment of science and success in it as a subject, combined with the attitudes of the family and school towards science, influence the child. Third, if students commenced high school with positive attitudes to science, which were in turn reinforced by success in initial science subjects they were more likely to continue and extend in science. This resulted in continued positive experiences in science which were most likely to remain with the student on a life long basis. It is important to note that aspects of Simpson and Oliver's (1990) model were descriptive, based on conclusions drawn from observations rather than attempts to facilitate change. Nevertheless, the ideas may have the some relevance to early childhood and the importance of young children's early experiences of science.

Influences on the Attitudes of Young Children

In the present study, the attitudes to science of young children are of interest and how their early experiences of science contribute to the development of attitudes. As the models of Simpson and Oliver (1990) and Kahle et al. (1993) suggest, both family and school influences are important. Parents and teachers are adults whose own attitudes to science may be "transmitted" in some way to the children. This may not be a deliberate effort to change attitudes (as represented in the persuasive communication model, for example) but the unconscious effect of one person's attitudes and ideas affecting those of another.

There are some sound psychological ideas which may have some relevance, although they have not been developed in science education. Hollander and Hunt (1971) claimed that attitudes fulfil a specific role in the functioning of the personality of the individual, functions that include adjustment, ego defence, value expression and knowledge. Augoustinos and Walker (1995) speculated on a number of social functions of attitudes that include the identification of an individual's position on a social matrix. That is, an individual's attitudes in relation to the attitude of the group, the justification of an individual's position in the social order and the mechanism by which attitudes might be changed. The authors suggested that the expression of an attitude by an individual generally stimulated a response in other people, which in turn facilitated discussion, exchange of ideas and clarification of thought.

These processes force the individual, perhaps unwittingly, to resolve inconsistencies to consider one attitude in relation to many to figure out what he or she believes in and how strongly, to commit publicly to a position - in short, to think about his or her attitude and its object (Augoustinos & Walker, 1995, pp. 18 -19).

This concept of attitude change or challenging attitudes is a central feature of this study although Augoustinos and Walker (1995) found that little research had occurred in the area. Earlier, Osgood (1960) indicated the complex nature of attitude formation by explaining how the input of written text, mass media and individual conversation constantly reacted with the individual's attitudes. Hollander and Hunt (1971) contended that children "took on" attitude statements from these sources without actually having had experience in the area. However Ringness (1975) held that in education systems, attitudes also were transmitted through repetitive training or learned from experience.

In the early part of the century, attitudes were seen to be transmitted to young children by books, family magazines and the mother figure (Steedman, 1985). More recently,

in a curriculum guide for South Australian Early Childhood Education, Hogburn and Wasley (1989) took the view that attitudes were transmitted to children by adults who related to them with care and understanding. They explained that positive attitudes in science were developed as children gained “an understanding of themselves and others” (Hogburn & Wasley, 1989, p. 15). These ideas were reflected in later studies by McGrath and Gordon (1991), who wrote that attitudes held by pre-school staff were transmitted to children through their interactions and contended that children learnt more in this social way than from planned learning activities. Gardner (1975a) also suggested that teachers might unconsciously choose the attitudes that children develop in science. Similarly, Harlen (1992) stated that the attitudes were reflected in the way that people behaved and were transferred to children by a combination of teacher approval and example that revealed the attitude of the teacher. However, Johnstone and Reid (1981) argued that the cognitive components of attitudes held by children were more easily altered at school than affective components, suggesting that cognitive changes may need to occur for attitude change to be enduring.

Shrigley and Koballa (1983) provided an example of attitude change when they examined the effect of attitudes to energy conservation held by teachers and how they intended to communicate their attitudes to children. The authors noted that once a teacher had become aware of an attitude, for example, placing importance on turning off a light to conserve energy, they appeared to be prepared to apply it in teaching about energy (Shrigley & Koballa, 1983). Duckworth, Easley, Hawkins and Henriques’ (1990) contention that the transmission of attitude in the classroom was dependent on the way that teachers saw themselves is most relevant to this study because it emphasises the importance of how teachers view themselves in terms of their attitudes about science, and possibly in terms of their enjoyment and confidence in teaching it.

So far, the review has considered the meaning of attitude and attitudes to science, and considered models of attitude change. The review has established that teachers are very likely to be key influences on student’s development of attitudes to science, especially in early childhood when children have their first science experiences. The focus now moves to research about the attitudes to science of those people involved in early childhood, and then to research that has attempted attitude change in this area.

Attitudes to Science in Early Childhood Education

According to Tobias (1992), the “best” science students discovered and enjoyed science early in life. In the literature describing the promotion of attitudes in the teaching of science, a number of studies were found which described attitudes in Early Childhood

Education and had relevance to the study. They are discussed under headings that reflect the groups of people in the study.

Academic Staff and Pre-service Teachers

The review of literature found that studies about academics in science education were often closely linked with pre-service teachers. For instance, Ofchus and Gnagey (1963) postulated that a tertiary instructor might unconsciously influence the attitudes of pre-service teachers. They proposed that unless students sensed a sizeable gap between their own attitudes and those of the instructor, cognitive dissonance might result. In order to resolve the resultant conflict the student would have to change the relationship with the instructor in some way.

The Discipline Review (DEET, 1989a, 1989b, 1989c) investigated teacher education in Australia and included information about the science and mathematics contained in early childhood teacher education courses. Aside from providing an accurate and broad-based description of attitudes held by pre-service teachers, the review was important to the present study because its recommendations provided a basis for the course structure for the pre-service teachers in the study. It was reported in the review that many pre-service teachers expressed anxiety about the level of knowledge that they held in science and their ability to teach science and mathematics to children. This finding may be explained in part by a later study of Wynstra and Cummings (1995) who categorised high school students' anxieties towards aspects of science and mathematics and suggested that, overall, anxiety directly affected achievement. Similarities between the backgrounds and attitudes towards science of primary and Early Childhood Education pre-service teachers were noted in the review (DEET, 1989a). Their attitudes to science were considered "negative" by the review panel and were based on their the lack of confidence, skills and ability to learn science. Although more than 60% percent of early childhood pre-service teachers had taken at least one science subject to year 12, only 14% of these had studied physical science (DEET, 1989a).

The Discipline Review also suggested that the knowledge of science at the community level was low and could be improved through education programs (DEET, 1989a). These findings were reiterated by Fensham (1991) in a study of science in preschools, and by Young and Kellog (1993), who suggested that many pre-service teachers related their present interest (or lack of interest) in science to the influences of elementary and secondary school teachers.

The Discipline Review (DEET, 1989a) also recommended that there should be an increase in the amount of time and content given to the pre-service *mathematics* and *science* courses, specifically, in regard to enhancing pre-service teacher understandings of science. It was proposed that all pre-service teachers received background information in both general and curriculum science, while an elite group was targeted to take further science as an elective subject (DEET, 1989a). This suggestion was supported by studies of Tolman and Campbell (1991) who felt that courses in science content background and teaching methodology gave pre-service teachers positive attitudes to science. The Review panel considered that the studies taken by pre-service teachers should aim to change their attitudes to science teaching and learning. The panel also suggested that it was important to consider the attitudes of children:

As attitudes and beliefs develop early in a child's life priority needs to be given to equal opportunities in the early childhood setting (DEET, 1989a, p. 40).

In this quotation, the report acknowledged the integral role of attitudes in child development. It was further suggested that unless confidence in the pre-service teacher's ability in science learning and teaching increased, their work with children would lack the necessary sense of "exploration" and "adventure" considered part of the everyday events in a child's life. The report continued by arguing that pre-service teachers therefore needed to be able to encourage children to observe, and to report on and make basic interpretations about what they had seen (DEET, 1989a). The report found that in addition to having such skills themselves, pre-service teachers should also have knowledge of the different affective and cognitive responses that children may display to various science topics. It was also noted that in the area of early childhood, science was often taught as part of an integrated program of learning areas (DEET, 1989a).

Many science educators had little or no formal qualifications in the area of early childhood (DEET, 1989a). Although academics were employed to teach in science courses in Early Childhood Education, they were precluded from supervising pre-service teachers undertaking practicum. In 1993, Hardy expanded further on the role of academics by claiming that teacher educators were important influences on the attitudes of pre-service teachers and should adjust their courses to respond to the needs of their students. This finding was in keeping with the ideas of Gunstone, Baird, Fensham, and White (1988), who suggested that it was important that pre-service courses allowed pre-service teachers the opportunity to develop attitudes, through reflection about their affective and cognitive needs, as they moved from the position of student to the position of teacher. It was also interesting to note that before *The Discipline Review*, Adler and Byrd (1976) had examined the influence of the instructor's attitude to physics on their students. They noted that by the end of the course the students' attitudes to the physics methods concerned coincided with those of the staff.

The issue of gender in relation to Early Childhood Education was also raised in *The Discipline Review* (DEET, 1989b). The panel found that 97% of pre-service teachers in Early Childhood Education were female and representative of a large section of successful secondary school students (DEET, 1989a). The Early Childhood Education pre-service teachers did not believe that they had ability or interest in science, despite the fact that most had taken some senior biology. The review panel criticised the fact that the gender-stereotyped attitudes of the students was not confronted in science subjects taken at university (DEET, 1989a). The pre-service teachers had positively chosen to enter Early Childhood Education courses (DEET, 1989a), a point that was supported by information from Feather (1970), who earlier had hypothesised that tertiary students chose a course and faculty which matched their values. For instance individuals who valued the open discussion of ideas selected humanities. Of the science taken during their training, the pre-service teachers indicated a preference for curriculum science (DEET, 1989a) over other science subjects offered. Such a choice of subject may be indicative of values related to teaching children.

Other researchers have reported on studies that were able to provide added detail to the above findings of the review. Grinrod, et al. (1991) suggested there may be little change in the attitudes of pre-service teachers over a three year period, even though when interviewed, 75% of third year students reported increased confidence in science and tried to teach the science they had learnt at university. Jane, Martin, and Tytler (1991) found that "exiting" pre-service teachers had increased confidence, interest in and appreciation of integrating science with other subjects. Although studies about pre-service teachers often reported changes in attitudes to teaching science, Crompton (1971) maintained that these were transitory changes that disappeared after the teacher commenced work.

Teachers and Children

The findings of Piburn and Baker (1993) indicated that young children enjoyed group work in science, strove to be "empowered" in science lessons and enjoyed "hands on" activities. Their suggestions were in keeping with the opinion of McIntyre (1984) who stated that scientific activity was constantly happening throughout the child's environment and that;

a young child quickly perceives an adult's attitude to science. If we are excited about exploration, we ask questions and demonstrate a let's find out attitude basic to learning, children know it and absorb the enthusiasm. Learning becomes an enjoyable experience (McIntyre, 1984, p.6).

Tasker (1981) also supported the notion that children developed views at an early age, while Kuhn (1993) maintained that it was important to support the exploratory behaviour of infants and children in order to establish basic tools in scientific thought processes. Williams and Jinks (1985) suggested that attitudes were formed early and from then became difficult to change. It was for this reason they stressed the importance of developing confidence in young children that allowed them to have influence, and to experience a sense of control over their environment.

Neuman (1978) claimed that the science that most people remembered was difficult for them to understand and was therefore considered inappropriate for young children. He found that 3- to 5-year-old children were motivated in science when parents and teachers conveyed attitudes about the self worth of the child and interest in the child's skills. Bloom (1976) also emphasised the relationship between self worth and attitude to learning in young children. In addition, Browne (1991) believed that the early years were crucial in the development of science skills, concepts and attitudes.

Fleer (1993b) acknowledged the importance of attitudes in Early Childhood Education when she suggested that the unique attitudes of preschool children should be taken into account when teaching them science, rather than presenting them with a diluted version of primary science. Fleer (1993a) elaborated this idea in an article which considered the development of a K-3 Science Program. The program included the notion of working from the child's needs and interests, acknowledgment of the influence of the family, and the need to be aware of the different physical development along with science educational requirements across the early childhood range.

Haladyna, Olsen and Shaughnessy (1982) emphasised the influence that teachers had, particularly through displays of enthusiasm, on children's attitudes to science. In Wright's (1990) study, teacher attitudes changed when they were presented with the methodology of science that allowed them to work with children and to have fun. Wright also reported similar findings in pre-service teachers.

In 1991, Fensham presented a paper that was critical of preschool education, with findings that suggested that children were not encouraged to make observations of scientific phenomena, nor to form ideas about them. He attributed the problem to several issues: Firstly, that the community, particularly parents, had no memory of studying science in their early years and therefore did not expect it for their children, secondly, that pre-service courses did not sufficiently build upon pre-service students' self worth to provide them the confidence to teach science effectively and thirdly, the community of professionals representing Early Childhood Education were predominantly female, and the stereotypical masculine image of science afforded it little place in their thinking.

Gender and Attitudes

Given that science traditionally has been seen to have a masculine image and that most teachers in Early Childhood Education were female, this study involved attitudes related to gender. Indeed Jackson (1993) noted that the area of Early Childhood was associated with “women’s business”. The literature revealed a number of studies in respect to gender and science. Papers that have considered the relationship of attitude to science and gender have been presented by Erickson and Erickson (1984), Harlen (1985a), Klein (1985), Whyte, Deem, Kant and Cruickshank (1985), Robertson (1988), Kahle (1988) and Meikle (1989). These, along with larger works edited by Kelly (1987) and Rennie, Parker and Hildebrand (1991a;1991b), have provided considerable insight into the attitudes and expectations of girls and boys in science and the effect of such attitudes on girls’ perception of science.

According to Browne (1991), differences in gender also affect the ways in which boys and girls learn science during their early years. In order to facilitate gender inclusive methods of teaching, Browne advocated “girl friendly” approaches to teaching science, the development of a broader set of ideas about how children learn, and evaluation of the impact on girls of various teaching methodologies currently in practice. Browne’s findings seem particularly pertinent in relation to Weinburgh’s (1995) meta-analysis indicating that boys have consistently shown more positive attitudes to science.

Gardner (1975a) noted that different attitudes to science might be apparent between girls and boys as early as preschool. Delamont (1990) contended that the nursery school fostered and reinforced stereotyped gender attitudes which impacted across the curriculum and included science. Shepardson and Pizzini (1992) found that girls received negative messages (often from females whom the girls regarded as important) that discouraged them from participating in science activities. For instance, they noted that female teachers asked boys more encouraging questions and girls were given more passive tasks. Similar findings were reported by Kahle (1985), who claimed that through subtle messages, including interaction involving lower levels of cognition, teachers have subtly conveyed messages to students that girls do not succeed in science, a message that continued throughout higher levels of education both in and out of school.

In respect to out-of-school experiences, Parker and Rennie (1986) showed that in the physical sciences, the out-of-school experiences were likely to be stereotyped according to the sex of the child. For instance a lack of experience in tinkering with motors placed girls at a disadvantage when they were required to apply their skills to physical science activities in the classroom. Girls then lost confidence in themselves, which in turn was displayed as a lack of interest in science.

Kirkwood, et al. (1996) suggested that explicit confrontation of gender issues in in-service programs could affect the attitude of female teachers towards the classes that they taught. Rennie et al. (1985) contended that the behaviours of teachers in the area of science and technology were a critical influence on the attitudes of their students. They recommended that pre-service training should focus on the special needs of girls in science and technology, which related to their different background experiences compared to boys. In Australia, two studies have made some attempt to change the attitude of pre-service and in-service teachers.

Women And Science Teacher Education Project

Bearlin, et al. (1990) described three models built from the results of the Women and Science Teacher Education (WASTE) project that investigated science attitudes held by pre-service female teachers in early childhood and primary education. Data were collected from a representative sample of academic science educators from universities throughout Australia. The project found that science education courses were reported to use hands on practical approaches that were termed "non threatening" and closely related to classroom practice. The findings further suggested that all women pre-service teachers were seen as lacking in confidence prior to taking science education courses.

Three models described by Bearlin et al. (1990) were based on familiar models of curriculum design and described the ways in which academics approached attitudes and science education. The first model aimed to change attitudes within a subject-centred model, therefore the mastery of scientific concepts was emphasised. Science was seen as a body of knowledge and women were empowered by developing science skills. In the second model, subjects/units were identified as learner-centred as they changed the student's perception of what science and science teaching was perceived to be. The second model focussed on the methods of teaching and learning of science in young children. The participants in the second model gained and built confidence in science through doing simple activities.

Having considered these two commonly used models, a third model was generated by the authors and referred to as a gender sensitive model. It described what Bearlin et al. (1990) believed would effectively change women's attitudes to science. It was built from courses that were both knowledge and person centred. It was characterised as changing attitudes to science by changing gender expectations and perceptions. The intention of the model was to enable the women to understand why their attitudes to learning in science had changed. An understanding was achieved through reflection

on their teaching practices, thereby encouraging women to value their own science knowledge and experience.

Primary and Early Childhood Science and Technology Education Project

The Primary and Early Childhood Science and Technology Education Project (PECSTEP) was successfully based on the third model of Bearlin, et al. (1990) and was designed to join pre-service education with appropriate practice in schools through the provision of a year long in-service program recommended by WASTE (1990). The methodology of PECSTEP linked an interactive model of teaching with work on gender and the learning and teaching of science and technology. The approach used was deeply respectful of the knowledge about science and individuals. The teacher was encouraged to focus on developing the students' knowledge. In this way, the knowledge of science was not alienated from other areas. The program aimed to change teacher consciousness by a number of steps. They included the modification, teaching and evaluation of an existing semester length pre-service unit in science and technology education for pre-service teachers and the establishment of regional support networks for in-service and pre-service teachers. The program was designed to improve both the attitude of the participants to science as well as the attitude of the girls that they taught (Kirkwood, et al. 1996). The emphasis placed on the empowerment of women in learning contained elements of empowerment advocated by Belenky, McVicker-Clinchy, Goldberger and Tarule (1986).

In 1992, Goodrum, et al. reported on a study that investigated the lack of confidence of primary teachers towards teaching science and ways of overcoming it. Their investigation followed a pilot study of Yates and Goodrum (1990), which indicated that Primary and Junior Primary teachers in Western Australia consistently indicated a lack of confidence which inhibited their ability to teach science. The year-long project commenced with an in-service day to identify the needs and concerns about science held by the teachers. This was followed a week later by a three day in-service program and the provision of a kit of materials. Support was provided at intervals over the remainder of the year. On the conclusion of the project it was found that both the perceived levels of confidence and competence and observed levels of confidence for the majority of teachers had changed. Goodrum et al. attributed the increased confidence from the teachers' perspective to provision of a structured science program, in-service support, equipment, and positive reactions of the children. The background knowledge of the teachers was also improved. The results of this project indicated that a lack of confidence in science teaching can be overcome through the provision of appropriate support.

The Measurement of Attitudes

This section provides an overview of how attitudes have been measured, particularly in science education. It has already been established earlier in this review that there are multiple definitions of attitude and several theories for attitude change. Not surprisingly, the measurement of attitudes is also not clear-cut. As noted by Evans (1965), a problem in the measurement of attitudes is that the act of measuring may alter the attitude. Shrigley (1983a) argued that the key to any effective study of attitude was a definition that produces a valid concept from which an instrument could be designed. As late as 1986, Abdel-Caid, Trueblood and Shrigley reported that a common problem in the construction of an instrument to measure science attitudes was the lack of a plan for the establishment of validity.

In 1932, Likert had suggested a procedure for the development of attitude scales. He used a number of attitude statements that promoted responses from individuals with widely ranging viewpoints. The respondent evaluated each statement and indicated the level of agreement or disagreement with it. Each statement was scored with numbers on a continuum from "strongly agree" to "strongly disagree", usually with a five-point response format. The concept of a Likert-type scale has been used with great effect in science education in studies by Shrigley and Trueblood (1979), Thompson and Shrigley (1986), Shrigley (1974), and Wareing (1982). Similar scales have been devised by Fraser (1981) who presented a Test of Science Related Attitudes (TOSRA). This multi-dimensional test is designed to assess the attitudes of secondary school students to science.

Hassan and Shrigley (1984) have illustrated that the design of a Likert-scale is a complex procedure, in which the nature of each item, length of scale, balance of negative and positive statements, and tense of statements need to be taken into account. Shrigley and Koballa (1984) stated that if a valid attitude statement was to reflect the definition of the attitude, then the emotional intensity of a test item should be considered. According to Shrigley and Koballa's (1983) study on attitudes to energy, the overall data distribution across each Likert scale should have a distribution of high scores at each end (strongly agree or strongly disagree) of the scale, with only a small number of responses for the neutral midpoint. Shrigley (1977) used another variation on the measurement of the attitudes of teachers. The purpose of Shrigley's study was to survey the attitudes of elementary school teachers to teaching science and classify the responses in terms of barriers to science teaching. Shrigley reported a number of implications for in-service teachers including the reinforcement of positive attitudes to teaching science by administrators, through the provision of pleasant classroom climates, materials and equipment and teaching strategies.

Moore and Sutman (1970) developed the Scientific Attitudes Inventory which contained six separate scales to measure students' attitudes and was widely used in the early 1970s. This Inventory was recently revised (Moore & Foy, 1997) but is not particularly relevant to this study because apart from several items, it measures scientific attitudes rather than attitudes to science. Ofchus and Gnagey (1963) measured the attitudes of pre-service teachers by a standard screening test named the Minnesota Teacher Attitude Inventory (MTAI). The results were compared with the students' perception of the instructor and they found that pre-service teachers may unconsciously transfer their attitudes towards their parents to the instructor. Although an attempt was made by the experimental instructor to influence the pre-service teachers, it was suggested that these attempts were counteracted by outside influences. It also compared the personality of pre-service teachers with their attitudes to children. The relevance of this research to the present study relates to the relationship and possible influence of tertiary staff on pre-service teachers.

The study of attitudes is still plagued with problems of quantitative measurement and analyses. In his 1975a review, Gardner provided many examples of poorly designed scales with resultant low reliability and validity. More recently, Gardner (1996) reiterated these concerns particularly over the issue of multi-dimensionality. More than 20 years ago Wiechman and Wiechman (1973) advocated the use of multivariate analyses of attitude data, because it assisted the determination of factorial validity of statements by determining whether or not they measured a single construct or a complex set of characteristics.

Rennie and Parker (1987) have suggested that the nature of attitudes and their imperfect fit with behaviour have always caused difficulties in their measurement. They found that the main problems associated with the measurement of attitudes were first, scale multi-dimensionality, and second, a lack of consideration given to the structure of the population to be measured. Their paper used the development and administration of a Likert-type scale (The Science Interest Scale) to demonstrate the effects of different analyses on the same set of data.

In this study, an attitude scale was needed to measure the attitudes of pre-service teachers. After consideration was given to the variety and types of instruments available, the instrument selected for use in the study was one designed by Coulson (1992) and called Early Childhood Educators' Attitudes towards Science (ECEAS). The purpose of the instrument was to assess attitudes towards science of students who were commencing pre-service Early Childhood Education courses. The instrument was considered appropriate for use in the study because it met the criteria

for design and analyses of Likert scales as described by Gardner (1975a), and had been field tested on a sample that was similar to the population under study. Further information about the selection of the scale and its properties is given in the next chapter. Attitude scales are suitable to obtain a broad picture of the attitudes of a large group (such as the pre-service and in-service teacher groups in the study) but not for small samples (such as the number of academics) or very young children. Thus the scale is only one of several methods used to collect data about the attitudes of those involved in the study. In keeping with the qualitative methods of data collection used by Beacham and Hoadly (1979), Stewart and Cash (1979) and Minichiello, Aroni, Timewell and Alexander (1990), the present study has also used interviews as a data gathering technique. The language of the interviewee can provide qualitative insight into events that the researcher may not be able to directly experience (Lindlof, 1995). According to Anderson and Meyer (1988, p. 247), "qualitative research methods are distinguished from quantitative methods in that they do not rest their research methods on the logic of mathematics, the principle of numbers, or the methods of statistical analyses." Since the present study seeks to both understand and verify attitudes towards science and science education, both qualitative and quantitative research methods are employed.

The Influence of Teacher Resources on Attitudes to Science

Since pre-service and in-service teachers frequently used written materials such as curriculum documents and other teacher resources when they were learning about or teaching science, this chapter concludes by examining some examples of these materials. Particular attention is given to the attitudes conveyed in the materials, and direct references to the attitudes that children should develop.

Curriculum Documents for In-Service Teachers

Curriculum documents are written with the intention of transmitting information to teachers about the current policies on educational philosophy, methodology and content that can be translated into practice. Curriculum documents produced by both state and national writing teams were available to teachers throughout the duration of this study and are therefore considered to be possible sources of influence on the attitudes of teachers (pre-service and in-service teachers). The influence that documents such as *Foundations for the Future* (Department for Children's Services, 1992) was potentially considerable, as it exemplified the philosophy-guided development of programs for Preschool/Kindergartens. This document maintained that Early Childhood Education had a significant input on the development of children and

their families. It was claimed that through play, children developed skills related to environmental awareness that included process skills, technology skills and skills about questioning. The teachers were provided with a list of the ways that they could model behaviour, promote interactions and provide suitable materials for the development of skills. A document, which evolved from this philosophy, was introduced to preschool teachers in 1996. It emphasised the growth of self esteem of the child and from this principal foundation area, encouraged programming that centred on communication, creativity, critical thinking, cultural understanding, environmental understanding, health and physical development and technology (Department for Education and Children's Services, 1996).

In contrast to this state-produced preschool curriculum document, eight nationally produced documents were adopted by the State Education Department, each of which focussed on a separate learning area including science and technology. The *National Statement on Science for Australian Schools* (Curriculum Corporation, 1994a) aimed to outline science content and methodology for school-aged children. The document included a section which specifically covered strategies for the encouragement of scientific attitudes and attitudes to science in children. The statement placed varying emphases on attitudes in science that ranged from statements about the development of self esteem through science education, to statements related to upholding scientific attitudes, and valuing the role of girls in science. The intention of the document was to ensure that teachers taught a range of science and then reported on the children's progress to parents on a regular basis, in accordance with the guidelines from the accompanying Curriculum Profile (1994b). The document catered for children from the commencement of school to Year 10 of formal schooling. Although in-service teachers used the documents directed to their area of teaching (either Pre-school or Junior Primary), pre-service teachers in Early Childhood Education were required to become familiar with both sets of documents.

An example of a widely available curriculum document is the child centred K-3 science program entitled *They don't tell the truth about the wind* (Fleer, Hardy, Baron & Malcolm, 1995) which was written to support the information from *A Statement on Science for Australian Schools*. The program emphasises the idea that teachers should encourage children to take control of their own learning through participation in carefully selected experiences. The program encourages children's interest and curiosity in science yet makes no overt reference to their attitude development. However, by adopting a specific stance in respect to the content covered and methodology used, the widely available program is influencing teacher attitudes about the ways that children learn science.

Curriculum Documents for Pre-service Teachers

As part of the policy of the tertiary institution, pre-service teachers are required to receive an outline of each subject specifying the expectations of the lecturers in charge of the subject, descriptions of assignments and an overview of the subject. The subject outlines indirectly transmit some of the attitudes of the academics through descriptions of the work to be covered, rules and regulations, and an outline of assessments. The aims of the subjects in science education were clearly documented in the subject outlines used by pre-service teachers in the study. An example of an aim is: "to see the relevance of science in everyday life at home, at school and at play" (General Science, Subject Outline, 1992, p. 3), however this document did not specify that "relevance of science" could be considered to be an attitude towards science. Since the subject outlines gave considerable detail to the description of assignments it was likely that the pre-service teachers paid more attention to assignments rather than to statements which described the notions that the staff wanted to engender in the pre-service teachers.

Commercially Produced Publications

Apart from the curriculum documents available to guide the teaching of science, a number of commercially produced books are available through retail outlets and book suppliers. The attitudes promoted in some of these publications, spoke directly about the development of curiosity, interest in science, or caring for aspects of the environment, as evidenced in *An environmental curriculum for preschool children* (Targowska, 1991). Almost all of the publications covertly encouraged the enjoyment of science in young children. Most attitudes promoted in the written materials promoted the acquisition of knowledge or skills, such as helping children to construct their own investigations of science (Biddulph & Biddulph, 1992). A number of books centred on the methodology of constructivism. For instance, *Making sense of our world: An interactive teaching approach* (Biddulph & Osborne, 1984) discussed the ways that children regarded science and presented a model of interactive teaching which was based on the concept of constructivism. Faire and Cosgrove (1988) also described in detail the interactive model of teaching for Primary teachers. Later, Biddulph and Biddulph (1992) produced a science series especially for Junior Primary children, based on a modified version of the interactive model of teaching. The science series was centred on a number of topics and presented in the form of a teacher guide, "Big Books" and individual children's books. The series devoted considerable time to encouraging children to learn about science through their own investigations. In 1995, a series of books (including Teacher Resources, Big Books and kits) called *Science Alive* continued to encourage children's investigations and promoted a long list of

attitudes that highlighted the idea of developing the child's curiosity and, like the preceding books, were aimed at Junior Primary and Primary Children. Fleer and Hardy (1996) published a modified version of their pre-service teacher science curriculum. This comprehensive book covered theories behind teaching science to young children and included examples of hands-on learning activities. The book encapsulated the philosophy of a decade of ideas in Early Childhood Science Education and encouraged pre-service teachers to form their own opinions about teaching science.

In 1987, Richards, Collis and Kincaid described simple science activities that could be used with children in both indoor and outside settings. Richards et al. emphasised the development of the skills of observing, exploring and manipulating materials, rather than the development of specific attitudes to science and once again were directed to the upper age range of Early Childhood Education. A variety of teacher resources, including books by Hope (1978, 1981), promoted the integration of science with other areas but little attention was given to the development of attitudes, which were mentioned mainly in reference to caring for animals.

Science 5/13 was published in the early 1970s by McDonald Education and is an example of an older set of science books sometimes used in Kindergartens which feature in this study. It comprises a series of books about teaching science to school-aged children and included titles such as "Early Experiences," "Toys," "Early Explorations". The writers, who included researchers such as Harlen (1972), linked each book in the series with Piaget's stage theory and described science activities that centred on a theme.

One of the older series of science publications for teachers that did not centre on a theme was known as the *New Zealand Primary Science Program* (1981). The program comprised a series of small booklets on specific topics (such as Farm Animals, Small Animals On and Under the Ground) containing lesson aims, ideas for evaluation, and simple hands on activities to use with a class. Each booklet also referred to specific scientific attitudes and skills that the teachers could encourage in children. However during the 1990's the booklets became increasingly difficult to obtain.

Generally, pre-service and in-service teachers tended not to rely only on one published resource. Instead although they might have one favourite, they took ideas from a number of books, and it was therefore likely that they encountered a number of attitudes from a range of written material. Teachers would also use locally produced items

such as the Gould League publications, materials from the Science Teachers' Association, teacher resource centres and Lady Gowrie Kindergartens. These publications mention a number of attitudes ranging from attitudes about caring for the environment, fostering curiosity and exploring ideas. Other publications used by teachers include journals published by Early Childhood Associations which address general concerns in Early Childhood Education and focus on the well being of the child, and several specific science journals such as *Investigating* which publishes simple science activities and methods. As each journal article reflects the ideas and attitudes of a given author it is likely that the reader is again introduced to a variety of attitudes.

Although there was a wide range of written resources available for teachers (and children), comparatively few directly referred to the development of attitudes in science and those that did, appeared to assume that they were introducing the concept of attitude for the first time. The books made little attempt to refer to attitudes which children may have already held, nor did they define the term attitude.

Summary

There have many studies established about attitudes in science education. From the information that they have generated it is possible to select definitions about attitudes and to construct hypotheses about the influence of attitudes. For the purpose of this study, attitude was defined as a social construct in terms of an individual's evaluation of science that generates an emotional or affective response, expressed in terms of like or dislike.

The models for attitude change described in literature about science education appeared to borrow heavily from models of social psychologists. It was unfortunate that few of the models described were specifically constructed for Early Childhood Science Education, although a number of ideas and steps from existing models could be used in the generation of a new model in the area.

Since the 1930s there has been considerable development of instruments to measure attitudes in science education. The most popular style of instrument was a Likert-type scale, a variation of which was selected for use in this study as one of a number of data gathering methods.

Despite the research available on attitudes to science, the written materials that have been specifically published for teachers and children pay little overt attention to

attitudes. Instead, publications tend to focus on the generation of knowledge, styles of learning and science-related activities and the attitudes portrayed by the publications appear to emphasize the importance of science knowledge and problem solving.

The next Chapter describes the approach taken when examining the attitudes of the four groups of people involved in the study. It outlines the methodology selected to build on the ideas about attitudes and attitude measurement from literature.

CHAPTER 3

METHODOLOGY

The chapter contains a descriptive summary of how the study was carried out. It describes the various sources of data, the survey, interviews with academics, pre-service and in-service teachers, video tapes of children participating in science learning activities, and records of children's written work. Subsequent chapters consider aspects of the methodology in relation to the reporting of results. The research design incorporated triangulation in that data were collected from more than one standpoint and qualitative and quantitative methods were combined over an extended period of time. This approach is consistent with the findings of Mathison (1988), who, in an investigation into methods of good research practice, proposed that it was essential for the researcher to triangulate that is, to employ "multiple methods, data sources, and researchers to enhance the validity of research findings in order to withstand critique by colleagues" (Mathison, 1988, p.13). Thus, triangulation was viewed as a means of increasing the validity of the research. The following sections of the chapter describe the research design, description of the sample selected, the instrumentation and an overview of data collected.

Research Questions

The study was guided by the general research questions:

What are the affective factors which influence the teaching of science to young children?

What kinds of attitudes to presenting science to young children are held and modelled by academics to pre-service teachers?

What kinds of attitudes do in-service and pre-service teachers hold? Some possible attitudes and attitude components may include the perceived usefulness of learning about science, application of knowledge of science, perceived interest in the subject and the emotion of liking or enjoying it. The study further asks, what kinds of attitudes are modelled by teachers to children?

Specifically the study investigated the following questions.

1. How do academics promote the teaching of science to young children?
2. What factors influence the willingness of pre-service teachers to present science to young children?
3. What are the factors that influence in-service teachers to teach science to young children?
4. How does the classroom teacher (pre-service and in-service) influence young children's responses to science at school? This question was addressed by asking how children respond to science and what effect the teacher has on the children's responses to science.

Research Design

The construction of the research questions reflected the need to understand the relationship between the groups in the study (academics, pre-service and in-service teachers and children), their backgrounds and attitudes to science and, in particular, science education. The research questions "translate concepts and terms into queries" (Lindlof, 1995, p. 94) and set the expectations for the study. In this study, the information collected was used to build a dynamic picture of the attitudes to science held by each group and how the attitudes held by one group might influence another.

In an endeavour to keep the research to a manageable size, and the data as consistent as possible, the study was confined to groups central to Early Childhood Education in a specific locality. Data about attitudes to science education were collected over a four-year period in the form of interviews, a survey, video tapes and written material. The survey data were then analysed through a SPSS program. Thus the research design was quasi-longitudinal, with both quantitative and qualitative approaches to data collection and analysis, involving a number of different groups.

To some extent, the size of the groups influenced the method of data collection. Quantitative data were collected from pre-service and in-service teachers through an instrument called Early Childhood Educators' Attitudes towards Science (ECEAS) developed by Coulson (1992). The subjects filled out what was referred to in the instrument as the Science Opinion Survey which described their attitudes to science in terms of confidence, enjoyment of science at secondary school, usefulness of science to daily life and the appropriateness of science to young children. Background information about the subjects was also recorded along with their responses to several open-ended questions. The instrument was administered to six groups, four cohorts of pre-service teachers and two groups of in-service teachers. For the purpose of

reporting the results of the survey, relevant pre-service teachers were assigned numbers that corresponded to their year level. A total of 299 pre-service teachers and 75 in-service teachers were surveyed. The administration of the survey was repeated on two year-levels of pre-service teachers.

The administration of a survey permitted the canvassing of views from a large number of subjects in a short period of time. The quantitative data obtained were supported by information from interviews which allowed the collection of more detailed information from smaller groups.

Interviews were carried out with 7 academics (the science staff and 3 educators from the Institute), 58 pre-service teachers and 46 in-service teachers who were prepared to volunteer detailed information about their backgrounds in and attitudes to science, particularly science education. There were two sub-groups of in-service teachers who were particularly sought for interviews. One sub-group (referred to in other chapters as exemplary teachers) comprised seven teachers or former teachers who seemed extremely interested in promoting the teaching of science to young children. The members of this sub-group were interviewed to determine how and why their attitudes to science differed from other teachers. The other sub-group (referred to as exit students/graduates) were in-service teachers who, having completed the course in science education were in their first year of teaching. The data collected from this sub-group of six, provided a link between pre-service teachers taking science education and in-service teachers, who had been in the work force for usually over 10 years. A total of 27 interviews were also conducted in schools where pre-service teachers were teaching science during a four-week practicum. The pre-service teachers, supervisory teachers and administrative personnel were interviewed on site. The sample of people interviewed is described in Table 3.1.

Table 3.1

Description of Interviewees

	Interviewees	Number
Academics	Science	4
	Institute	3
Pre service	First	4
	Second	11
	Transition	10
	Third	6
	Practicum	27
In service	Exit	6
	Kindergarten	6
	Exemplary	7
	Supervisory	27

Information about preschool children’s attitudes to science was collected from video recordings of children participating in science activities. The attitudes of Junior Primary children were obtained from their written work about science lessons and scientists. Pseudonyms or numbers were used to protect the identity of the children and schools involved. Both methods of obtaining data were considered appropriate for the age group of the children.

As described above, the study used data collected over a period of four years from academics, pre-service teachers, and in-service teachers, as well as children. A time frame over-viewing the groups and data collection is given in Table 3.2, and Appendix 3.1 provides more detail.

Table 3.2

Summary of Data Collection

Year	Details of type of participants and data collected
1992	Selected and administered ECEAS to 1st, 2nd, and 3rd year (transition) pre-service teachers and interviewed volunteers. Commenced academic interviews.
1993	Conducted interviews in Junior Primary Schools hosting 3rd year practicum. Interviewed in-service teachers, graduates, 2nd, and 3rd year pre-service teachers. Video taped at Preschool Location 1 and collected Junior Primary children’s written work. Continued academic interviews. Administered ECEAS to 1st, 2nd, and 3rd year pre-service Teachers, Kindergarten and Junior Primary Teachers.
1994	Video taped at Preschool Location 2. Completed academic interviews. Collected children’s recordings. Commenced interviews with exemplary teachers.
1995	Analyses of some data from ECEAS Transcribed interviews and video-taped at Preschool Location 3.

The Sample

The sample was intended to be representative of groups in the study who were involved in science in Early Childhood Education, that is, academics, pre-service and in-service teachers and children. The academics and pre-service teachers belonged either to the Institute or the Science Department within the same University campus while the in-service teachers and children were mainly from local schools and pre-schools.

Academic Staff

A total of seven academic staff were involved in the study. Four staff belonged to the Science Department of the University and were given the pseudonyms of Debbie, Don, James and Doug. The other three academic staff from the University's Institute of Early Childhood Education were interviewed and called Tom, Annette and Maria.

Debbie, Don, James and Doug taught subjects in science education to the pre-service teachers studying Early Childhood Education (the process of teaching tertiary students from another department was known as "service teaching"). Tom, Annette, and Maria expressed a profound interest in science education and on behalf of the Institute shared some administrative responsibility for Early Childhood Science Education, taught mathematics and supervised practicum (the placement of pre-service teachers in Preschools, Kindergartens and Junior Primary Schools for the purpose of field experience).

Interviews with academic staff from both departments provided a wider picture of pre-service and in-service teachers in Early Childhood Education and the expectations of them from academic staff. The backgrounds of the academic staff, and in particular the staff who taught science education, are described in detail in Chapter 5 of the study.

Pre-service Teachers

The pre-service teachers who entered Early Childhood Education from secondary school had an average age between 17 and 20 years, and were predominantly female. The number of mature age students accepted into the 3-year Early Childhood course varied between 10% and 12 % each year. The total number of pre-service teachers enrolled in Early Childhood Science Education averaged over 100 in the first year of the course, 80 in second year and 70 in third year.

The pre-service teachers taking the degree in Early Childhood came from both country and metropolitan areas of the state. To gain entrance to awards in Early Childhood Education, they required a tertiary entrance score of around 350 points out of a possible 500. Some students did not elect to become teachers in Early Childhood Education yet entered the course when it was the only offering they received to attend a tertiary institution. Other students transferred into the course from other awards or institutions.

Background of pre-service teachers

The pre-service teachers had a mixed socio-economic background and had attended a variety of private and state secondary schools. Some ethnic and minority groups were represented.

The pre-service teachers in Early Childhood Education had taken very few science subjects in year twelve (unpublished tertiary entrance scores, SATAC, 1993). Of the science subjects that were taken, the most common were Biology and Geography. These subjects were accompanied by school assessed subjects in Mathematics, English and a range of other subjects such as Business Law, Accounting, Art, Home Economics and Child Studies. The Biological Science that was taken in year 12 was also usually internally assessed by the high school attended by the students. [In an internal or school based assessment procedure, students were required to submit assignments throughout the year rather than sit for an external yearly examination (PES) set by a public examination board.]

Description of Science taken at University

Upon entering university, the compulsory science that individual year levels of pre-service teachers took comprised:

A semester long background science subject called "Developing Understandings in Mathematics and Science", that covered basic concepts in Biology, Chemistry and Physics, which was offered to students in the second semester of their first year at university. The subject was referred to by both staff and pre-service teachers in the science department as "General Science" a name that has been used to describe the subject in all other chapters. The mode of delivery for General Science tended to be subject-centred as described by Bearlin, et al. (1990). General Science was also offered to primary pre-service teachers in the preceding semester.

The pre-service teachers then took a ten-week introduction to curriculum methods in science in the second half of second year (entitled Fostering Mathematical and Scientific and Technological Concepts) and a semester long curriculum methods in science and technology (called Curriculum Studies in Mathematics, Science and Technology) early in third year. Both subjects are referred to in this study as "Curriculum Science". The mode of delivery for Curriculum Science tended to be child-centred as described by Bearlin, et al. (1990). The science staff also placed a strong emphasis on teaching science to Junior Primary children. The Curriculum Science available to primary pre-service teachers ran for 13 weeks, followed similar topics and was taught by the same science staff.

The mathematics component of each subject was taught by staff from the Early Childhood Institute (namely Tom, Annette and Maria) and the subjects in Curriculum Science were followed by a period of field experience referred to in the study as “practicum.” General Science and both Curriculum Science subjects were assessed through assignments and examination. In all, the pre-service teachers undertook almost three semesters of science education over a three-year course. This was in light of the recommendations of *The Discipline Review* (DEET, 1989b).

In-service teachers

The group of around 120 in-service teachers comprised teachers, school administrators (principals and deputy principals), Kindergarten Directors, Regional Coordinators, and specialist personnel. Teachers from both government and non-government schools were represented. Both Preschool and Junior Primary teachers were predominantly female with considerable teaching experience.

The knowledge about science education held by the teachers was mainly based on training received in past decades. Generally their pre-service training was characterised by a shorter length of time than the current pre-service teachers, and focused on the methodology of the period. For instance, depending on when they graduated, teachers seemed to be trained in nature science, “one off” science activities, or integrating science with other subjects. Teachers tended to be specialists in either Kindergarten/Preschool or Junior Primary and sometimes described themselves as “Kindergarten or Junior Primary trained” as opposed to a teacher of “Early Childhood.” In-service teachers are referred to in reports of interviews by a number, or colour code of their school.

Exemplary Teachers

One small sub-group of seven in-service teachers had considerable experience in providing in-service and/or pre-service teacher information on science education. These teachers were of particular relevance to the study because they were interested in leading others in science education, and are referred to as exemplary teachers of science. Yet despite their enthusiasm for sharing science with others, the members of this sub-group did not necessarily hold many qualifications in science. Each teacher was able to talk at length about their ideas on science education, children’s reactions to science and their opinions about the attributes of an effective science teacher. The exemplary teachers are described separately in the study from the other in-service teachers and individual members of this sub-group are referred to specifically by number in reports of interviews.

Exiting or graduating teachers

A small sub-group in the study comprised individuals who had obtained a substantive contract of employment immediately after graduation. They were employed to work in remote country schools and were contacted to obtain information about the science they were currently teaching and their recollections of science education at university. These participants, called exiting or graduating teachers were excited about obtaining employment at a time when teaching jobs were difficult to find. The majority of their colleagues had registered on graduation for work as “relief” teachers or “child-carers” (caring for babies to three-year-olds) The comments of the exiting teachers are included separately in Chapter 5 at the commencement of the section on interviews with in-service teachers.

Children in Preschool and Junior Primary School

Information was obtained from around 120 children with a wide variety of socio-cultural backgrounds. The children’s ages ranged from 3.11 to 8.6 years. The physical build, language and skill development of the children varied. Below the age of six, children are not legally required to attend any educational institution. For various reasons however, some parents elected to place their children either in a Kindergarten that catered for children who were approximately one year away from commencing Junior Primary School, or a Child Care Centre that catered for a wider age range of children and contained a separate section and curriculum (or program) for Pre-school children (4- and 5-year olds). Around the age of five years, children usually began a three year period in the Junior Primary school. The curriculum of the Junior Primary school became gradually more structured as the children began formal lessons rather than participating in informal learning activities.

The Survey Instrument

A number of instruments were considered for use in this study, including the Scientific Attitude Inventory of Moore and Sutman (1970) which had been used by Skamp (1989) with pre-service primary teachers; the Test of Science Related Attitudes (Fraser, 1981) which is designed for secondary students; the Science Interest Scale, an instrument measuring attitudes for children in Year 5 used by Rennie and Parker (1987); and Likert-type scales used by Shrigley (1976, 1978) to measure the attitudes of pre-service and in-service elementary teachers to science education. However, these instruments were not specific to Early Childhood Education and were likely to have needed modification and additional field-testing before use with the intended sample.

The instrument selected was known as the Early Childhood Educators' Attitudes towards Science (ECEAS, Coulson, 1992) because it was intended for use with pre-service teachers and in-service teachers in Early Childhood Education and covered the attitude components identified as important in the study. It was simple to administer and took little more than ten minutes to fill out, a particularly important consideration for in-service teachers who were likely to be short of time. Shrigley (1976) suggested that the length of the instrument was an important attribute in encouraging accuracy of responses and it seemed likely that the simple format of ECEAS might encourage honest responses.

ECEAS consists of two parts: a 32 item section which Coulson (1992) termed The Science Opinion Survey, and an open-ended biographical section. The Science Opinion Survey (SOS) comprised four sub-scales, each of 8 Likert-type items, measuring confidence in doing science, enjoyment of science at school, personal usefulness of science and appropriateness or relevance of science for young children. The responses were scored from 5-1 for strongly agree, agree, not sure, disagree, to strongly disagree. The score was reversed on negative items. Thus, the possible range of scores for each of the sub-scales is 8 to 40, with higher scores indicating more positive attitudes. In this study the full sub-scales were used but their titles have been abbreviated to Confidence, Enjoyment, Usefulness and Relevance in other chapters, for easy reference. An example of sub-scale items is described in Table 3.3. This table also includes the Cronbach Alpha Coefficients reported by Coulson (1992) as a measure of internal consistency of each scale.

A copy of the instrument (ECEAS) is included as Appendix 3.2. The open-ended biographical section asks whether students are mature age, their sex, which university course they were doing, what science subjects they studied at school and their date of birth. In addition, two questions asked students to comment on how they felt about science in general, and particular aspects of science.

Table 3.3
Examples of Scale items

Scale	Item	Reliability
Confidence in doing science scale	I am capable of succeeding in science I feel nervous about having to do science	0.83
Enjoyment of science scale	Science lessons at school were exciting I found most science lessons at school boring	0.86
Usefulness of science scale	I'll need science for my future work Science is of no help in every day life	0.88
Relevance to children scale	Preschool children can easily do science Science is not relevant to young children	0.88

Data Collection

Survey Data

According to (Lindlof, 1995. p. 121) a survey is a powerful means of determining the attitudes held by a given population. ECEAS was given to several groups of pre-service teachers towards the completion of science education subjects in the first year, second year, or third year. The survey was also given to a cohort of first year pre-service teachers at the commencement of their first year of General Science. The surveys were administered and collected before the start of a lecture. It was not compulsory for pre-service teachers to complete the survey. Those who did were asked to place their identification number on the questionnaire if they were willing to be interviewed (at another time) about their attitudes towards science/science education. The fact that the groups completing the survey were volunteers means that they may not be representative of their cohort.

Two cohorts of pre-service teachers were surveyed in consecutive years, 1992 and 1993. Table 3.4 summarises details of the year levels surveyed, the time of survey,

the tertiary science experience and the numbers of participants in each year level. It can be seen that groups 1 and 2 were surveyed in the following year as groups 6 and 4 respectively. The surveys were administered approximately one year apart.

Table 3.4

Time Line for Collection of Data from ECEAS Survey

Date	Cohort	Tertiary Science taken	n
Oct 92	1. 1st yr pre-service	General Science	113
Oct 92	2. 2nd yr pre-service	General and 2nd year Curriculum Science	55
Oct 92	3. 3rd yr transition	All Curriculum Science and General Science	47
May 93	4. 3rd yr pre-service	General Science all Curriculum Science	44
July 93	5. 1st yr pre-service	Start of General Science (ie No science)	12
Aug 93	6. 2nd yr pre-service	General, some 2nd year Curriculum Science	28
Aug 93	7. Kindergarten	Varied with experience of teacher	43
Aug 93	8. Junior Primary	Varied with experience of teacher	32

Note - Cohort 4 was surveyed in 2nd year (cohort 2 on the table).
 Cohort 6 was surveyed in 1st year (cohort 1 on the table).

Group 3 is a cohort of pre-service teachers, known as “transition students” who were required to take both third year curriculum science and first year general science, during their third year of Early Childhood Education. This came about because the course structure was in transition between old and new requirements. Data were collected from the transition students to provide information about any effect on attitudes of the order in which science subjects were taken. In addition, another group of first year pre-service teachers (Group 5) was surveyed in 1993.

The two groups of pre-service teachers who had the survey administered twice, were later identified and matched by their date of birth. Their survey responses were compared to see if there was any evidence that attitudes may have changed while taking science education. This was considered an appropriate use of the instrument as Coulson (1992) intended that it could be used to determine the productiveness of courses in encouraging positive attitudes to science.

Since the administration of Junior Primary and Preschools varied slightly, so too did the method of contacting them to collect data. Preschools/Kindergartens are generally small and administered by a Director who also teaches. Junior Primary Schools tend to be larger and administered by a Principal who may or may not teach. The Directors from 70 randomly selected Preschools/Kindergartens were contacted by a letter, which explained the purpose of the study, and was accompanied by the survey. The letter also invited the respondent to comment on what attributes a teacher of science should have along with any other feedback they cared to make. Over the following two months a total of 43 responses were received giving a response rate of 61%. A copy of the questionnaire and a similar letter was sent to 50 Junior Primary School principals, who were asked to direct the letter and questionnaire to a teacher who showed an interest in science (this was to ensure that the questionnaire reached a teacher interested in science and therefore more likely to respond to the questionnaire). In all a total of 32 responses were received over a two-month period, giving a response rate of 64%.

Collection of Other Data

Qualitative data were collected from adult participants through interviews. Audio-recorded interviews were the main source of data collected from the seven academic staff. The academic staff members were interviewed in an office and timeslot of their choice. Interviews were also conducted with voluntary pre-service teachers from each cohort after the administration of each survey. Interviews were conducted with Kindergarten/Preschool, Junior Primary teachers, and exemplary teachers in a variety of settings over several years. Transcripts were made of interviews of academic staff and a record was kept of the field notes made at all other interviews.

Information about preschool children participating in science activities was obtained through video-tapes made in three different locations. Locations 1 and 2 were in the Pre-school section of a suburban child-care centre and Location 3 was in an inner city Kindergarten. Children's written work about science was collected from four different classes within one Junior Primary School in a lower middle class socio-economic metropolitan area. All children were assigned a pseudonym for the purpose of reporting results. Table 3.5 describes the participants and dates for the collection of qualitative data.

Table 3.5

Time Table for Collection of Qualitative Data

Date	Group Interviewed
August 1992	commenced interviews with academic staff
November 1992	interviewed 1st, 2nd, 3rd year (transition) pre-service teachers
April 1993	interviewed 3rd year pre-service teachers on practicum and in-service teachers in Junior Primary Schools
June 1993	commenced interviews with in-service teachers
July 1993	video taped children in Preschool at Location 1
September 1993	continued interviews with Kindergarten Directors
September 1993	interviewed 2nd year curriculum science pre-service teachers
September 1993	began to collect children's written material from the Junior Primary School
October 1993	contacted graduates who had been employed as teachers
May 1994	video taped in Preschool Location 2
September 1994	commenced interviews with exemplary teachers and completed interviews with academic staff
September 1994	continued to collect children's written work
December 1995	video taped at Preschool Location 3 and completed interviews with exemplary teachers

Details of Interview process

Interviews were conducted on a one-to-one basis during which the researcher asked a series of open-ended questions. The questions were intended to encourage the interviewee to talk freely and at length about their backgrounds in science, present and previous attitudes to science, role of science in their present position, interest in and intention to teach science (if pre-service teacher). The researcher was also keen to find out how the interviewee had felt influenced, and felt they had influenced others, about science.

The structure of the interview, the nature of the questions and method of recording were slightly varied to suit the interviewees. Generally, the interviews lasted between

twenty and forty five minutes. The interviews were pre-arranged and at a time and location suited to the interviewee. Interviews with academic staff were audio-taped with permission and later transcribed, while interviews with pre-service and in-service teachers were recorded by field notes. An example of a transcript of an interview with an academic staff member is located in appendix 3.3, whereas field notes from an interview with a pre-service teacher and an in-service teacher are provided in appendix 3.4. These appendices provide the reader with information about the amount and type of information collected for the study.

Video-tapes and Children's Written Work

Children's drawings, scribed (the child's spoken ideas written by the teacher) and written comments about science lessons and scientists were collected from a Junior Primary School in the local area and analysed. The child's sex and age were noted on the material obtained. The written work was collected from children in Reception/Year 1 (commencement of Junior Primary and referred to as Red Class), Year 2/3 (Blue Class), and Year 3 (Yellow Class). The teachers were interviewed after the collection of the written material to obtain their responses to the children's work and their attitudes to teaching science in general. Field notes were made about the interviews.

Three preschool group activity sessions, each comprising 12 to 14 children, were video-taped as they participated in science-based activities related to Australian animals, and magnets. The preschool locations were selected first, due to their close proximity to the University, second, the Directors openly encouraged academic staff to visit their establishments, and third, they had an established reputation for teaching science. The video camera was set up prior to the arrival of the children on a predetermined spot and allowed to run. Focal adjustments were made when considered necessary to the collection of data. The video camera also recorded sound. The teachers were interviewed at the conclusion of the video taped segment to assess their responses to the lessons and their attitudes to science in general. Examples of transcripts of video taped sessions with preschool children and children's written work are contained in Appendices 3.5. and 3.6 respectively.

Overview of Data Analysis

A research assistant entered the quantitative data from ECEAS onto standard SPSS files. From the first administration of the SOS a principal components factor analysis with varimax rotation was performed for individual item scores in order to check

the structure of the four component sub-scales and to examine possible differences between groups. Analyses of variance were applied to non repeated groups while paired differences t-tests were carried out on the two cohorts who repeated the survey in different years.

The year-level responses to open-ended items were tabulated and compared, and SOS scores were compared with the biographical items, identifying science subjects taken at high school.

The qualitative data consisted of field notes, transcriptions and children's work. Each data set was examined, looking for patterns and trends in the data. Case studies for the academics were built up in this way and more general summaries were made for the other groups. In all cases there was a search for disconfirming data.

Ethical Considerations

All participants were invited to be part of the study on a voluntary basis and could withdraw at anytime.

Letters requesting permission to approach the target groups were sent to relevant people in the University, education sectors and where applicable information letters and parents. Samples of letters, which grant permission for the study, together with letters to parents, teachers and kindergarten directors, are located in Appendix 3.7.

The purpose of the study was explained to the participants and their anonymity and confidentiality was assured. In the case of the collection of qualitative data from interviews, the participants were informed that although the information they were providing might be used directly in the study, their identity would be coded. It was emphasised that participation in the study was voluntary and that participants also had the right to withdraw (or in the case of a minor be withdrawn by a caregiver) from the study.

In respect to Education Department guidelines protecting the safety and rights of students (children) permission was not sought to video tape Junior Primary children. The identity of children's written material and drawings was coded and the drawings are not published in the body of the study.

It was the policy of some Preschools to allow children to be video-taped, interviewed and photographed for the purpose of research or publicity and parents had already signed a consent form granting permission for this to occur. However parents were still informed of the research and their consent was sought. The names of the Preschool children on video-tape were coded during transcription. In short, an attempt was made to treat the participants in the study with respect, dignity and anonymity.

This Chapter has described the research design, the nature of the samples and data collection. Chapter 4 reports the results from the ECEAS survey and Chapter 5 presents the findings from interviews and children's data.

CHAPTER 4

RESULTS OF THE ECEAS SURVEY

This Chapter reports the attitudes to science held by in-service and pre-service teachers and their backgrounds in science. The information was obtained through analyses of data collected from the responses of the participants who completed the Early Childhood Educators' Attitudes towards Science (ECEAS). This instrument provided quantitative data about the attitude components of confidence, enjoyment of science at secondary school, appreciation of the usefulness of science and its appropriateness to young children. In addition to the attitude data, the open-ended component of the instrument allowed for a brief investigation of the science subjects taken at secondary school and accompanying comments on feelings about science.

Science Opinion Survey

The Science Opinion Survey part of the ECEAS instrument comprises four sub-scales, described in the study as Confidence, Enjoyment, Usefulness and Relevance. Table 4.1 shows the set of means, standard deviations and Cronbach Alpha co-efficients for internal consistency reported by Coulson (1992, p. 104), when she tested the instrument on a sample of 200 pre-service teachers, in the first year of a course in Early Childhood Education. She points out that all the scales were above the minimum recommended criterion of 0.70 for the value of Cronbach's Alpha.

Table 4.1

Mean Scores, Standard Deviations and Cronbach's Alpha Co-Efficients for the Four Scales (Coulson, 1992).

Scale	Mean	Standard Deviation	Reliability
1. Confidence	27.39	5.01	0.83
2. Enjoyment	26.76	5.84	0.86
3. Usefulness	28.65	5.05	0.88
4. Relevance	29.85	4.52	0.88

In this study, the instrument was administered to pre-service teachers in three separate year levels of a course in science education as well as to Kindergarten and Junior Primary teachers. The instrument was administered to pre-service teachers to measure their attitudes to science, to determine if attitudes to science varied with the science education subjects taken at university and to document if attitudes to science changed according to the amount of science education that the pre-service teachers received. The instrument was administered to Kindergarten and Junior Primary teachers to measure their attitudes to science and to determine any differences in attitude between teachers who chose to work in pre-schools and teachers of junior primary children.

Six year-level groupings of pre-service teachers (students) and two groups of teachers were asked to complete *The Science Opinion Survey* which examined their view of science and science teaching. The different year levels of pre-service had different educational experience at the University. Three year levels of students had completed a subject in General Science and Curriculum Science (described on Table 4.2 as Groups 2, 3, 4 respectively). One group had experienced only the General Science subject (described on Table 4.2 as Group 1). One year level had experienced neither (Group 5), and one year level (Group 6) had completed General Science and was half way through their second year of Curriculum Science.

One specific cohort, referred to on Table 4.2 as third year transition (Group 3), attended the same subjects but experienced their General and Curriculum Science in reverse order (it was considered possible that taking the subject in a different order may affect attitudes to science). The students in Groups 4 and 6 were tested in the previous year level. It can be seen that Group 4, in third year, was also tested as Group 2, in second year, and Group 6, second year students, were also tested as Group 1 at the end of General Science in their first year. The purpose of the different patterns of testing was to note any differences in attitude that might have arisen as the students took more subjects in science education.

As previously mentioned, the participants in the two groups of teachers comprised Kindergarten and Junior Primary teachers respectively. Table 4.2. also provides details of the experiences of each cohort, and the number of participants tested.

Table 4.2.

Descriptions of the Eight Groups of Subjects

Group	Year Level	General Science	Curriculum Science	Number
1	First year pre-service	Yes	No	113
2	Second year pre-service	Yes	Yes	55
3	Third year transition	Yes	Yes	47
4	Third year pre-service	Yes	Yes	44
5	First year pre-service	No	No	12
6	Second year pre-service	Yes	Some	28
7	Kindergarten Teachers	No	Some	43
8	Junior Primary Teachers	No	Some	32

Note: Groups 2 and 4 and 1 and 6 are the same cohorts at different stages of science.

Findings

Sub-scale structure of the Science Opinion Survey

The *Science Opinion Survey* (from ECEAS) was designed to produce four sub-scale scores, Confidence, Enjoyment, Usefulness and Relevance. The construct validity of the four sub-scales was examined by conducting a principal components analysis with varimax rotation on the relevant questionnaire responses (Rosenthal & Rosnow, 1991). The first four unrotated factors had eigenvalues of 10.73, 3.61, 1.83, and 1.29, and together accounted for 54.6% of the variance. The loadings for the rotated four-factor solution are displayed in Table 4.3. The patterns of loading indicate that the four factors correspond well with the four sub-scales. There is some overlap, on the Relevance sub-scale, perhaps not surprisingly, for three items on the Usefulness sub-scale. Nevertheless, it was concluded that the sub-scales were sufficiently consistent with those found by Coulson, and thus the sub-scales were retained for use in this study. Cronbach's Alpha was calculated for each sub-scale. The resulting values were .85, .86, .88 and .85 for the sub-scales Confidence, Enjoyment, Usefulness and Relevance, respectively. These match closely with those reported by Coulson (see Table 4.1).

Table 4.3

Four-Factor Solution for ECEAS Science Opinion Survey

Item	Scale	Factor 1	Factor 2	Factor 3	Factor 4
1	Confidence			0.55	0.32
5	Confidence			0.74	
9	Confidence			0.60	
13	Confidence			0.66	
17	Confidence	0.34		0.38	
21	Confidence			0.66	
25	Confidence			0.71	
29	Confidence			0.63	
2	Enjoyment		0.81		
6	Enjoyment		0.38		
10	Enjoyment		0.70		
14	Enjoyment		0.46		
18	Enjoyment		0.83		
22	Enjoyment		0.74		
26	Enjoyment		0.64		
30	Enjoyment		0.83		
3	Usefulness				0.59
7	Usefulness				0.71
11	Usefulness	0.55			0.36
15	Usefulness			0.33	0.66
19	Usefulness				0.68
23	Usefulness			0.34	0.67
27	Usefulness	0.48			0.53
31	Usefulness	0.58			0.44
4	Relevance	0.54		0.30	
8	Relevance	0.62		0.32	
12	Relevance	0.75			
16	Relevance	0.66			
20	Relevance	0.68			
24	Relevance	0.74			
28	Relevance	0.70			
32	Relevance	0.72			

Note: Factor loadings < .30 have been omitted. (N=374)

Table 4.4

Means and Standard Deviations obtained for each Sub-scale for each Group of Teachers

Group	<u>Confidence</u>		<u>Enjoyment</u>		<u>Usefulness</u>		<u>Relevance</u>	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre-Service Teacher Groups								
Group1	23.37	2.51	25.09	2.79	24.31	1.40	24.52	1.34
Group2	23.11	1.50	24.60	2.10	24.24	1.26	24.66	1.04
Group3	23.16	1.86	24.75	2.53	24.30	1.64	24.53	1.52
Group4	23.70	1.47	24.30	2.51	24.25	0.73	24.11	1.27
Group5	23.35	2.14	24.67	3.05	23.64	1.47	24.35	1.25
Group6	23.80	1.57	24.80	2.89	24.00	1.60	24.31	0.95
In-service Teacher Group								
Group7	23.24	1.53	25.98	2.09	24.49	1.18	24.44	1.08
Group8	22.81	2.26	25.21	1.91	24.03	1.28	24.00	0.86

Table 4.4 shows the means of the sub-scale scores for each of the participant groups.

The mean scale scores for the Confidence, Enjoyment, Usefulness and Relevance measures reported in Table 4.4 are also graphed in Figure 4.1. Mean scores are joined in Figure 4.2 for ease of inspection and the horizontal scale is expanded to show the trends. Inspection of the means shows little variation for each of the four sub-scale scores across the groups the first time they were measured, that is, Groups 4 and 6 are not included because they were much smaller than the original Groups and therefore may have biased the results. It is also clear that the lowest means for every group are on the Confidence sub-scale with means around 23. As the mid point of the scale is 24 (possible score range is 8-40) this result is just on the negative side of the mid point. All the other scores are just above the mid point. The pattern is shown clearly in Figure 4.1. Scores for Confidence and Relevance are consistent across the groups. There is a dip for Usefulness in Group 5 (first years just beginning science) and the highest scores tend to be for Enjoyment, especially for the in-service teachers (Groups 7 and 8). Note that Figure 4.1 has a large vertical scale which accentuates the differences between the groups.

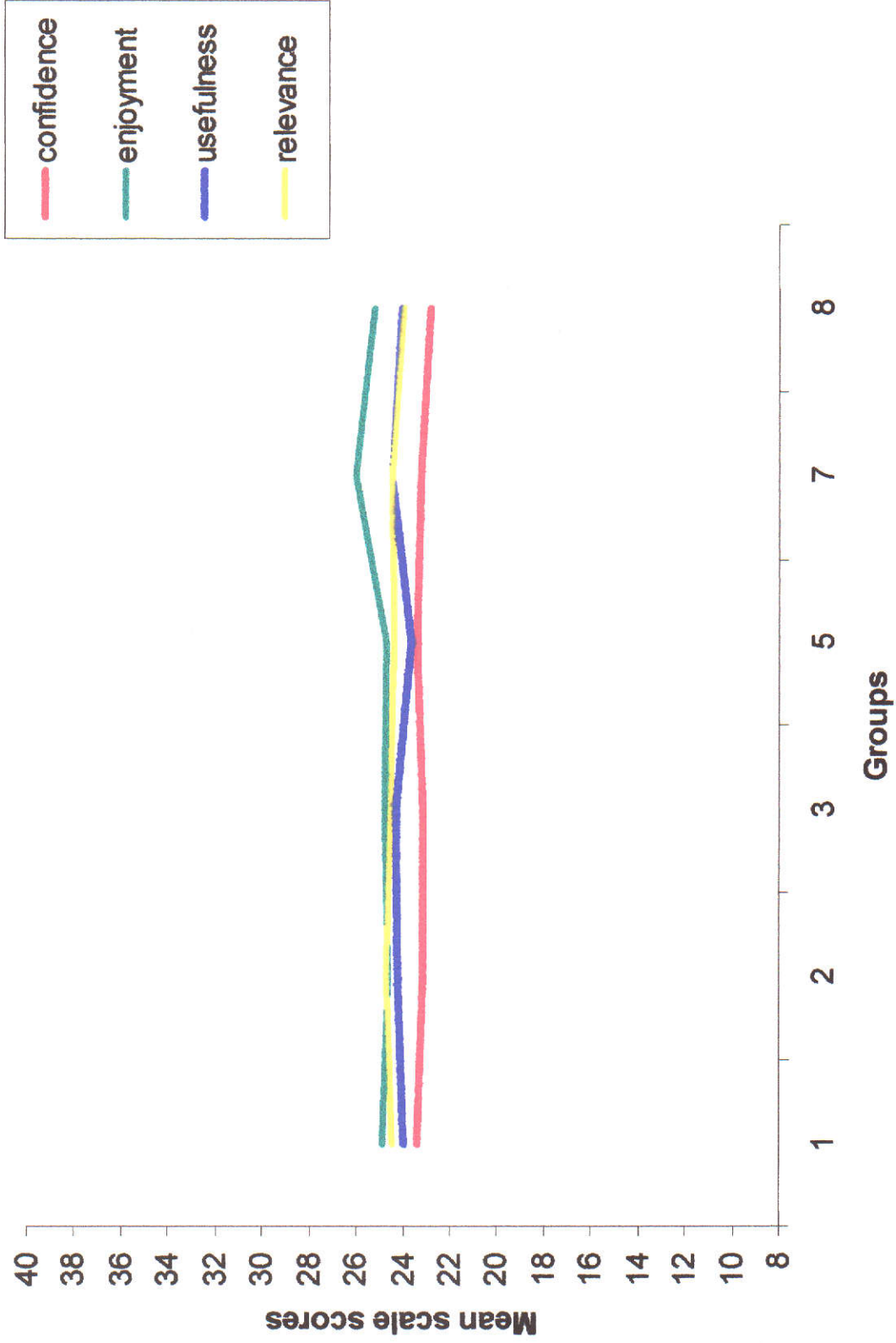


Figure 4.1. Graph showing mean sub-scale scores for each non-repeating group.

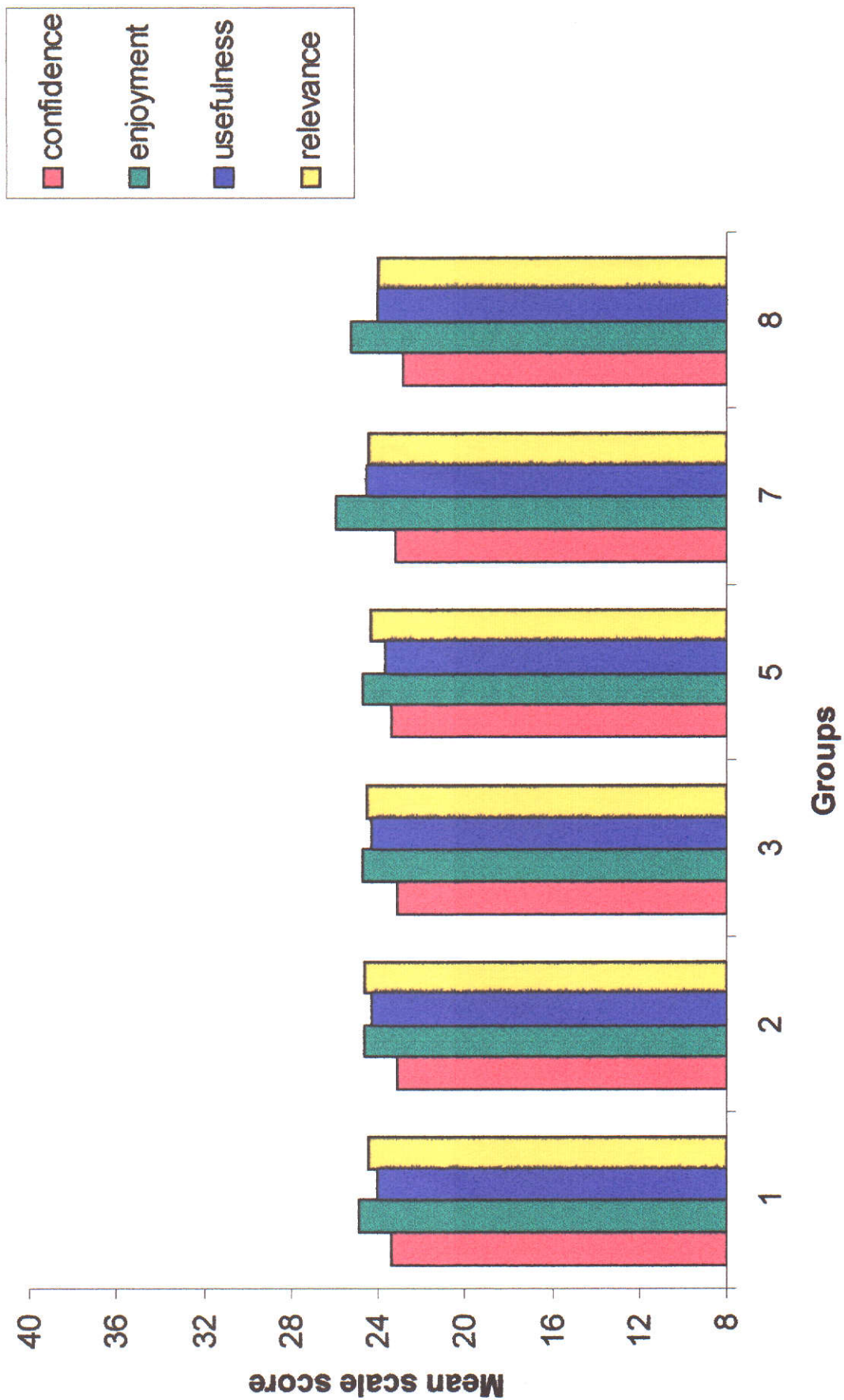


Figure 4.2 Bar graph of mean sub-scale scores for each non-repeating group.

A different overview of the results is given in Figure 4.2, which is a bar graph with a vertical scale equal to the possible range of scores, 8 - 40.

This graph allows an easier comparison of the patterns of sub-scale scores within groups, where as Figure 4.1 emphasised trends in sub-scale scores across groups. Figure 4.2 shows a very similar pattern for groups 1 and 5, which are the two first year pre-service groups (see Table 4.2). The patterns for the two in-service groups of teachers Groups 7 and 8 are also similar, although different to the others, with almost identical means for Usefulness and Relevance.

Overall, however, it can be seen that the differences between the groups are trivial, and that Enjoyment is generally the most positive and Confidence the least but overall, there are no clear trends.

Comparison with Coulson's (1992) Results of Pre-Service Teachers

It is interesting to compare the overall results with those reported by Coulson (1992). Because the present scores are so similar, scores are averaged over Groups 1, 2, 3 and 5 for the comparison, that is, the scores representing the first or only administration of survey. The means and standard deviations are reported in Table 4.5, together with effect sizes for the difference between the means. The effect sizes were calculated using the within-group standard deviation as the denominator.

Table 4.5

Comparison of Means between Coulson's Study and the Present study

Sub-scale	Coulson's Scores		Groups 1,2 3 and 5		Effect Size
	Mean	SD	Mean	SD	
Confidence	27.39	5.01	23.26	2.06	0.88
Enjoyment	26.76	5.84	24.79	2.64	0.83
Usefulness	28.65	5.05	24.12	1.46	2.14
Relevance	28.85	4.52	24.51	1.29	2.66

Two features are of interest. First, Coulson's results are more positive, around 2 to 3 points more positive. This is shown clearly by the effect sizes. Second, the present study has remarkably small standard deviations, especially in Usefulness and Relevance. There is no obvious reason for this finding, but as the data were collected

in different Universities in different States, many reasons could explain the differences, including differences in science taught at high school, and different criteria for university selection. However, the results do emphasise that attitudes to science held by the groups in the present study are generally not positive.

Comparisons between Groups

The differences between the means of the groups in the study were compared statistically using analysis of variance. First, a MANOVA was conducted on the four sub-scale scores by the four non-repeated pre-service groups (that is, Groups 1, 2, 3 and 5). There were no significant differences between the groups ($F_{12,588} = 1.02, p=.43$). As expected, univariate ANOVAs calculated on each of the sub-scale scores again showed no significant differences between the groups. A similar MANOVA calculated on the two teacher groups and the four non-repeated undergraduate groups also found no significant differences between the groups ($F_{20,1056} = 1.46, p>.05$).

Mean scores for the two cohorts which had repeated the survey were subjected to dependent t-tests and the results reported in Table 4.6. Unfortunately, not all the subjects completed the questionnaire on the second presentation, so the calculation was performed on a sub-sample of 28, and 44 students (groups 6 and 4 respectively). This may have biased the results because it might be expected that the subjects who reacted more positively to the program would have been those more likely to have completed the second questionnaire. Hence these comparisons must be treated cautiously.

Table 4.6. shows that on all but one sub-scale, Confidence, the mean difference is negative, that is, there was a decrease in the attitude score between administrations.

Table 4.6

Means, t Values and Effect Size for Groups Repeating the ECEAS

Sub-scale	Group	Mean of sub sample	Repeat Groups	Repeat Mean	Mean Difference	t	Effect Size
Confidence	1	23.67	6	23.80	0.13	0.32	.08
	2	23.16	4	23.70	0.54	1.92	.17
Enjoyment	1	26.67	6	24.80	-1.87	-2.54*	-.89
	2	24.35	4	24.29	-0.06	-0.11	-.04
Usefulness	1	24.88	6	24.00	-0.88	-1.48	-.37
	2	24.31	4	24.25	-0.06	-0.26	-.21
Relevance	1	24.50	6	24.31	-0.19	-0.59	-.46
	2	24.65	4	24.11	-0.54	-2.61	-.43

* $p < .05$

Paired t-tests were calculated on the sub-scale scores for each of the repeated groups (ie. groups 1 and 6 and groups 2 and 4). The resulting t-values and effect sizes are indicated in Table 4.6 . For Groups 1 and 6 the largest effect size was associated with the difference in Enjoyment. A statistically significant ($p<.05$) decrease in Enjoyment is indicated by the participants on their repeat survey. The other effect sizes are smaller and differences are not statistically significant with this sample size.

Responses to Biographical Items from ECEAS

The ECEAS had a number of biographical items on which comparisons with other variables could be made. These included items about sex, category of student (such as mature age entry) and subjects taken at high school. There were insufficient numbers of male participants to make comparisons with females. The item identifying the respondent as mature age or not, was inappropriate for teacher groups however, a comparison was made between science taken at high school and ECEAS scores.

The science taken by participants at Years 11 and 12 was recorded and is summarised in Table 4.7. It can be seen that the most common response was that the participants had taken either the Biology or no science in their years 11 or 12. Chemistry was the next choice taken by around 10% of the students. Clearly these participants do not have a strong science background from high school.

Table 4.7

Subjects taken at Year 11 or 12 Level in High School

Subjects taken by pre-service teachers	Group 1 First year general science	Group 2 Second year curriculum & general	Group 3 Third year transition	Group 4 Third year all	Group 5 First year (no science)	Group 6 Second year general no curriculum	Group 7 Kindergarten teachers	Group 8 Junior Primary teachers
Biology	61 (54.0%)	37 (67.3%)	24 (51.1%)	30 (68.2%)	9 (75%)	13 (46.4%)	21 (48.8%)	17 (53.1%)
Chemistry	6 (5.3%)	5 (9.1%)	5 (10.6%)	5 (11.4%)	1 (8.3%)	3 (10.7%)	5 (11.6%)	7 (21.9%)
Geology	2 (1.8%)	1 (1.8%)	3 (6.4%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	1 (3.1%)
Other science	7 (6.2%)	1 (1.8%)	1 (2.1%)	1 (2.3%)	0(0.0%)	4 (14.3%)	3 (7.0%)	0(0.0%)
No science	37 (32.7%)	11 (20.0%)	14 (29.8%)	8 (18.1%)	2 (16.7%)	8 (28.6%)	14 (32.6%)	7 (21.9%)

Students who had not completed any science subjects in Years 11 or 12 did not differ significantly in their ECEAS scores from students who had taken at least one science subject, $F_{1,223} = .02, p = .90$. This finding differed from Coulson's (1992) study of first year pre-service teachers. She found that mean scale scores for students who had studied science to year 12 were statistically significantly higher than for those who had not studied science in their senior years. Thus it can be concluded that taking science at school is not reflected in different attitudes as measured in this study.

Summary of Responses to Open Ended Items from ECEAS

ECEAS also contained two open-ended items which asked participants to comment about their feelings towards science. Usually just a word or a few words were written in response, but some participants did not respond at all to this section. The comments were tabulated and samples are included in Appendix 4.1. They were examined for trends or patterns of responses reflective of the participants' attitudes to science. Two obvious overall trends are described in this paragraph while other patterns are considered under each year level grouping. First, it was apparent that although the items required the participants to comment about how they felt about science per se, over half the respondents restricted their comments to their high school experiences of the subject. These included comments expressing a hatred of physics and enjoyment of life sciences or blaming high school science for their present negative attitude. Perhaps understandably, many of the pre-service teachers confused the question "how do you feel about science in general?", with the General Science subject encountered in Science Education and their responses were typified by comments such as "chemistry was interesting and fun, usually it is not that exciting", "disliked learning about machines", "liked General Science" or "General Science was a waste of time". Second, it seemed that as the pre-service teachers advanced through the science education components of their course, their comments became increasingly centred around science pedagogy, an interest also reflected by in-service teachers.

Group 1. First year students with General Science, 1992 (n=113)

There were 61 nil responses to the open-ended items. Examples of other responses included, 10 responses indicating that science was interesting, six liked practicals/experiments and two expressed a hatred of science. Other responses referred to specific subjects such as "prefer biology" (7).

Group 2. Second year students with Curriculum Science, 1992 (n=55)

The responses indicated a change of perception of science. For example the term “confidence” was used by six respondents, along with “enjoyed learning” (7). Seven participants did not respond to the open-ended questions.

Group 3. Third year Transition with Curriculum and General Science, 1992 (n=47)

The examples of comments included “comfortable to teach” (3), “enjoyed teaching it” (5). Other positive references were also made to teaching and learning science. Three participants made no comments.

Group 4. Third year students with General and Curriculum Science, 1993 (n=44)

Once again the comments centred on enjoyment of learning and/or teaching science (24), with one student wanting to study the philosophy of science and another suggesting that children “love it”. Fourteen participants did not respond.

Group 5. First year students commencing General Science, 1993 (n=12)

This small group had experienced only one introductory lecture and workshop, and only five students responded. Those that did, indicate that they were very optimistic about it, for instance, three students reported gaining confidence, two students indicated that they would like to learn more, two students thought that science “improved knowledge.” It was unfortunate that the students had not been given any science content at this stage.

Group 6. Second year students, with General and some Curriculum Science, 1993 (n=28)

The comments from this group were similar to the students in Group 2. They indicated that science was becoming more interesting, particularly in comparison with General Science. Eight students did not record a response.

Group 7. Pre-school teachers, 1993 (n=43)

The comments of the pre-school teachers related almost entirely to teaching science to children. There were three blank responses to this item. Each response seemed to be unique to the individual concerned. The comments ranged from one word responses, such as “exciting,” to “can handle it at pre-school level”, “an important part of the pre-school program,” “we grow our own things, make compost, breed worms as well as learning about light; magnets etc and making mud bricks”, and “every child that I

have worked with has found science an exciting and valuable part of our program.” However, in other responses the teacher almost appeared to be asking for help, for instance, “staff need work shops on science curriculum with experiments to do with children.”

Group 8. Junior Primary teachers, 1993 (n=32)

Responses were given by 29 teachers. The comments made related to working with young children and personal experiences of science. There were three references to positive in-service programs, and eight references to teaching hands on science and problem solving. One teacher complained that there was a lack of equipment. Two others felt that they had poor science experiences at high school which they didn’t wish to pass on to their classes. One teacher said that: “high school science was boring—felt put down by boys...science should encourage girls as much as possible”. Another teacher said: “prefer natural science.” Only one teacher noted her experience with nature science during her pre-service studies. Another stated that she gained confidence in physical science when she was expected to teach science to four other classes.

In the introductory letter, which accompanied ECEAS, teachers were invited to make any additional comments about science that they considered appropriate together with their ideas about the attributes of a good science teacher. The teachers’ responses were recorded on the back of some surveys. Their comments have been compiled and are presented in Tables 4.8 and 4.9. The responses indicate that some teachers were willing to express their opinions towards science with young children.

Table 4.8.

Summary of Kindergarten Teachers' Ideas about the Attitudes Held by a "Good" Science Teacher.

Kindergarten teachers comments about attitudes of a "good" science teacher

"Curious, resourceful, patient, good questioning techniques, love of science, knowledge of science. Knowledge of science, a learner themselves".

"A good science teacher is one who encourages her students to observe, hypothesise about situations and outcomes, investigate properties of objects and develop skills in recording and displaying information".

"Attitude, Attitude, Attitude!"

"Science must be seen to relate to human level of feelings and language".

"I am fascinated by discovery. I want to know why, how, why not."

"At school it was for exams. School science tended to be boring (as I remembered it) but when I started at Teacher's College (CAE) it was for your own knowledge. The teacher was fantastic and I fell in love with science for myself and young children. The teacher encouraged us to keep asking how and why. To this day, I idolise this man and his method of making discovery vital and exciting."

Table 4.9.

Summary of Junior Primary Teachers' Ideas about a "Good" Science Teacher.

Junior primary teacher's comments about the attitudes of a "good" science teacher

Promotes science subjects and topics as worthwhile.

Integrates science with other subjects.

Teaches students how to record efficiently.

Teaches the language of science.

Sees science in all areas as well as a specialised subject.

Sees herself as an active learner.

Understands capabilities of children.

Challenges children.

Understands many ideas concerning science.

Statements referring to problems with teaching science

Researching topics is time consuming.

Organisation and finding equipment.

Feeling bogged down with demands from other subjects - in particular, reading and maths.

Discussion

Overall, in respect to in-service and pre-service attitudes to science, including their levels of confidence and their background in science, the findings of ECEAS generally concurred with studies reported in the literature. Further, there was very little difference between the sub-scale scores for each group. The findings of ECEAS may also give credence to the notion that pre-service and in-service teachers who chose to teach in Early Childhood Education tend to hold aversions to science. The responses to the open-ended items were also generally consistent with the sub-scale scores although the open-ended responses from in-service teachers were more detailed than those of the pre-service groups. This finding may be explained in terms of the greater amount of experience reflected in the teacher groups.

The generally negative attitudes to science held by all groups may be attributed to a combination of their lack of confidence in their knowledge of science and skills in presenting it to young children, coupled with memory of negative experiences of high school science. It follows that the negative attitudes to science might also hinder in-service and pre-service teachers' ability to gain any additional knowledge about science. For instance, teachers mainly reported increases in knowledge, confidence and/or skills after they were forced to extend their ability in science by having to take greater responsibility in the area. It also appeared that such a *forced* increased knowledge of science ultimately increased their level of confidence in the subject. Three teachers mentioned the impact of professional development (that is the provision of information about science to in-service teachers through workshops and conferences) as an influence on teaching science. Although this number is too small to allow generalisations to be made about the influence of professional development on attitudes to science, it does indicate that when teachers are provided with additional knowledge about how to present science their levels of confidence in teaching the subject are likely to improve.

It seemed that in-service teachers and in particular, Kindergarten teachers, enjoyed science slightly more than pre-service teachers despite their lack of confidence in it. Thus it may be likely that the lack of confidence was a stronger influence on their attitudes to teaching science than the enjoyment they derived from it. In respect to the term *enjoyment* it appeared that when responding to the open-ended items, pre-service teachers and in-service teachers used *enjoyment* to describe attitudes to their present science experiences, for instance, enjoyment of science at Kindergarten or enjoying Curriculum science. This point is interesting, as the items in the Enjoyment sub-scale of ECEAS only referred to secondary school science and there was no evidence

in open-ended responses to suggest that in-service teachers enjoyed the science taken at high school any more than the pre-service groups did.

There was no evidence from the Groups with repeated measures Groups (1 and 6, and 2 and 4) that more science necessarily influenced the attitudes of pre-service teachers towards the subjects, indeed Enjoyment seems to have slightly decreased, perhaps because the students did not enjoy filling out another survey! However the low response size of the repeat groups may have biased the results. The response size for the repeated Group 6 cannot be attributed to attrition alone. It is also possible that the students who felt negatively about the subject did not fill out the survey. The response size for Group 5 possibly was also small because the first year students were still uncomfortable with the University, its expectations and staff and were suspicious of anything asked of them.

There was also no evidence to suggest that General Science was having any positive influence on pre-service attitudes to science, perhaps because it was not related to classroom teaching and therefore the pre-service teachers were dismissive of it even if they enjoyed aspects of it. It was likely that General Science was wrongly placed in the order of science education subjects. The responses to the open-ended questions from the transition year students who took General Science in third year, rather than during their first year of science education, were a little more positive than those of their first year colleagues. It is possible that the first year students lacked the maturity to realise the potential advantages of gaining additional knowledge in science whereas third year students were able to find some value in the subject.

It was interesting to note that the findings from ECEAS suggested that there was no link between attitudes to science and the amount of science subjects taken at high school. In contrast, the responses to the biographical question about science taken at high school suggested a link between the memory of science subjects taken at high school and present attitudes to science. For instance, teachers who had left high school 15 years previously could still recall feelings about high school science, including a fear of exams.

It is unfortunate, in respect to the development of attitudes to early childhood science education, that the findings of ECEAS were not able to be directly used in planning the science education subjects taken at university.

It was particularly worrying that mean scores on the sub-scale for Confidence remained consistently low for both pre-service and in-service teachers. There seems little reason

to believe that science will be taught effectively and consistently to young children when teachers lack confidence in how to present it to them. The low level of confidence experienced by teachers may in part explain their preference for topics related to Biology. It follows that if teachers lack confidence in an area, they may be more likely to only teach familiar aspects of it. As many teachers studied Biology at high school, they might be more prepared to teach it (or nature study) rather than an aspect of physics that, according to their open-ended responses, they rarely encountered or understood. In view of the available literature, it also seems reasonable to link the popularity of Biology with the fact that almost all in-service teachers were female. It has been well documented that Biology has been a science subject that has been traditionally preferred by women. It also follows that young children may be mainly familiar with experiences in natural sciences and that in following the role model of their female teacher, girls in particular, may be influenced towards Biology from an early age.

The term “hands-on” was mentioned frequently in the open-ended responses by pre-service and in-service teachers alike, and it is possible that they perceived science with young children to be a practical, activity based subject. However, the fact that science was considered to be a hands-on subject does not necessarily mean that it was always taught in that manner, or indeed that it was taught at all. There has been considerable discussion about the correlation between attitude and behaviour (Kiesler, Collins & Miller, 1969) and as an instrument which measures attitudes, ECEAS cannot be expected to provide definite proof that science is taught. On a more positive note, it is likely that teachers, particularly in-service teachers who made time to respond to the instrument, did present science through the provision of at least some hands-on activities.

The in-service teacher comments in Tables 4.8 and 4.9 suggest that some teachers have a high level of expectation as to what makes a “good science” teacher. Likewise, a number of reasons for not teaching science were documented. Both sets of comments indicate that science may be seen as a difficult subject to teach. However, as the short sentence answers were not sufficient to give an in-depth picture of attitudes in science, and the instrument selected only measures responses from pre-service and in-service teachers, it is also important to examine the results of the qualitative data from academics, teachers (in-service and pre-service) and children. These results will be reported in Chapter 5.

CHAPTER 5

RESULTS OF QUALITATIVE DATA FROM ACADEMICS, TEACHERS AND CHILDREN

The previous Chapter reported the results of the ECEAS questionnaire administered to pre-service and in-service teachers, and the present chapter reports the qualitative data obtained from all groups in the study: academic staff, pre-service and in-service teachers, and children. The data, obtained through interviews and observations over a four year period, provided information about the background of the subjects, the attitudes that they held about science education and, where applicable, their attitudes to teaching science.

The report of qualitative results has been arranged in two parts. The first part of the Chapter comprises data obtained from interviews with adult subjects and is divided into three sections. Section 1 describes information contained in audio-taped interviews with academic staff, section 2 describes information obtained from field notes of interviews with pre-service teachers and section 3 describes information obtained from field notes from interviews with in-service teachers. Each section explores the backgrounds and attitudes to science of each group as well as the factors that influence its members to promote the teaching of science to young children.

The second part of the Chapter concentrates on around 120 children's responses to science. It describes the results of video-taped sessions of pre-school children participating in science activities, as well as field notes about interviews with their teachers. It also contains summaries of Junior Primary children's written work from science lessons and field notes made during general classroom observations. The purpose of collecting data from children was to obtain information on how some children respond to science lessons and the effect of the teacher's behaviours on their responses.

Attitudes of Academic Staff

Seven of the eight staff involved in teaching mathematics, science and science education to the pre-service teachers were interviewed. Three of the academic staff (Tom, Annette and Maria) were not directly involved in teaching science at the time of the interviews despite a keen interest in the subject. They were interviewed because they supervised Early Childhood students on teaching practicum, and had continual contact with them over a three-year period. Unlike the science staff, they had qualifications in Early Childhood Education and were employed as general educators in the Institute. The staff who taught science education forwarded their pre-service teachers' assessment results to one of Tom, Annette or Maria. The other four academic staff interviewed (Debbie, Don, James and Doug) taught science education, either General Science, Curriculum Science, or both, to the Early Childhood pre-service teachers. Depending on the rotation of lectures and assignment to laboratory or workshop groups, they saw the pre-service teachers on a weekly basis over a period of time that ranged between one and three semesters.

Attitudes of Early Childhood Academics

Apart from teaching mathematics, Tom, Annette and Maria had the following points in common. They had been encouraged to explore their environment during childhood and recalled an early interest in mathematics and science. Despite these interests, they had generalist backgrounds, and did not specialise in mathematics and/or science until well into their careers. Tom, Annette and Maria all trained as teachers and had a variety of teaching experiences. They joined the University after teaching ten years or more in other areas and undertook a number of duties apart from lecturing in mathematics. All three were enthusiastic about mathematics and science, they stated that science was still not well taught in Pre-schools or Junior Primary schools and that teachers often taught the subject on an ad hoc basis. For instance, Tom said,

In child care [science is] - not much more than growing carrot tops. It's at a superficial level - it's see what happens [to the carrot tops].

Same in Kindergarten [pre-school] they think it's not necessary to plan science, it's hit and miss. The children who are interested probably get it from elsewhere. It [science] gets so integrated with other stuff that it doesn't exist

In the Junior Primary there must be some brilliant teachers of science, but mostly they seem to be people working recipe book science. Opposite extreme to Kindergarten. Science needs to be put into a context of learning.

(Tom, interview transcript, 1994)

Tom, Annette and Maria perceived science and mathematics as subjects which could be slotted easily into the school curriculum and were particularly interested in how children learnt science and mathematics as well as general theories about learning. Annette summarised their attitudes towards teaching science and mathematics when she contended that pre-service teachers needed both “competence and confidence” in science and mathematics, that is, competence at the level at which they would teach, rather than in tertiary level maths or science.

All three claimed that they had very little influence on the attitudes held by the pre-service teachers, for instance, they said,

Our students hit barriers during teaching practice. The teachers tell them that our theory is impractical. They [teachers] have a poor perception of what we do.

(Tom, interview transcript, 1994)

I just think that its, you know, feel as if I thought I was a great influence on students. I'd like to think I was but I think the reality is something quite different.

(Maria, interview transcript, 1992)

Despite reservations about influencing attitudes Tom, Annette and Maria still attempted to challenge their pre-service teachers' attitudes and knowledge by talking with them, sharing their own enthusiasm and providing a variety of experiences for the pre-service teachers to try. These academics felt that the teaching community in general had a sense of fear and misunderstanding of mathematics and science. For instance,

With science I've been rather disappointed to find that where there's a science specialist in the school, the science is removed from the classroom and also sometimes the classroom teacher has expressed relief that science is being done elsewhere by somebody else. And to me it's a terrible pity because it's really almost putting into a category that you go into a laboratory to do science, in that you go into the science room to do science. It doesn't happen anywhere else and teachers quite often seem surprised if you say, Oh! what a lovely science experience those children are having when they are engaged in cooking something, teachers sometimes look at you quite blankly and say Oh! but they're doing maths.

(Maria, interview transcript, 1992)

Understandably, Tom, Annette and Maria also felt that teachers in schools wanted a specific guide as to what to teach.

In respect to improving pre-service teachers' attitudes to teaching science, Tom, Annette and Maria were of the opinion that the three semesters of science education

were having an influence on the students' level of confidence and ability to teach science. However they were unconvinced about the influence of General Science on first year pre-service teachers. Tom particularly noted that,

The best group [of students] though were the ones that have science and maths all muddled up in order [reference to transition students]. Probably because the first years are operating in a vacuum, they have a lack of curriculum knowledge and understanding of how their own attitudes can impact upon it.

Attitudes of Academics Teaching Science Education

There were few common responses from the academics who taught science education. Consequently, the individual responses of each lecturer are summarised and presented as small case studies.

Science Education Lecturer 1 — Debbie

Debbie taught General Science (background science in biology, physics and chemistry) and Curriculum Science (methodology of teaching science) to Early Childhood Education pre-service students. She had attempted chemistry experiments in primary school and recalled that she seemed to be the only person in her family to have a strong interest in science from childhood.

Debbie felt positive about high school science, where she took general science, biology and astronomy. In Year 12 she was "inspired" by a female teacher to understand the "relevance of science to everyday life". Debbie studied science at tertiary level as part of a primary teaching award and later regretted not having the opportunity to study physics. Her interest in science continued and after graduating she specialised as a science teacher, and then as a project officer in science, later joining the University. Although she found the area of science education to be exciting, she claimed that she did not yet feel entirely confident in all aspects of it. Debbie said that she enjoyed the reaction of both children and students to science. For instance,

I've always enjoyed seeing kid's reactions to science because they get so excited and they don't want to stop, they want to explore further and I think that always made me feel even better towards science. Because of how they reacted because you can see that it's something that they are enthused about. Yes I guess that affects my attitude in a way although I've always enjoyed it myself.

(Debbie, interview transcript, 1992)

Debbie also maintained that many pre-service students had poor science experiences at high school and felt negative towards the subject. She aimed to try to motivate the pre-service students to improve their science backgrounds, to develop an interest in science, to find it fun. She contended that if the students enjoyed science they were more likely to provide the children that they taught “a better chance in science”. Debbie claimed that she did not have a definitive answer for encouraging students in science, as all were individuals, with specific needs. However, she always encouraged students in hands-on activities and group work. Through practical classes, she had observed that students from different cultural and geographical backgrounds approached science in different ways.

Debbie felt that the pre-service teachers taking their third year of science were more responsive to the subject and she hoped that she’d been able to influence them in terms of the methodology they would use in schools, choice of resources and enjoyment of science. Although sometimes, when observing students teaching “poor” science lessons, she realised that this didn’t necessarily occur.

When referring to in-service teachers, Debbie maintained that the quality of science taught was closely related to how “comfortable” they felt with the topic. She felt that in some clusters of schools, in-service teacher attitudes towards science had been improving but she remained challenged as to how to change the attitudes of other teachers who remained indifferent to science teaching, regardless of the availability of ideas and resources in the area.

Science Education Lecturer 2 — Don

Don taught General Science and Curriculum Science to pre-service teachers in Early Childhood Education. He recalled memories of his own primary school science, such as collecting insects, and had developed an interest in agriculture. He studied mathematics and science at high school with mixed results and particularly disliked chemistry. As a tertiary student, Don enjoyed university life and took a degree in Agriculture.

On leaving university he obtained work with a chemical company but did not enjoy aspects of it, for example, entertaining clients, the effects of chemicals on health. His voluntary work with a Boy Scout group inspired him with the idea of becoming a teacher. After obtaining teaching qualifications he taught a variety of secondary school subjects including Agricultural Science. After several attempts Don obtained a position as lecturer in Natural Science and gained experience in teaching Secondary, Primary

and Junior Primary pre-service students. Later he transferred to another teacher training establishment and commenced a master's degree.

Don sounded confident of his ability in science and mathematics and enjoyed working with other colleagues. He also enjoyed working with teachers on a consultancy basis and stated that more could be achieved with in-service teachers, in a shorter period of time, than could be achieved with pre-service teachers. His attitude was evident in the statement:

Teachers demonstrate their appreciation much more than pre-service students but that may be just the teachers. The group [of teachers] that I have almost every year in the semester break, are just so grateful for what you do for them. It's incredible. And maybe they see its application much more than the students do. I've always liked to feel that I'm very classroom oriented. I've always had practical application in the class and it works. That's what I feel about the students, I think. With the students, they like my classes, I usually do very well on the relationship. (Don, interview transcript, 1992).

Don talked enthusiastically about establishing a centre for excellence in science. He maintained that it was necessary to provide both pre-service and in-service teachers with a long term series of science programs and stated that:

I don't believe that we're training the students for when they first get out of training and have to survive in their schools. And they suddenly discover they can teach, they can control a class, they can do all the things a teacher does and they say, "Oh, this is boring, I do the same thing year in and year out. Now what can I do to make it better for me and the kids?" And they think back to when they did science and think maybe I should try some of that. That's what I believe we're training them for.

(Don, interview transcript, 1992)

In terms of pre-service teachers, Don considered that General Science was correctly placed in the first year of the teaching award and maintained that the third year students were the most responsive to science education. In his role of lecturer, Don placed an emphasis on helping students to understand the content of the science.

And I'm very concerned, I think it's obvious to the students when they don't understand things I spend a lot of time going over stuff they don't understand.

Therefore I'm positive that as a university lecturer I'm too much a teacher. So that within the general science our students write things in their diaries like "Don spends a lot of time helping us understand the ideas".

(Don, interview transcript, 1992)

Science Lecturer 3 — James

James taught General Science to Early Childhood Education pre-service teachers. He had spent much of his childhood in parts of the Northern Territory and northern South Australia in what he called an "unstructured environment" and enjoyed natural science explorations. He had also enjoyed working with electrical equipment from an early age and was considered good at mathematics and physics at high school. He believed that his positive memories from childhood guided the development of an interest in geology and environmental science at tertiary level. James enjoyed tertiary work having joined the University after spending a few years as a professional geologist. Although he had no formal training, James was interested in education and its associated philosophy and methodology. He placed a heavy emphasis on the notion of childhood experiences shaping learning.

As a natural scientist I was very keen on the whole environment studies movement of the seventies because it seemed to mimic best the kinds of experiences I had with children. As a lecturer in natural sciences I saw part of my duty to give people experiences in zoology. The problem is that as soon as you institutionalise things which originally happened naturally, you develop another agenda and I think in the long term, at least, you can't engineer people's childhoods, but given a variety of experiences and the role of education really is to fill in the things that you can never possibly know about, and maybe it needs to offer students more opportunity to develop the numeric side, the writing side, the formal side.

(James, interview transcript, 1993)

James tried to provide students with skills in critical thinking, and encouraged the Early Childhood pre-service teachers in General Science to have a wide range of science experiences, and difficult problems to solve. However, he did not believe that this made up for what he considered to be a lack of childhood experiences in science.

Science Lecturer 4 — Doug

Doug taught General Science and, on occasion, Curriculum Science to Early Childhood Education pre-service teachers. Doug had studied science intensely at high school. The subjects that he had taken included mathematics, physics, chemistry and biology.

His tertiary studies included a bachelor's degree in botany and zoology, followed by master's degree in taxonomy and botany. He joined the University as a biologist after completing several years of teaching in a secondary school and later obtained a PhD in virology. Like James, Doug did not often teach pre-service teachers and was initially unsure what to expect from the Early Childhood students.

Certainly they didn't know much, quite basic things, but general knowledge mostly.

(Doug, interview transcript, 1993).

However he found that the students were "fantastic once they got over that initial fear."

He stated that the pre-service teachers were keen to work in General Science and he encouraged them to try to attempt problems, to think they experienced success thereby gaining confidence in science. Doug found that the third year (transition) students were more willing to learn than the first year students. He attributed this to their practicum experience, in which they saw the purpose of being able to teach science to young children. Doug stated that it was important that science was presented in a hands-on fashion and believed that the students would repeat the science that they tried at university when they were in schools. He felt that it was important to "push the students on" to try to overcome their lack of confidence in science. He recommended the idea of using the scientific method but did not expect that he would particularly influence the students,

If you don't know something, let's find out. It's the method they can manage. It's very hard to get that over to kids who are going to be teaching a little bit of science in the school not much of the time. If you get one or two to improve that's all you can hope for.

(Doug, interview transcript, 1993).

The lecturers in science education responded to the interview in various ways. Some talked at length while others answered the questions briefly. Those who were trained specifically in science, rather than in teaching, provided shorter responses, but like the others, held definite opinions about the science that they taught to the Early Childhood Education pre-service teachers.

Summary

The academics who specialised in Early Childhood Education (Tom, Annette and Maria) placed an emphasis on encouraging pre-service teachers to become competent teachers. They were interested in promoting child development and general learning theories, in particular, theories related to the development of concepts in mathematics and science. They were not optimistic about pre-service teachers' willingness to teach science and mathematics after graduation. In addition Tom, Annette and Maria felt that they had very little influence over the attitudes of pre-service and in-service teachers to science and mathematics.

It appeared that all of the science lecturers (Debbie, Doug, James and Don) retained an enthusiasm and interest in science which they had developed early in life. They made references to tertiary science qualifications but had less formal knowledge of child development in the early years than their colleagues in Early Childhood Education. The science lecturers tried to influence the attitudes of the pre-service teachers by either role modelling methods in science teaching and lesson planning, openly stating their expectations or trying to encourage the pre-service teachers to feel enjoyment and success with the subject. They were also concerned about the level of science competency achieved by the pre-service teachers. The science lecturers seemed to assume that once the pre-service teachers achieved a degree of competence in science knowledge and teaching, then confidence levels would also improve. The science lecturers strived to establish a positive rapport with the pre-service teachers. Unlike their colleagues from the Institute, Debbie, Don, James and Doug did not supervise the pre-service teachers during practicum, nor did they have backgrounds in Early Childhood Education.

All academics interviewed expressed opinions about in-service teachers. Debbie, and in particular Don, appeared to be very interested in working with in-service teachers, finding them more responsive to their teaching, than pre-service teachers possibly because the in-service teachers responded both immediately and positively to their influence.

Attitudes of Pre-service Teachers

As mentioned in Chapter Three, pre-service teachers from each cohort were asked to volunteer to be interviewed about their attitudes to science education. Twenty-minute interviews were conducted with each volunteer student in the office of an academic staff member.

First Year Pre-service Teachers

Four first year pre-service teachers volunteered to be interviewed on completion of General Science (a compulsory background science subject that explored basic concepts in biology, physics and chemistry), two females and the only two male pre-service teachers taking the subject. The male teachers both reported that they had “played” with and repaired electrical equipment during childhood. Both males had at least two science subjects including Biology to year 12. They enjoyed the “practical hands-on” approach to science at tertiary level and expressed an interest in teaching science to young children. It was interesting to note that both pre-service teachers expressed the opinion that it was important to interview them as they were the only male students in the cohort.

Two female pre-service teachers were also interviewed. One expressed a hatred of science, and anger at the way that it had been taught to her at secondary school. She also felt that the tertiary General Science subject was not relevant to teaching. This pre-service teacher maintained that she would only teach science to children if she could make it fun. The second female student was classed as mature-aged. Although she recalled a farm background which allowed for “lots of childhood explorations” she had little formal experience in science.

All four pre-service teachers regarded the academics in science education as experts in science and mathematics. They also seemed to have high expectations of the lecturers and were critical of some of the lecturing styles employed. It was observed that the mature-aged pre-service teacher frequently would approach relevant academic staff for advice about science problems and sometimes even asked them for help in solving other problems in mathematics.

Second Year Pre-service Teachers

Eleven female pre-service teachers who had completed General Science and one semester of Curriculum Science were interviewed. Curriculum Science was a compulsory subject that instructed pre-service teachers about the methodology of teaching science to young children. It was taken over two semesters, one of which was during second year. There were no male pre-service teachers in the second year cohort. Four of the pre-service teachers interviewed were mature-aged. Although some recalled from their childhood, farm backgrounds, freedom to explore and supportive parents, the most definite recollections of science were from high school. Most of these pre-service teachers had taken Biology until year 12. One pre-service

teacher reported “hating maths and science” and refusing to take the subjects past year 10. Another took Biology only to year 11. One mature -aged pre-service teacher had little recollection of science at high school.

The pre-service teachers gave responses to the General Science subject that ranged from “enjoyable, confidence boosting, exciting hands-on,” to “some of it was good and other bits were a real turn off”. In contrast they all gave positive responses about Curriculum Science. They had developed ideas about the ways in which they planned to teach science, for example, by integrating science, teaching collaboratively, and aiming to encourage girls in science lessons.

If you feel comfortable and make it not scary for the children, they will enjoy it.
(Pre-service teacher 2:2, field notes of interview).

Comments were also made about how the pre-service teachers perceived the way that in-service teachers taught science. The comments appeared to be based on recent practicum experiences and thus were influenced by the teacher with whom they had been placed. For instance, if they had been placed with a teacher who modelled how to teach science, they generalised that all teachers were interested in science. Conversely, if the teacher with whom they were placed showed indifference to or dislike to teaching science, then they concluded that all teachers tried to avoid teaching science. Most pre-service teachers felt that teachers did not like to teach science perhaps because the teachers that they had encountered on their various placements had not taught science.

Transition Pre-service Teachers

Ten pre-service teachers from the transition group of students were interviewed on completion of the General Science and third year component of Curriculum Science. As mentioned in Chapter 3, these pre-service teachers were in transition between old and new course requirements and had to take General Science and the third year component of Curriculum Science concurrently in third year.

The only male pre-service teachers in the third year student population volunteered to be interviewed. He was also classed as mature aged. He had very little recollection of science-related activities during childhood. He had felt no affinity for science at high school and originally had trained as a social worker. This pre-service teacher reported enjoying Curriculum Science, and in particular the opportunity to teach it during practicum. During practicum he volunteered to teach science and deliberately

“extend himself” from teaching situations in which he felt safe to untried areas in science teaching. He felt happy about the idea of involving parents in science lessons. This pre-service teacher believed that teachers didn’t enjoy teaching science; but that children were really excited about it. He further observed that teachers appeared uncomfortable with the noise level of the science classroom. The pre-service teacher definitely planned to teach science when he began his own teaching career as he viewed it as practical and enjoyable. He believed that his attitude had changed from seeing science as something which was irrelevant to “not so scary, demystified, something that kids enjoy”. In this context, it is important to note that a video segment about children doing science, was later made at the Kindergarten where this pre-service teacher had been appointed as Director three years after graduating in Early Childhood Education. The Kindergarten had a reputation for teaching science and for strong parental involvement.

The nine female transition teachers who volunteered to be interviewed gave responses that fell into several categories. Their recollections about childhood science revealed that five of the pre-service teachers talked about a childhood that was spent “exploring the environment” while several others remembered family members who encouraged them to try science-based activities in their childhood.

Four pre-service teachers found high school science “interesting”, and took science subjects to year 12. Two others claimed that all high school science was “boring” and found it “threatening”, while two more reported liking aspects of science such as practicals and agricultural science.

All pre-service teachers reported they enjoyed Curriculum Science, finding it useful, relevant or practical. There were mixed feelings about General Science that ranged from “irrelevant” to “comfortable” and “interesting”. Five of the pre-service teachers believed that Early Childhood teachers were not interested in science. Five of the female pre-service teachers expressed a desire to teach science, while two other students were willing to teach science by integrating it with other areas of the curriculum.

The pre-service transition teachers had varied experiences about teaching science during their practicum. Those who had taken the opportunity to teach science tended to try out ideas learned during Curriculum Science. The science academic staff noted that in Curriculum Science classes the pre-service teachers sometimes asked for clarification of science terminology that they had difficulty using with children, for instance, a common point of confusion involved the classification of fruit and vegetables.

Third Year Pre-service Teachers

Six female students who had completed General Science in first year, and Curriculum Science in second and third year were interviewed.

They had little recollection about childhood experiences in relation to science. All of the students had memories of high school science until Year 11 and the subject most enjoyed was Biology. For instance,

Biology was realistic and got me better marks, and I felt more positive about it all.

(Pre-service teacher 3:1, field notes of interview).

Collectively, the third year pre-service teachers' attitudes to high school science were: that it was too difficult, boring, unrealistic, not enough hands-on experiences, assignments one after the other, "nothing different" that is, experiences of non varied routine science curricula.

Their comments about science at University suggested that while some aspects of General Science were interesting, it was usually regarded as "irrelevant" to their teaching award. All their responses to the second and third year Curriculum Science were positive. The Curriculum Science was perceived as interesting, and providing many ideas about teaching science to young children.

For instance, one pre-service teacher said

My attitudes to science have changed because we have to look at science from a child's perspective rather than an adult's.

(Pre-service Teacher 3.3, field notes of interview).

Report of Third Year Teaching Practicum

Twenty seven third year pre-service teachers who elected to specialise in teaching science during the teaching practicum (that followed a semester of Curriculum Science) were interviewed during their placement in 10 metropolitan schools. All the pre-service teachers had experienced Curriculum Science and several of the pre-service teachers had already been interviewed about their attitudes to science. The pre-service teachers were interviewed to find out if their attitudes to teaching science were influenced by their experiences with children. Field notes were made of the pre-service teachers' experiences in teaching science, the comments of their supervising teacher and references to the children's responses to lessons. As such, this section of the Chapter provides information from in-service teachers which also relates to the following section on attitudes of in-service teachers.

The schools that hosted the students for practicum covered a range of socio-economic backgrounds, from state schools in lower socio-economic areas to both state and private schools from wealthier localities. The schools had various arrangements for science teaching. In some cases the Principal or Deputy Principal oversaw the teaching of science, in other schools there was a specialist science teacher (a teacher who was denoted to have specialised skills and was often responsible for teaching science in the school usually from a "science room"). Other schools left the teaching of science to the classroom teacher (who taught all subjects).

The pre-service teachers planned a series of science lessons in discussion with their supervising teacher. The science taught ranged from physical to natural science with some students planning and leading excursions in science. The most popular science topics appeared to be minibests (snails, caterpillars, slaters), other animals and the beach.

The attitudes of the pre-service teachers to teaching science on practicum were positive in that the majority of pre-service teachers reported that they felt confident and had experienced varying degrees of success in teaching science. For instance, the three pre-service teachers at Indigo School reported experiencing difficulty in coping with the demands of the school in terms of classroom discipline. At the suggestion of their teachers, they chose to teach science during activity time (in which groups of children work on selected activities such as painting, drama, construction). Although these pre-service teachers were experiencing success in teaching both physical and biological science, they still felt that they lacked the confidence to teach science to the whole class.

Apart from being very willing to describe in detail the lessons taught and the reactions of the children to the lesson, many pre-service teachers commented favourably about the Curriculum Science that they had taken at University, stating that they were able to apply directly much of the Curriculum Science to the classroom.

There was no apparent difference noted between the type of school (eg private or public) and the pre-service teachers' success in teaching science, however, there seemed to be more emphasis placed on science by the schools located in upper socio-economic areas. Five of the schools allowed the pre-service teachers to work directly with the specialist science teacher. Pre-service teachers in other schools taught science under the guidance of classroom teachers.

Although the teachers themselves had mixed feelings about science, which ranged from dislike to disinterest, they were all highly appreciative of the pre-service teacher's science lessons. For example, the Year 2 teacher at Yellow School expressed an intense dislike for teaching science. She claimed that it was "messy and difficult" to allow the children to pursue problems and in order to teach the subject as well as possible, she had developed a series of topics which she repeated each year. One classroom teacher at Green School reported that her student had "inspired her to re-look, think and develop a constructivist's approach". A Year 3 teacher at Green School regularly published articles in science journals and was referred to with pride by other in-service and pre-service teachers in the school.

The specialist teachers were also receptive of the pre-service teachers' input to the science program in the school and tried to encourage and support them, as teachers of science, by providing them with positive feedback and allowing them to try different activities and approaches. The specialist teachers had various attitudes towards their fellow teachers, for instance, the specialist teacher (male) at Blue Junior School who had the role of in-servicing other staff in science, felt that the other female Junior Primary Staff were lacking both in confidence and knowledge. In response, he developed a program that emphasised physical science (the teachers were more prepared to teach nature science) and was careful to model interactive methodology. He also felt that the children whom he once perceived to be disinterested in science, were slowly changing their attitude.

The administrative staff (Deputy or Principal) from five of the schools expressed an interest in developing science throughout the school. Some also maintained that they were extremely confident in the ability of staff to teach science, others were more diffident. For instance, the Principal of Red School was very interested in teaching science and held that when a teacher expressed an interest in specialising in science she should be encouraged. However, this principal also felt that very few teachers, in her experience, had this ability or "spark". She defined a "spark" as the teacher showing a prolonged interest and willingness to learn along with the children, to touch, feel and handle spiders, ants, etc, as well as physical science and technology (computers).

Summary

It appeared from the references they made to subjects taken at high school that many of the pre-service teachers had already developed negative attitudes to science or had chosen not to study it further. None of the pre-service teachers expressed a depth of enjoyment of science similar to the academic staff, and some expressed an intense

dislike for the subject. With the exception of those in Transition year, most pre-service teachers reported that although aspects of General Science were fun, the subject bore little relevance to teaching, whereas they found the ideas and activities presented in Curriculum Science to be enjoyable and relevant to teaching. The third year pre-service teachers interviewed seemed to have developed some confidence in themselves as teachers of science during their course and expressed a willingness to teach it in the future. It is important to note that although the pre-service teachers appeared to enjoy Curriculum Science, there was no evidence to suggest that their attitude had changed to science per se because of this experience.

In terms of practicum experiences, the feedback these pre-service teachers obtained from their supervising teachers seemed to greatly encourage their enthusiasm for science teaching although it was likely that since the pre-service teachers had elected to teach science they probably felt a little positive about it beforehand. It also appeared that although the majority of the supervisory in-service teachers did not have positive attitudes to science they were interested in what their student teachers were presenting. Those in-service teachers who were interested in science often seemed to hold positions as specialist science teachers. It was sometimes difficult to discern from their comments, the administrative staff's attitudes to science.

Attitudes of In-service Teachers

In this section, the results of interviews with in-service teachers are reported. These include information from teachers who taught in Pre-school/Kindergarten, a sub-group of exemplary teachers and a sub-group of exit or recently graduated teachers in their first year of teaching. As mentioned in Chapter 3, the latter group may provide a link between the influence of science education at University and in-service teaching.

Exit or Graduate Teachers

Six students who had completed their teaching award at the end of third year and had taken a teaching position were contacted. Information was obtained from these first year out teachers referred to as exit students. The responses indicated that all taught science. Two of the respondents tried to integrate science as much as possible into other areas. All the respondents noted that the children asked many questions, that required many science activities to help them find answers. One respondent noted,

It was fantastic, the children always wanted to know more and do more of the activities. Much of the science taught was because children asked questions eg., How come the shoots are coming from the plants? How come the tyres go round?
(Graduate teacher 4:1, field notes of interview).

Despite the fact that one teacher had most of her science lessons taken by a specialist teacher, all six reported that the children enjoyed and were interested in science. They, in turn, seemed to be excited about the children's reactions. They stated that they felt confident about teaching science to children and had drawn on information obtained during Curriculum Science, for instance:

Throughout high school I hated science. Even the word made me cringe! I think that it was due to the way every thing was presented to us, eg., lots of notes that had little relevance to me, and teachers who did not explain things clearly. Having seen at college some great ideas for teaching science to children, I have gained quite a different perspective. In addition, seeing how positively the children respond adds to the pleasure of teaching it. I also love to learn with the children.
(Graduate 4:2, field notes of interview).

Kindergarten Teachers

Six kindergarten personnel were selected at random from a short list provided by Maria, one of the Early Childhood lecturers. The list comprised in-service Kindergarten teachers (Directors or head teachers) who had a reputation in the Early Childhood Department for teaching science in their Kindergartens. When contacted, each agreed to be interviewed for the study. The interviews were conducted with the Director of the Kindergarten who had overall responsibility for full time programming and teaching. However, on several occasions, the other Kindergarten staff also sat in on the interview.

Each Kindergarten Director interviewed had a stated interest in science and contended that it was a subject that was taught easily and readily to children. For example, the Director of Yellow Kindergarten professed to have a strong interest in science and particularly the environment. She recalled that her science lecturer at college frequently quoted "that there were good nature experiences and bad nature experiences and as a teacher you had to get dirty and tackle everything". The Director of Yellow Kindergarten held the opinion that her childhood experiences with the outdoors, combined with her teacher training and experience with children, sustained and developed her attitudes towards science. She also felt that science was easily taught

in an unstructured fashion to both children and parents, providing that the teacher was aware of how to take advantage of every possibility for learning to occur.

The Directors also had a firm belief in the necessity of encouraging their teachers to teach science. One male Director insisted that female staff taught science in order to present positive role models to children. He also attempted to encourage parents to be involved in the science program by asking them to contribute materials, sending home science ideas, and asking the parents to help small groups of children participating in science activities at Kindergarten sessions.

In the majority of Kindergartens, nature science seemed to be the dominant science presented. Two of the Directors appeared to have science programs that covered a range of physical science topics, such as magnets, bubbles, rust, use of kitchen utensils and Lego construction. In contrast, the Director of Green Kindergarten preferred science that was taught out of doors. She felt that it was extremely easy to interest the children in science as it was a subject that lent itself to all aspects of the curriculum and since scientific knowledge was often changing, it was wise to learn along with the child. Her favourite ideas centred around keeping animals. She believed that although most teachers felt compelled to tell children the answer, she contended that it was more important to ask questions to prompt the child to investigate further. This Director also felt that the local Science Centre was beginning to influence parents' and children's attitudes to science through promotional material.

The Kindergarten Directors seemed to consistently value and apply their knowledge of child development and also placed importance on parental involvement in the child's learning. The Director of Indigo Kindergarten published some science ideas in her Kindergarten's Newsletter to encourage the interest of parents in science. She believed that the staff of most preschools would teach some science because it related to the curriculum and the child's needs so strongly. She also recalled that much of what she practised had been taught to her at training college. The Director was prepared to learn along with the child, ask questions and utilise the expertise of various parents and visitors. Often she would introduce science-related information to the children and they would be told "you'll learn a lot more about this when you get to school".

In addition to the Directors, two Regional Coordinators were contacted and interviewed. A regional Coordinator was responsible for the standard of curricula provided by Kindergartens in a given area. Consequently, the Coordinators were familiar with the amount and type of science presented in their regions. Both Coordinators believed that the science taught in Kindergartens was biased towards

the “natural sciences” (that is, Biology). One Coordinator suggested that the style and type of science being presented to children had not changed for many years. The other Coordinator indirectly supported this notion by indicating a favourite science book which she encouraged Kindergarten staff to use. The book was from a series of science books which were thirty years old! Other information obtained from the interview suggested that areas such as technology, or gender issues, were not often addressed at Kindergarten, or in the case of gender and science, not recognised by the staff.

The Coordinators were also of the opinion that with the exception of a small number of Kindergartens, teachers felt a lack of confidence in the area of science, there was little evidence in programs that science was being addressed.

Exemplary teachers

A small sub-group of teachers were identified who had an intense interest in science from an early age and maintained it through all their years of formal schooling as well as throughout their teaching career. Ultimately, they had taken a position which enabled them to specialise in, or oversee the presentation of, science to teachers and children. When talking of their backgrounds in science, they frequently mentioned enjoyment and also indicated that the subject was very important to them. They held strong beliefs about teaching science to children and were able to articulate ways in which they influenced teachers to present science to children. For this reason they were categorised as a sub-group called “exemplary teachers.” It was considered important to interview these seven teachers to see whether they had attributes that set them aside from other teachers.

Teacher 1 had a background in Junior Primary teaching and, at the time of the study, held the position of science project officer. She maintained that that most teachers were aware that children enjoyed science, but didn’t know where to start teaching it. In her opinion a good science teacher was one who

- was perceived by her peers as active in science,
- was able to articulate ideas about science,
- was able to initiate science programs,
- continually emphasised and promoted science within the classroom,
- demonstrated a sound knowledge of resources and materials,
- taught a related sequence of lessons; and
- was prepared to acknowledge where kids were at.

Teacher 2 was the Director of a large pre-school which took children aged 2 - 5 years. The teacher had recently completed the University's science program. She stated that a good teacher of science needed to have

- enthusiasm,
- a love of children,
- a sense of fun,
- enthusiasm for life,
- a willingness to prepare, investigate, explore, play and learn along with children, and
- a view of science as a big part of the learning environment of the child and an integrated part of mathematics and language.

Teacher 3 was a specialist science teacher who had a long history in teaching junior primary science. She also held the position of president of the local primary Science Association. She believed that a good teacher of science needed basic competency in behavioural management and curriculum development as well as willingness

- to let children make their own discoveries and understandings of the topic,
- to encourage children to take risks,
- to treat children with respect when correcting misconceptions, and
- to question and extend gifted children.

Teacher 4 was a former academic with a strong interest in junior primary teaching. He was a free-lance consultant in science teaching, and president of the local Nature Club. His main interest was in the area of natural and environmental science. He believed that

- science teachers needed to be given confidence in taking children out of doors,
- science educators must be wary that their own science background and knowledge did not "scare off" prospective science teachers,
- science educators needed a well-formed conservation ethic, and
- it was important for science teachers to impart a sense of wonder in children, as well as a questioning attitude towards the environment.

Exemplary Teacher 4 also felt that children could better understand themselves if they learnt to "love" and appreciate other creatures.

Teacher 5 was the Deputy Principal of a large Junior Primary School and specialised in teaching science. She reported being heavily influenced during her tertiary studies by Exemplary Teacher 4. Teacher 5 had been a founding member of the local Primary Science Teachers Association and had studied with many teachers who had a profound interest in science. She suggested that teachers generally found science

- too hard, and they lacked knowledge or time to teach it,

- unenjoyable, and
- something that could be taught to them for a financial profit via a professional development program.

Teachers 6 and 7 worked as science officers in a Science Centre. They both had extensive academic qualifications in science. They reported that teachers didn't know how to use a science museum but expected to find hands-on activities there. The science officers were of the opinion that the centre was best used when both teachers and children had set pathways to follow. They also liked to see the children return after a school visit and bring their parents. They further noted that children were enthusiastic about the science offered, but liked a change of approach and activities. The science officers tried to enhance the children's visits to the Science Centre by offering low cost in-service programs to teachers prior to their visit with a class and encouraging teachers to become involved enough to take out membership. In addition the science officers ensured that the programs offered to teachers were well organised. The science officers found that there was a notable difference between the attitudes of primary and secondary teachers to science. Teachers of young children were:

- tentative,
- cooperative,
- likely to see the museum as stimulating, but
- slow to change their awareness of science and mathematics.

Summary

With the low teacher employment rates experienced over the decade, it was difficult to determine if the pre-service teachers who stated a willingness to teach science actually ever had the opportunity to do so. However those who did obtain long term work and were interviewed as exit students appeared to enjoy teaching science. Like the pre-service teachers, these beginning teachers responded positively to the ideas presented in Curriculum Science but made almost no reference to General Science.

It was interesting to note that the list of Kindergartens provided by Maria were considered to be good, in that science was observed to be taught in them, however this did not mean that the science taught in them was always "good" or that the Directors necessarily had a reputation for being good science teachers. At least two of the Kindergarten Directors focussed their attention on teaching nature science rather than including a range of physical and nature based science activities. Indeed, the information provided by the Regional Coordinators indicated that a limited range of

science experiences were provided in Kindergartens. It was also interesting to note that the Kindergarten Directors placed an emphasis on child development in a similar fashion to the Early Childhood lecturers (Tom, Annette and Maria).

In general, the teachers (both pre-service and in-service) indicated that when children appeared to show interest, enjoyment and curiosity, the teachers derived enjoyment or satisfaction from teaching science. The supervisory in-service teachers also derived satisfaction from encouraging pre-service teachers to teach science. The interviews with teachers did not provide any direct evidence to support the statements of Tom, Annette and Maria that teachers supervising a practicum adversely influenced the pre-service teachers, although it was apparent that the pre-service teachers made strong generalisations about schools, teachers and methods of teaching science from their practicum experience.

The in-service teachers appeared to model their science teaching on information gained from teacher training or personal beliefs held about the environment. Some teachers recalled the influence of a specific academic. The in-service teachers regarded science with children as an active hands-on subject.

Like the science lecturers, the exemplary teachers interviewed had developed an interest in science in their early years that was sustained throughout high school and reinforced through tertiary studies. The enjoyment of science that was expressed by exemplary teachers also was similar to that of academic staff. It seemed that their interest in science pervaded their early years of work and they were able to use their interest in science to further their careers. The exemplary teachers had firmly established opinions about how a science teacher should behave, opinions that were perhaps understandably more comprehensive than the statements of teachers reported in Chapter 4 (in response to the open-ended items on the ECEAS).

Information from Children

In order to obtain information about children's attitudes to science, observations of them in class, video-tapes of their activities and written work compiled by children were collected and analysed. Pre-school children (aged 3 to 5 years) were video-taped with permission, doing science activities, but due to complications involved with gaining permission, Junior Primary children (aged 5 to 8 years) were not video-taped. Instead, their written material, comprising drawings and stories about science were collected. Both Pre-school and Junior Primary teachers were briefly interviewed at

the conclusion of the children's activities to gain their reaction to the children's responses.

Information from Junior Primary Children

After the teacher had introduced the topic under study, the children wrote or drew their responses to the topic. Two year levels discussed what science and scientists (Blue Class, Year 2/3 and Yellow Class, Year 3) were about, and the Red Class (Reception /Year 1 levels) wrote, or had the teacher scribe for them and drew pictures, after a series of lessons on seeds. The teachers were encouraged to introduce a topic that appealed to their class and to themselves. The teacher's choices resulted in, a simple assessment task on the affective responses of the children to lessons on seeds. Yellow Class produced a set of drawings about scientists because the teacher had read a number of studies related to the Chamber's (1983) Draw a Scientist Test and wished to attempt a similar exercise with her class. Although the other teacher rarely taught science, he also asked the class to draw their ideas about scientists and science after having a discussion about the topic.

Analyses of the written information collected from around all 90 children, revealed that children had a variety of ideas about science, which often appeared to be related to recent experiences. For instance, children's drawings and comments about science and scientists reflected the activities of a geologist, shortly after a film on dinosaurs had received considerable exposure.

Year 3 children's drawings

The children in Yellow Class described their drawings in these ways:

Rachel, 8 years, drew a picture of a tractor with a large scoop, uncovering bones. Underneath the picture she wrote, "Scientist on a tractor digging up a dinosaur."

Chang, 7 years, drew a man dressed in jeans, jumper and lab-coat, sorting bones and wrote, "this scientist has some of the bones of the Brontosaurus. The scientist has the head and body. The scientist is going to find the rest of the Brontosaurus".

The children's drawings also suggested that science was usually a hands on active subject with the scientist doing something, rather than standing passively. The drawings often showed the scientist in some form of costume, such as a raincoat, long dress, rubber boots or a jacket. Mary, aged 8 years, drew a picture of a scientist showing a woman in a long dress, surrounded by stoves and pots. Her caption read: "My scientist does potions at home! I don't like my picture."

James (7 years) drew a picture of a scientist in jacket, jeans and boots in a laboratory extracting gold from a rock and labelled the picture "gold scientist".

Sometimes the children seemed unsure of what a scientist was, for instance 8-year-old Stephanie drew a picture of a figure in black rubber boots, glasses and showing lots of teeth looking at a smaller person and saying: "She's lost a tooth-Yey!" "Dental lady". The children's drawings depicted both males and females as scientists.

In response to the children's written work the Year 3 teacher who indicated that he rarely taught science, seemed disinterested in the children's recordings, while the year 2/3 teacher, who frequently taught science appeared to be most interested in the children's ideas.

Year 2/3 children's drawings

The Year 2/3 children in Blue Class, drew similar styles of pictures. The year 3 children in the class wrote about their pictures by writing words and phrases such as "I love it. It is great" to "I hate rats", on their pictures. In general their pictures reflected the stereotypical image of a scientist in a laboratory with unusual hair, a lab coat, making explosions.

The children in Year 2 also drew pictures about science and scientists and wrote about them.

This scientist does birds on my picture. The tools are bird cages, nets and needles. (Luke, 7 years),

My scientist is working [at a desk]. He is writing about how the energy in his legs make him walk. (Jed, 7years)

My mad scientist is creating alphabet lightening. (Tyson, 7 years)

My scientist is a mad scientist. She is a lady and is wearing overalls.

(Amanda, 7 years)

My scientist is a lady. She is doing an experiment with water. She is seeing the things that float and the things that don't float. (Natasha, 8 years)

It was interesting to note that the girls often drew pictures of female scientists and the boys always depicted images of male scientists.

Their teacher expressed disappointment at the children's drawings and comments, apparently she expected that the children would depict scientists as people who were caring for the environment. She particularly expressed disapproval of the term "mad

scientist." This teacher was extremely interested in natural science and the class was regularly involved in some form of science and, in particular, plant propagation and bird conservation programs on a daily basis. A sample of the children's drawings is included in Appendix 3.6.

Reception/Year 1 children's drawings

Following a series of science lessons the children in Red Class, a reception/year 1 (a reception class comprises children in their first 12 months of Junior Primary School) painted pictures of their work and their verbal comments were written down and attached to the bottom of their drawings by the teacher.

The scribed captions included:

I feel happy when I do science. I am writing about a seed. (Kylie, 6 years)

I am happy when I do science (and sometimes mad when things don't work out).
(Michel, 5 years)

That's my seed and it's growing underground. I feel happy and excited when I do science. (Serena, 6 years)

Although the Reception teacher tried to present interesting science lessons, she said that she preferred to teach technology. Nevertheless she appeared to be pleased with the children's ideas.

Summary of Responses of Video-tapes of Pre-school Children

The responses of pre-school children were recorded at three separate locations as they talked about or went on with the science activities provided for them by a teacher. In each location the children usually worked in groups on the activities for periods of time ranging between 5 and 30 minutes over a morning or afternoon session. The verbal responses of each group were transcribed and summarised to aid the analysis of data. The teacher's responses to the children's ideas were sought at the conclusion of each video-taped session.

Location One

Location One was a child care centre which provided a semi-structured programme for children between 2 and 5 years of age. The science corner (an area designated for formal science activities) was in an attractive, sunny room at the front of the centre. It comprised a large round table covered with plastic, seating for six children, bookshelves covered with children's science books, a tank of goldfish, a semi transparent container

which housed a caterpillar, an insect catcher and a magnifying glass. The walls were hung with large paintings of Australian animals made by the children.

The Director (who was exemplary teacher 2) explained that the topic selected for the first half of the term was Australian Animals and the children's art/craft, language and excursions had been centred around that theme. Although the Director appeared to have planned and showed considerable interest in the lesson sequence, one of the other teachers supervised the children during the video segments. The teacher stated that the purpose of the lesson was to revise the ideas formed over the past six weeks about Australian animals by making plasticine models of the animals. Two groups of children were video-taped doing the planned science activities with their teacher.

Group 1

Two boys and two girls aged 4 years were in this group. They appeared interested in, and kept glancing at the container of caterpillars sitting on the cupboard. They also smiled and pointed to their art work. The teacher showed them the plasticine and initiated the activity.

The children discussed Australian animals while making snakes, whales, elephants, a kookaburra and other animals from plasticine. They talked about snakes and expressed a fear of them. They commented on the caterpillar in the container. Boy 1 seemed to be afraid of caterpillars but also suggested that the caterpillar was afraid of them because it was very small. "I'm scared of caterpillars...they're scary. I don't like them because they make me scared" he said.

The boys referred to their families in their conversation. One related a story about his father and a snake. They also talked about a television program on animals. The group decided that "men" were able to work with animals. They talked about exploring, doing and making various animals including an elephant and galah bones. They expressed an interest in catching animals "with a net" "its all right to catch mice". One boy stated that he made things from plasticine for girls..... "birds, snails and puppies".

The girls were slower to participate in the conversation, and were invited by name by the teacher to join in. The teacher interacted with the children at various intervals. She tended to question the children about animal facts, possibly to keep them to the topic. It appeared that without the questions asked by the teacher, the topic of conversation would change to something not relevant to the activity. The teacher's

questions were initially directed mainly to the boys, who, dominated the conversation. Towards the end of the session she addressed the girls, however, by this stage one of the boys had left the group.

In general, the group displayed a knowledge about the structure of animals. They appeared more interested in baby animals or animals that they could touch. There seemed to be a mismatch between the teacher's questions, which apparently were aimed at eliciting a specific response, and the children's conversation, which seemed to deviate to pets, their family and general interest. After fifteen minutes most children seemed to lose interest in the activity and were sent outside to play.

Group 2

A group of three girls and four boys aged between 3 and 5 years of age entered and sat in the area that group 1 had just vacated. The same teacher started the discussion by talking about the animals in the pictures on the walls.

"Can you see the some of these big animals? A big kangaroo behind you!" she said. The children responded by talking about smaller animals such as joeys, snails and caterpillars. After ten minutes the composition of the group began to change as several of the boys went out to play and two others joined in. In response to their references to caterpillars, the teacher allowed them to take the caterpillar out of the plastic container and touch it.

The girls seemed to be able to maintain equality of action and conversation with the boys. One girl eventually dominated the conversation. The children were hesitant about touching the caterpillar. The teacher allowed them to hold it and examine it through a magnifying glass. Two children thought that the magnifying glass allowed the caterpillar to grow. The others thought that they were seeing two animals. They became extremely excited and jostled for a turn with the magnifying glass until the caterpillar moved. Then the children displayed a mixture of fear and excitement. Four-year old Amy said:

"Go on. Put it over the edge. Oh it moved over my hand (laughter)." "Be gentle, let Sam have a turn. It's Sam's turn now Amy. Can you share it with Sam? Good." said the teacher.....

"Don't"! said Amy, to the crawling caterpillar.....

"Hurry, hurry". Sam said to Amy.

One girl hit the table behind the caterpillar with a ruler to make it to move across the table. At the teacher's suggestion they reluctantly replaced the caterpillar in the jar and covered it with leaves and bark.

"I put the caterpillar in because he was tired", said Amy.

The agenda of the teacher changed from talking about native Australian animals to following the children's interest in looking at the caterpillar. The teacher encouraged the children to observe the caterpillar. She was also concerned with the notion of "sharing", "taking turns" and handling the caterpillar gently, "be gentle, children". The teacher and the children did not discuss the needs of the caterpillar. A transcript from Group 2 has been included in Appendix 3.6.

Location Two

Location 2 was in a noisy area adjacent to the kitchen of the preschool section of a child-care centre that catered for children aged between 3 months and 5 years. There was also a constant movement of parents and children through the area. In this location, three groups, each comprising four children (aged 4 years) were video-taped in sequence as they participated in activities with magnets. The children were seated at two small tables which were placed together and covered with two sheets of thin cardboard. Four magnets with large coloured handles were placed on top of the cardboard, along with two margarine containers housing an assortment of magnetic and non-magnetic materials.

Group 1

The teacher called two boys and two girls inside and asked them to sit around the table. The children tentatively picked up the magnets and the session lasted approximately fifteen minutes.

The teacher dominated the activity. Her attention was particularly directed to the girl sitting her right hand side. The teacher asked many directed questions. She also repeated some of the children's responses as in support of conversation.

Teacher; "What's in there? Is it picking them up? What's picking them up? "

Eric: " A magnet"

Teacher : "A magnet"

Teacher: "Does it pick up everything that's here?"

The group seemed quite interested in playing with magnets. It was difficult to tell if they all listened to the questions of the teacher as the boys in the group seemed to be engrossed in exploring the magnets. When one of the boys attempted to show the teacher what he had been doing, the teacher appeared not to notice.

Another boy had a worm in a milk carton beside him. Near the end of the activity, the teacher asked him to show what was in the milk carton. He spent five minutes elaborating on how to care for the worm. He appeared to be proud and caring towards his worm. Whilst he was talking about it, two of the children went outside. The remaining girl, sat silently and passively until told to go outside by the teacher.

Later, the teacher said that the children were very rough in the way that they handled the equipment and also explained that they needed considerable direction when involved in activities. She was pleased with the level of language used by the child with the worm.

Group 2

Again, two boys and two girls sat around a table as they had for Group 1. The teacher entered and sat by a girl. She explained to the children that they could find out about the magnets. The children began to try to pick up objects with the magnets. The teacher seemed to direct the activity by asking questions and often directed them to the girl sitting at her right. For instance:

Teacher: "What are you doing Monique? What are you doing?"

Monique: "I am putting it on there" [the magnet onto objects].

Teacher: "Why did you get it on to there?"

Monique: "So it can get there" [object stuck to magnet].

Teacher: "How did it get there? Can you tell me how it got there?"

The teacher asked a number of questions about magnets and generally dominated the group. The children either followed her directions or played with the magnets irrespective of the teacher's directions.

The magnets were of one type. They were backed with plastic and had one pole exposed. The children appeared interested in them. The teacher seemed intent on eliciting a response to her questions from the children as well as encouraging them to manipulate the materials as much as possible.

Group 3

A group of four boys were sitting around a table working with magnets, in the same fashion as groups 1 and 2. The teacher sat to one side and again directed her questions towards the child on her right. The children began to use the magnets.

Teacher: "Do you know what they're called? They're called magnets".

Children: "Magnets"

Teacher: "Why is it picking up the.....Michael, what do you think it is doing to yours? What about this truck? Do you find out that your magnet can pick it up?" The teacher indicated a small toy truck.

Michael: "No".

Teacher: "Yes. Okay. There are more different things on the paper. Try to pick it up. Do you know how, Michael? What about you, Luke, how do you pick them up?"

The teacher directed much of the activity by asking questions. She helped several children to manipulate the equipment. She appeared to be guiding the group towards observing the type and number of materials attracted to a magnet. The teacher also frequently repeated basic statements about the function of a magnet ... "it picks up things". The children responded in brief words or phrases such as "yes," "no," "it sticks to the magnet".

The children appeared to be following the teacher's questions closely and carrying out her directions. The group appeared to work together well and followed instructions.

In the interview, this teacher explained that it was her responsibility to decide on and incorporate the science activities into the "older children's programme". She tried to vary the activities as much as possible as well as the areas used. When the weather permitted, science activities were set up out of doors. The teacher reported that although she had enjoyed the Curriculum Science recently taken at University (with science lecturer Don) she had no particular interest or background in science prior to University. Her main area of interest was language. The teacher reported that she enjoyed interactions with the children. She also believed that there was no difference in responses between boys and girls to science activities.

The teacher noted that the groups of children who worked with the magnets had problems concentrating and she felt that their level of interest in any activity was "poor."

Location Three

Location 3 was a Kindergarten that catered for children for a year before they started school. The science equipment had been unpacked from a box labelled "Magnets" and was scattered on a series of tables near the wide open door of the Kindergarten. Under the direction of the Kindergarten Director (or head teacher), the science

one or two children at a time. Most children seemed interested in talking to him. When they did not wish to participate they either ignored him or walked away.

The children seemed to either work as individuals or cluster in small single-sex groups, with girls speaking to girls and boys to boys. The Director made no attempt to encourage the boys and girls to work together, rather he accepted the way in which each child elected to work with the magnets.

At the conclusion of the session, the Director talked about his beliefs about science and of strategies that he used to involve parents in science. His strategies included, inviting parents to special evenings where they were encouraged to try science activities, and to watch videos and photographic displays of their children participating in science activities. He also showed sets of science equipment that he and the staff had developed on a range of physical science topics, with the help of the parents.

Summary

The written work from the Junior Primary children indicated that they had formed attitudes about science that were influenced by both the media and their personal experiences of science. Clearly the idea that science was an active hands-on subject was reflected in the work of the Junior Primary school children. Many of the Junior Primary children also seemed to have firmly established ideas as to what a scientist did. The Year 3 children of Blue Class drew more stereotypical images of scientists than their Year 2 classmates. Moreover the children seemed to think that a scientist could be either male or female and tended to identify the sex of their scientist with their own sex. When given the opportunity, children were also able to express their feelings about science. In some cases, the children's ideas about scientists were not consistent with what the teacher believed they should be.

The Preschool children also seemed to have formed some attitudes about what they could do in science, and displayed curiosity, interest and enjoyment of their science activities. This may in part be attributed to the fact that they had the opportunity to work with unusual or interesting materials. It seemed that the 4-year-old children on video-tape possibly already held established attitudes, such as a willingness to investigate, which are traditionally linked with the study of science. In addition, the children exhibited confidence in stating their ideas and handling equipment.

CHAPTER 6

INTERPRETATION OF RESULTS

The present study evolved from an interest in obtaining information about attitudes to science from educators in Early Childhood Education in order to discover ways of improving the delivery of science education to young children. As mentioned in Chapter 1, the purpose of this study was to investigate the attitudes about science and science education of those involved in Early Childhood Education.

The study was generated initially from concerns about the negative attitudes to science held by many first year pre-service teachers and the potential effect these attitudes may have on the children that they taught. It focused on the backgrounds in science, the attitudes held by each group (academics, in-service and pre-service, teachers and children) to science and the ways in which members of one group influenced the members of another group. The study was unique in that although investigation of attitude is vital in research of the behaviour of teacher and student (Shrigley, et al. 1988), it was directed to an area in which little research had been carried out. Further, it examined the attitudes of adults as well as children.

The study was guided by general research questions which asked, what are the affective factors which influence the teaching of science to young children? Further, what kinds of attitudes to presenting science to young children are held and modelled by academics to pre-service teachers? What kinds of attitudes are held by pre-service and in-service teachers? What kinds of attitudes to science are modelled to children by teachers?

The study addressed the general research questions by the following more specific questions:

1. How do academics promote the teaching of science to young children?
2. What factors influence the willingness of pre-service teachers to present science to young children?
3. What are the factors that influence in-service teachers to teach science to young children?

4. How does the classroom teacher (pre-service and in-service) influence young children's responses to science at school? This question was addressed by asking how children respond to science and what effect the teacher has on the children's responses to science.

In this Chapter, the results of the previous two Chapters are drawn together to provide answers to these four research questions.

How do Academics Promote the Teaching of Science to Young Children?

Consideration of this question involves the perceptions of the academics about science and science education, along with pre-service and in-service teachers responses to tertiary science.

Perceptions of Academics

The results of interviews with academic staff reported in Chapter 5 revealed that the four academics who taught science to the pre-service teachers regarded the subject with interest, enjoyment and confidence. In addition they considered the knowledge of science and science education to be both personally useful and important in its own right. In view of the information from literature on teacher backgrounds in Early Childhood Education, it was somewhat ironic to note that the academics' formal qualifications in science also lay in the area of natural/biological science. However the academics expressed a keen interest in all aspects of science and from an early age had followed science-based pursuits.

Although the three other academics interviewed (Tom, Anna and Maria) expressed attitudes of curiosity, interest and enjoyment of science from an early age, they did not hold degrees in science nor did they choose to specialise in it. Rather, they perceived the knowledge of science to be an important part of a complete education and appeared to feel confident about their level of knowledge.

All the academics interviewed clearly expected that young children would ultimately be the recipients of the science education that the science lecturers (Debbie, Don, James and Doug) were presenting to pre-service teachers. However, analyses of the responses to the interviews found differences between the academics in the amount and type of science that they anticipated young children would receive. Debbie, Doug, James and Don, directly promoted the teaching of science to young children by the way that they presented science to pre-service teachers, and indirectly, because they thought that in

order to become good teachers of science, pre-service teachers needed to be given additional knowledge about science. In addition, Debbie and Doug had the most contact with in-service teachers and by updating the teacher's knowledge of ideas, methods and resources, facilitated the promotion of the teaching of science to young children. The academics believed that the majority of pre-service teachers had negative attitudes to science, such as lack of confidence, anxiety, and dislike of science, which often was accompanied by a lack of understanding of science content. It has been noted in Chapter 5 that the academics' beliefs were partially based on a number of studies about the attitudes of pre-service teachers, in particular the findings of *The Discipline Review* (DEET, 1989a), and also on comments made to them by the pre-service teachers themselves.

To try to counteract the negative perceptions about science of pre-service teachers, the academics responsible for science education promoted the teaching of science through subjects in Curriculum Science by encouraging pre-service teachers to become involved in practical hands on explorations, and to enjoy the science that they were taking part in. Terms such as "enjoy", "interest", "develop confidence" and "fun" were used by the academics, to describe the attitudes that they tried to promote in pre-service teachers through role modeling, questioning, and the provision of a supportive environment. The academics who taught Curriculum Science also ensured that the pre-service teachers had a repertoire of learning activities which could easily be replicated in a classroom. When teaching Curriculum Science, the academics emphasised the methodology of constructivism (that is, a theory that children construct their own knowledge from their experiences) and encouraged the pre-service teachers to learn along with children and to extend the children's knowledge by asking well considered questions.

In addition, the academics felt that the pre-service teachers should improve their background knowledge of science and become prepared to learn more about it, thereby improving their level of confidence and interest in the subject. The assignments and expectations listed in the subject outlines reflected their attempts to promote science with young children as interesting and achievable.

Debbie, Doug, James and Don attempted to present General Science to the pre-service teachers as a subject which was "relevant to everyday life". They attempted to give the pre-service teachers a wide range of practical experiences and problems to solve while at the same time encouraging the pre-service teachers to extend their background knowledge of science. They took turns to write units of work on specialised topics such as mechanics, biology, chemistry and time. The academic who was felt by the rest of the group to have the greatest expertise in a given area led the teaching with

the intention of providing the pre-service teachers with the best possible information. Annette, Tom and Maria (the Early Childhood academics interviewed) agreed with the teaching methodology used by Debbie, Don, James and Doug to promote science to pre-service teachers. They also reported that often in-service teachers did not have a clear idea as to what science was, taught it spasmodically or integrated it with other subjects but Tom, Annette and Maria also stated that they believed that academics in general had little influence over the attitudes of pre-service teachers.

Overall, Debbie, Don, Doug and James felt that the pre-service students had “quite a lot of catching up to do” in respect to learning science as well as presenting it to young children, hence they planned the science education subjects in ways that reflected those beliefs. They hoped that once joining the work force the pre-service teachers would, in time, teach aspects of science that they had learnt at university to young children. The seriousness with which the academics regarded their task was reflected in the time spent and detail presented in the planning of the subject. The overall methodology used by the academics when promoting science education, appeared to be a combination of knowledge-centred and child-centred models commonly used by teacher educators (Bearlin, et al. 1990).

Although individual academics placed different emphasis on the ways that they influenced pre-service teachers, the attitudes of the four academics who taught science education were consistent with their expectations that teachers (both in-service and pre-service) needed to provide children with a range of experiences in science. Debbie and Don, who had worked with teachers in the capacity of consultants, felt that teachers were more readily prepared to teach the science topics that they were comfortable with (Interview with Debbie), and that teachers easily adapted ideas presented to them at university into classroom experiences (Interview with Don).

Pre-service Teachers’ Responses to Tertiary Science

The information obtained from interviews with pre-service teachers in Chapter 5 and responses to open-ended items in the Science Opinion Survey indicated that they responded differently to the two science education subjects. The first, second and third year levels of pre-service teachers reported that although aspects of General Science were fun, they did not see the relevance of the subject, and thought that much of it was “boring” and “difficult to understand”. Their comments suggested that the academics’ aims for the subject, such as “to see science as relevant to daily lives,” were often not recognised, let alone achieved.

However, the responses of the third year transition students (who took General Science and third year Curriculum Science together) differed from the other year level cohorts, in that they viewed General Science to be “enjoyable” and “useful”. Interestingly, all academic staff in the study found the transition students’ responses to science education, and in particular General Science to be more positive than the other groupings of pre-service teachers and especially the first year students. The different responses of the transition students may be attributed in part to the intense amount of time per week spent on science, resulting in some transition students adopting the views of the academic staff. The notion of students adopting the attitudes of staff has been reported by Koballa (1988). It was also possible that as the third year transition group had studied both subjects together, the relevance of the material in General Science became clearer in the context of Curriculum Science.

The second year and third year students were more positive about Curriculum Science than General Science. They used terms such as “enjoy,” “fun,” “practical” and “able to teach” during interviews about the subject. In most instances, Curriculum Science was seen as a form of science that they could understand and present to children. In interview, the pre-service teachers also indicated a willingness to teach science to children, especially when they could integrate it with other areas of the curriculum. Also, the pre-service teachers who elected to teach science during practicum reported feelings of success and increased confidence in teaching science to young children. Some pre-service teachers suggested, on reflection, that participation in Curriculum Science aided their success in teaching science during practicum.

Responses of In-service Teachers to Tertiary Science

The interviews with in-service teachers revealed a range of memories about their pre-service education. Some could remember clearly the science taken during their teacher training, some could remember specific instances of science training, but others had no recollection of science taken during their training at all. It is important to note that the in-service teachers who remembered science, also remembered the specific academic who taught them, indeed the memory of the science learnt seemed interwoven with the memory of the personality who taught it. In addition, the amount of pre-service training remembered by the teachers appeared to be linked with their present attitudes to science. For instance, responses reported in Chapters 4 and 5 indicated that teachers who recalled ideas about tertiary science education, described and quoted the relevant academic and generally had instigated some of the academic’s ideas and attitudes into their classroom practice. One of the teachers interviewed was highly critical of his lecturer (who had left the university before the commencement of

this study) claiming that the information presented to him was outdated and of little use, but this response seemed to be an exception. Some teachers had been taught by at least one of the academics in the study and spoke highly of their efforts. Thus it seems that some in-service teachers were influenced quite strongly by their experiences with particular academics.

Similarly, the sub-group of in-service teachers, who were referred to in the study as exemplary teachers, reported detailed knowledge of the science they had taken during their tertiary studies and spoke fondly of the academics that they encountered. They recalled that the science that they had studied was an enjoyable experience, which proved useful in the classroom and was important for children to learn.

The exit/graduate teachers did not reflect on specific lecturers when reflecting on their commencing year of teaching, nor did they mention General Science. Instead, they recalled with "enjoyment" and "interest", the responses of their children to science. Consequently their memories of tertiary science focussed on the ideas that they had gained from Curriculum Science and it seemed sometimes that these beginning teachers were, through teaching, experiencing satisfaction with science for perhaps the first time. Their frequent references to Curriculum Science suggested that it influenced them to teach science.

Discussion

It was likely that each academic had slightly different attitudes to the ways of promoting science to pre-service teachers, and it was possible that due to differences in personality and teaching style, some academics were more effective in promoting attitudes towards the teaching of science to young children than others. For instance, although all of the academics held that it was important to have a knowledge of science, and tried to instil in the pre-service teachers some positive affective attitudes such as enjoyment, interest, and confidence; they each placed different emphases on the attitudes. Some academics believed that by providing the pre-service teachers with ideas on content and methodology, they would ultimately influence the information transferred to the classroom, while others felt that they had very little influence over the amount of science that the pre-service teachers might eventually choose to teach.

The pre-service teachers interviewed found that they enjoyed Curriculum Science and may have associated their sense of enjoyment with the academic staff. It was interesting

to note, however, that during practicum, the pre-service teachers gave precedence to the opinion of supervisory teachers over that of the academic staff. In general, the pre-service teachers did not enjoy General Science, perhaps because the subject was related too closely to subjects studied at high school or perhaps the subject did not seem to relate to the teaching of children and was therefore seen as less relevant. Whatever the reason, the academics were mainly unsuccessful in promoting the future usefulness and relevance of General Science, or instilling a sense of confidence in the pre-service teachers.

It was likely that the pre-service teachers responded more positively to Curriculum Science as it clearly had more relevance towards teaching children per se, that is the academic staff promoted ideas and methods that appeared to be workable with children. For example, in Curriculum Science the pre-service teachers had the opportunity to try simple activities drawn from a wide range of resources before using them in the classroom. In addition, the classes in Curriculum Science were perceived as non threatening and provided an environment in which they could build their confidence and willingness to teach science. In fact the recollections of some in-service teachers, and in particular exemplary teachers who recalled the personality of the academic staff who taught them science, suggests that the personality of the academic and their ability to establish rapport with their pre-service teachers may also assist in developing or reinforcing attitudes promoting the importance of science for young children.

It seemed that attitudes related to enjoyment of science and its relevance were the attitudes most likely to be influenced by academics. The comments of the pre-service teachers indicated that the activities presented in Curriculum Science caused them to consider how science could be fun and how it could be presented to children. It was possible that some pre-service teachers were stimulated to rethink their attitudes to science, having either experienced success in the completion of background science, or finding a great contrast between the two subjects.

What Factors Influence the Willingness of Pre-service Teachers to Teach Science?

Many factors, including the responses of pre-service teachers to tertiary studies in science, their backgrounds, experiences at university and teaching practice were considered in answering this question and they are addressed under several headings.

Influence of Background on Pre-service Teachers' Willingness to Teach Science

It could be said that the backgrounds of the pre-service teachers encouraged them to be unwilling to teach science. Their backgrounds in science at high school were well documented through interviews and the biographical items from the Science Opinion Survey and were indicative of a limited experience in science, consistent with descriptions from other studies, including that of Coulson (1992). Biology was listed as the subject most commonly taken at high school, although environmental science, botany, or indeed, any subject associated with the life sciences, was preferred to other science subjects. Difficulty was often expressed in respect to understanding physics and aspects of chemistry. It was often noted by the pre-service teachers that they disliked any subject that left them feeling inferior or "dumb," a feeling that was often associated with physics and chemistry. It could be inferred that, with the exception of aspects of Biology, the pre-service teachers found that science subjects they encountered at high school provided little motivation to teach science to children.

Interviews with pre-service teachers also indicated that little science was remembered from primary school, although some pre-service teachers from country areas recalled spending long periods exploring their environment and the opportunity to tinker with farm machinery. These pre-service teachers maintained that they responded positively to science education because they were prepared to "take risks" and "explore ideas".

Pre-service Teachers' Responses to Science Education

The interviews with pre-service teachers highlighted some positive attributes of the subjects in science education, while the analyses of the Science Opinion Survey from ECEAS suggested that overall their attitudes to science changed very little over their three years of science. The academics did not intend that General Science would directly influence pre-service teachers to teach science, rather it was intended that the subject would produce teachers who were more aware of the usefulness of science in daily life. General Science was not popular with the pre-service teachers, yet it enabled them to at least acknowledge their attitudes to science. The responses of the pre-service teachers indicated a full range of opinions about the subject. As indicated in Chapter 4, and repeated earlier in this chapter, responses included expressions of interest and enjoyment towards General Science, combined with references to boredom, difficulty and lack of confidence. It also appeared that some students were resentful

of the subject as they anticipated experiencing failure in it, just as they did at high school and therefore being made to “feel dumb” again. Similar findings were described in tertiary students by Belenky, et al. (1986). The few students who commented on laboratory work made positive statements about practical work, seeming to enjoy the hands-on aspect of the subject.

Curriculum Science was designed to encourage and to provide pre-service teachers with the mechanisms to teach science to young children. The pre-service teachers interviewed appeared to be willing to attempt to teach science. Investigation of open-ended items suggested that some pre-service teachers perceived that children “loved science”, that they felt “more comfortable” with Curriculum Science, and had “gained confidence” in their ability to teach science, although some felt that still more confidence was required. As with General Science, the pre-service teachers appeared to particularly like the hands-on aspect of the subject. There was little difference between the second and third year pre-service teacher responses to open-ended items of ECEAS. These findings are similar to those of Klindworth, et al. (1991) who found little change over time of pre-service teachers’ responses to science.

In summary, the pre-service teachers indicated from interviews and responses to open-ended items from ECEAS that they had learnt a little about General Science or had consolidated what had already been taught at high school. Some pre-service teachers also felt that they had a better understanding of science and how it related to everyday life, while others thought that their confidence in science had improved. The pre-service teachers also claimed that through Curriculum Science they had learnt how to teach science to children, what activities to give them and what resources and teaching strategies to use.

The Influence of Teaching Practicum on Pre-Service Teachers’ Willingness to Teach Science

As previously mentioned, one important influence on the pre-service teachers’ experience in teaching science during practicum was the supervising teacher. Interviews with pre-service teachers and their supervising teachers during practicum indicated that the pre-service teachers tended to generalise about teacher attitudes to science from their practicum experience. The pre-service teachers interviewed felt that their supervising teachers valued their ability to teach science and they appeared to gain confidence in teaching science (and possibly increased their self esteem) from the feedback that they obtained.

Some Principals and Kindergarten Directors took an interest in the teaching of science, and while these Principals may have encouraged the pre-service teachers in their endeavours to teach science or arranged for them to have additional advice about aspects of teaching or programming in science, it was unlikely that they directly influenced the pre-service teachers in any way. However as Kindergarten Directors had direct supervision of the pre-service teachers and spent time advising them in the development of programs, and child development in general, they were more likely to have the opportunity to influence pre-service teachers in the teaching of science.

When referring to the responses of children to science lessons, the pre-service teachers who were interviewed during practicum became quite excited and involved in describing the reactions of specific children and the general dynamics of the class. The supervising teachers reported on the planning carried out by their student teacher, the noise and behaviour of the children, and often noted the written work produced by the children either during or after the lesson. Both pre-service and supervising teachers seemed to consider the science lesson to be a success when the children were interested, enthusiastic and involved in the lesson via some form of activity.

Attitudes to Science on Leaving University

As mentioned previously, in terms of Confidence, Enjoyment, Usefulness and Relevance of science, as measured on the ECEAS, the attitudes of pre-service teachers to science altered very little. On interview, pre-service teachers frequently indicated a willingness to teach science, claiming it to be important for children; but also added that they intended to integrate science with other areas of the curriculum. This approach was mentioned by Tom as frequently seen in classrooms yet often done badly. Since the idea of integration was mentioned in curriculum documents, it was possible that the pre-service teachers found that it was a methodology often mentioned in other curriculum areas and one that was seen to be easy to adopt. As mentioned in Chapter 5, even commencing teachers with less than a year's experience in teaching mentioned using an integrated approach. Ironically the integration of science into other curriculum areas was not emphasised by academic staff who tended to spend time modelling the methodology of constructivism and sequential planning of lessons.

Other Influences on the Attitudes of Pre-service Teachers

The other possible influences on the pre-service teachers' willingness to teach science included the pressure of the peer group. For instance, the mature age students may have encouraged the other students about the importance of science and, as much of the practical work was carried out in groups, the interest and confidence of some

members were able to encourage the other members of the group. The pre-service teachers also spoke about their subjects with people whose opinion they valued, for example, boyfriends, peer groups and people in the workplace, and their responses may also have influenced the ways that the pre-service teachers saw themselves in respect to teaching science.

Discussion

It was likely that the pre-service teachers overtly viewed science education in the same way that they regarded the other subjects that they were required to take to complete their award in Early Childhood Education. They realised that in order to pass science education they had to fulfil attendance and assessment criteria so that they could continue to the next year level of their award. Many of the pre-service teachers brought with them to science education, feelings of low self esteem, a lack of confidence in and a dislike for science, coupled with anxiety about the subject itself and their own ability to cope with it adequately. Such feelings were manifested in comments about the lack of relevance of science, in particular General Science, and complaints about its complexity and dullness. Their feelings towards General Science to a large extent remained unchallenged, possibly because it seemed unrelated to children, and was still seen as similar to high school science. Both physical science taken at high school and General Science taken at University appeared to have an overall negative influence on the pre-service teachers.

When taking Curriculum Science however, the pre-service teachers were suddenly confronted with an aspect of science that they had not previously encountered, an aspect that was simple, readily understandable, enjoyable and directly transferable to children. Moreover, the academics who taught Curriculum Science were empathetic to varying degrees with their pre-service teachers' backgrounds and experiences in science. It seemed likely that the academics were most likely to influence the attitudes of the pre-service teachers during Curriculum Science as the pre-service teachers reconsidered their image of science. Certainly, the pre-service teachers appeared from their comments to be influenced through Curriculum Science, rather than General Science, to teach science to children.

The positive experiences of teaching science during practicum also influenced the pre-service teachers' willingness to teach science to young children. However, as mentioned earlier, less than 50% of pre-service teachers chose to teach science while on practicum. Although it was conceivable that those pre-service teachers who experienced success in teaching science during practicum already had positive attitudes

to science which were reinforced, they remained in the minority of the population of Early Childhood Education pre-service teachers.

It was also interesting to note that the supervising teachers placed more emphasis on the outcomes of the science lessons than the pre-service teachers did. It was possible too, that the positive responses of the supervisory teachers to their student's science lessons could be attributed partly to the teachers not wanting to teach science, or feeling anxious about science themselves. If so, it would be relatively easy for pre-service teachers to justify their reluctance to teach science by the fact that they had seen very little science taught and were therefore able to conclude that the subject was not rated highly.

Given that the pre-service teachers reported aversion to physical science, it was more likely that they would teach environmental science or science related to living things. In fact, these topics were often taught on teaching practice and were emphasised in some curriculum documents.

It was also possible that teachers in general, and in particular pre-service teachers, felt that they had a certain responsibility to teach science to children, and were drawn to strategies that presented science. It is possible that they perceived the process of integrating science with other subjects as comfortable in terms of organisation and methodology.

In sum, the major influences on the pre-service teachers' willingness to teach science included their past experiences of science, attitudes towards enjoyment and relevance of Curriculum Science, and positive experiences in teaching science during practicum that included the responses of the supervising teacher and children. The latter influences were likely to gradually increase the confidence and the self esteem of some pre-service teachers to science even if change was not clearly evident during the pre-service course.

What are the Factors that Influence In-service Teachers to Teach Science to Young Children?

The question is addressed by considering various influences on the teachers, including their backgrounds, secondary and tertiary experiences in science.

The Influence of the Background of the In-service Teacher

The early science experiences of the in-service teachers were similar to some of the pre-service teachers, in that they recalled exploring their surroundings with little restriction on where they went. There was also little mention of the science taught at primary school. Although all the in-service teachers who responded to ECEAS could be considered pro-science, in as much as they were prepared to provide information about their attitudes to science, the teachers who had the most positive memory of science from a young age fell into the exemplary category of teachers. The teachers' memories of formal science arose from experiences at high school, recalled during interviews and when responding to open-ended items from the Science Opinion Survey (ECEAS). Their memories often involved the recollection of negative attitudes, for instance; "the idea of physics still strikes terror in my heart" (Kindergarten teacher, Chapter 4), "high school science was boring— felt put down by boys" (Junior Primary Teacher, Chapter 4).

The Influence of Science at University

The group of exemplary teachers had a clear recollection of the science (mostly biological or science education) that they had taken at university. Other teachers also made reference to tertiary experiences in nature science. Some teachers made specific reference to the science lecturers that they had encountered, for example, one kindergarten teacher quoted in Chapter 4 described how the science teacher guided her to "fall in love with science for myself and for young children." Other teachers who emphasised the difference between high school and university experiences in science, indicated that learning about the curriculum methodology of the day made science relevant to them. It was interesting to note that no reference to practicum experiences by in-service teachers was ever made.

Influence of Teaching Experiences

The teachers had varying levels of success in teaching science. The exemplary group of teachers claimed to have taught it regularly, with great success, while at the same time deriving enjoyment and satisfaction from the responses of the children. Other teachers viewed the teaching of science in a variety of ways. The Kindergarten Directors interviewed preferred to teach nature science that is, the science of living things, partly in response to the interests of the children in their care, and partly because they were interested in it and held this aspect of science to be important. In the results from the open-ended items (ECEAS), the Kindergarten Directors stated that they taught science

because they enjoyed the process of teaching it, they liked the simple activities used when teaching science with children, they felt comfortable with the level of science presented at pre-school and/or they believed that it was an essential part of the curriculum.

The Junior Primary teachers suggested that teaching science was considered worthwhile as it promoted problem solving skills and could be integrated with other subjects, that the hands-on component was enjoyable for both teacher and child, that confidence in teaching science was gained when they were placed in situations in which they had to teach science, perhaps as a specialist teacher, and that nature science was a more comfortable subject to teach than physical science.

It was also interesting to note that some teachers felt that aspects of the preparation of science lessons, such as obtaining equipment, finding time to research topics, and organisation of activities made science difficult to teach. They also felt that subjects such as reading and mathematics commanded a large percentage of the curriculum and left little time for science. The written resources that were noted by the teachers were in the form of curriculum guides. As reported in Chapter 4, Junior Primary and Pre-school teachers maintained that an effective teacher of science should have some specific attributes, which included the ability to teach the language of science and effective recording skills, the ability to understand the capabilities of children and challenge them, as well as the ability to understand many ideas about science. Teachers had high expectations of a science teacher and it was conceivable that either they had difficulty in attaining their expectations, or that their expectations were unrealistic, and consequently many teachers did not often attempt to teach it.

The Influence of Professional Development

While Kindergarten Directors made no reference to professional development, some Junior Primary teachers cited it as a useful tool in providing ideas and inspiration to teach science. The Investigator Science Center was most frequently listed as a provider of professional development. Wright (1990) suggested that the attitudes of primary teachers to science changed when they were presented with simple methodology in science and it seemed that the professional development had a similar effect on Junior Primary teachers in the study.

The Influence of Principals

Although some Principals and Assistant Principals appeared to be very interested in science and supportive of teachers presenting science to children, they were only

referred to by teachers who had been designated to teach science as a specialist subject. The teachers stated that they were proud of what they had achieved in science teaching but would never have attempted to teach science without the urging of the Principal.

Discussion

The consideration of all the data suggests that there may be at least three approximate categories of teacher, ranging from the exemplary teacher to teachers disinterested in science. The table summarises the categories of teachers and what (if anything) influences them to teach science to young children.

Table 6.1

Categories of Teacher described by their Attitudes to Science

Category 1 reluctant teacher of science	Category 2 prepared to teach science	Category 3 exemplary science teacher
dislikes teaching science	enjoys aspects of teaching science	enjoys all aspects of teaching science
negative background experiences eg. feelings of failure, little science	some positive background experiences eg. likes biology	positive background experiences, may have decided to take science further
negative university experiences	some positive university experiences	all positive science experiences at university
no professional development in science	responds to professional development or makes own attempts to extend knowledge	often provides professional development to others
not seen as a science specialist	might be prepared to become a science specialist or teach science as an integrated subject	prepared to go beyond the role of classroom teacher eg. consultant in science education
negative classroom experiences such as problems with equipment or just don't want to teach science, interests elsewhere	tendency to teach nature science. Views science as worthwhile, receives positive feedback from children	usually offers a balanced curriculum although sometimes professes bias to environmental/life science

The mean scores on the Science Opinion Survey (SOS) indicated that in-service teachers responded slightly more positively on the Enjoyment sub-scale than pre-service teachers, a finding that was corroborated by open-ended responses and results from interviews. In-service teachers especially derived enjoyment from teaching science along with the feedback implicit in the positive responses of young children. It is not surprising that teachers in the study, and in particular pre-school teachers, enjoyed teaching some aspects of science. Since Early Childhood curricula advocated giving children a wide range of experiences, Pre-school teachers were free to select a variety of science topics. However Junior Primary teachers may have been confined to topics negotiated within the school's choice of science to be taught in each year level.

As noted in Table 6.1, the science background of the in-service teachers seemed to influence their attitudes towards teaching the subject to children. For instance, many teachers noted that Biology was a science that they enjoyed and it has been well documented that topics based on the biological sciences are those most likely to be taught. One possible explanation for the tendency of teachers in Early Childhood to teach biological science has been suggested by Whittaker (1990) who noted that traditionally Biology had been seen as a "soft option", promoted by women and not a "real science". Baker and Leary (1995) contended that females maintained an interest in science providing it was relevant to their life values. They also found that females did not always view Biology as a "true" science. It is therefore possible that when teachers talked fondly of Biology, they did not think of themselves as doing "real" science. This finding could partly explain why in-service teachers reported enjoying teaching aspects of Biology to young children. Some in-service teachers also had high expectations of a good science teacher, which may have partly been due to the perception that science (as opposed to Biology) was a complex and difficult subject, therefore only the best could teach it.

Some teachers maintained that children liked science and it was a worthwhile subject to teach, however, when teaching science they seemed to consider the skills of recording appropriately, or learning scientific language, or learning reading or mathematics to be more important than the development of attitudes in science. For example, in Chapter 4 it was noted that some teachers felt that there was not enough time to teach science after mathematics and reading. Further, Chapter 5 reports on transcripts of video-tapes of young children doing science activities, and also shows teachers providing them with the language related to the equipment that they were handling and using questions to build vocabulary and concepts about the activity.

In summary, in-service teachers rated themselves a little higher on Enjoyment than pre-service teachers did, although there was little difference between the groups on the other attitudes measured by the Relevance, Confidence and Usefulness sub-scales of the ECEAS. It was likely that memories of science experiences, either at high school, university or during teaching, influenced their attitudes to teaching science to young children. The in-service teachers who taught science, seemed to prefer to give children simple, easily managed activities that were oriented towards biology.

How does the Classroom Teacher Influence Young Children's Responses to Science at School?

This question was answered by considering first, the responses of young children to science at school, second, the influence of in-service teachers and third, the influence of pre-service teachers on the responses of young children to science.

The Responses of the Children

Pre-school children displayed a mixture of enjoyment, curiosity, enthusiasm, confidence and interest in the science that they were doing. The length of time that they spent on a particular science activity varied from 5 to 30 minutes and their attention was directed away from science when they experienced frustration or difficulty with the task that they were doing, another object caught their attention, or a friend encouraged them away. The children tended to work and talk in pairs or groups and their conversation addressed the activity that they were doing, real or imagined events in their daily life, statements made by their peers and questions or directions from the teacher. The children continually explored the equipment provided, often seemingly oblivious of instructions given by the teacher. A number of statements made by the children suggested that they were either starting to develop attitudes or reflecting on attitudes that had been heard elsewhere. These statements were reported in Chapter 5 and included, for example, the opinion of a group of boys that mothers couldn't do science, an opinion from a group of boys that snakes and animals of related shapes were scary, a preference for smaller rather than larger animals, and a willingness to show and talk about their findings.

Young school-aged children also appeared, on analysis of their written work, to enjoy science. In fact the 7- and 8-year-olds often drew smiles on the faces of the pictures of scientists at work. The school-aged children presented science as a hands-on event with the most passive activity depicted as a scientist working on a computer. The children also gave the impression through their written work that science was an

interesting and diverse subject, except when it didn't quite work out the way they expected. Although traditional stereotypes of scientists making strange concoctions were sometimes presented, they were in the minority, and presented by the older children in the study. The school-aged children also indicated that both males and females could do science, and tended to relate the sex of the scientist to their own sex.

It was possible to interpret the children's responses to science in terms of general enjoyment, however the attitudes of interest, enthusiasm, curiosity and confidence are difficult to differentiate by observation. It was apparent that the children felt reasonably confident about what they were doing, for instance, amongst the preschool children's responses, there were no statements of "I can't" or "I don't like," instead they simply addressed the task at hand and were prepared to show the outcomes of their work. One school-aged child expressed dissatisfaction about her drawing and another acknowledged that science experiments were frustrating when they did not turn out as anticipated, however neither comment necessarily indicated that the children lacked confidence in science. The children also appeared to be curious either about the outcomes of their activities, looking, for example, at how many objects were attracted to magnets, or depicting their scientist as discovering or investigating an event.

The fact that some of the children were not aware that they were participating in science also requires consideration. The school-aged children had a wide variety of ideas about scientists that ranged from a dental nurse to a palaeontologist. It was likely that teachers, particularly when integrating science with other subjects, did not necessarily distinguish between science and other areas of the curriculum. Nevertheless the science activities and the accompanying methodology were distinct enough for the children to eventually understand some criteria about the term science.

In short, the children had developed attitudes that they displayed towards science, they already viewed science as a hands-on subject, were curious about it and liked the investigative activities that they were given.

The Influence of In-service Teachers

The in-service teachers in the study selected the activities, the methodology and provided the equipment for the children to use in science lessons. They also decided

how much science should be taught, for how long and how often. In general terms, they had a great deal of influence over the children in respect to the amount and type of science that the children encountered at school.

The teachers also took responsibility for the creation of the classroom environment in science, thus they had a more subtle influence over the children in that they selected what written work was to be displayed on the wall and how the science area was to be set out. The teachers enriched the classroom environment by adding items of interest, such as a jar of caterpillars, an aquarium of yabbies, a sleepy lizard, native seedlings, or nest boxes. Other resources promoted by teachers were books related to the topic under study and, where possible, simple ideas for children to try. Presumably if the environment was interesting and pleasant, the children felt some interest in the topic under study. Certainly Harlen (1985) was of the view that the classroom environment played a considerable role in fostering the positive attitudes of young children to science.

The teachers had a further opportunity to influence the children in the interactions that they had with them during a science activity. When they wanted to extend, encourage or determine the child's knowledge of a topic, the teacher questioned the child intensely. Usually the pre-school teachers worked with a small group of children at a time, and their questions might be directed to several members of the group. The questions often served to shape the child's exploration and were at the expense of other investigations that the child was attempting to carry out. In order to interact with the pre-school children, the teacher sat or knelt so that their height was much closer to the children; they smiled and appeared to encourage them. Sometimes the teachers repeated the language of the child or rephrased the child's statement in a way that introduced scientific terms, for example, "magnets attract". According to McGuire (1985), there is a link between non verbal behaviour and the transmission of attitudes, and it is likely that attitudes to science were transmitted during these interactions due to the close proximity of teacher and child.

The teachers of the Junior Primary children used a similar investigative methodology but with larger groups of children. The teachers placed an emphasis on developing skills and knowledge and emphasised learning about science through finding out new facts and trying out ideas. The girls often received more, and were willing to accept, interactions with and directions of the teachers, whereas the boys were more likely to be able to carry out their own investigations unhindered by the teacher. Such behaviour might explain the comments of one boy who claimed to like making things for girls. He may have developed the idea that girls needed more help from some of the actions of the teacher.

The Influence of Pre-service Teachers

When they taught science, the pre-service teachers also encouraged children to learn about an aspect of science knowledge. They were keen to use resources such as books and displays to promote the science that they were presenting to the children but their influence over the classroom environment was dependent on the amount of freedom that the supervising teacher allowed them to have. When given the opportunity, the pre-service teachers interviewed on practicum seemed prepared to decorate the classroom, sometimes turning it into a "beach", or whatever related to the science topic. Understandably, the pre-service teachers were appreciative of the interest that the children sustained in the topic, as this often meant that the children were well behaved and that the lessons ran smoothly, albeit in some cases noisily. When working with small groups of children the pre-service teachers tried to talk to and use encouraging expressions with the children. In other words, the teachers probably used a range of familiar teaching strategies, including facial expression, eye contact, the use of questioning, equipment, modeling and classroom environment to influence young children during science lessons.

Discussion

It was interesting to note that the children readily displayed attitudes of enjoyment, confidence, interest/curiosity and enthusiasm for the science activity that they were involved in at the time. Harlen (1992) placed particular importance on the development of curiosity as an important component in the development of children's attitudes to science. The responses of the teachers suggested that they were aware that children derived enjoyment from science and, in particular, problem solving activities, while the teachers concentrated on extending the child's learning. When asking questions, the direction of the teacher's interest sometimes conflicted with the interest and explorations of the child. During this conflict, the teachers pressed on with their own agendas while the children extracted themselves from the group or continued with their own investigations oblivious to the questions of the teacher. In terms of learning, such mismatches have been well documented elsewhere (for example, by Osborne & Freyburg, 1985), however there also seemed to be a conflict of attitudes occurring that was relevant to the present study. It seemed that the children already had some fixed attitudes that they revealed during science, of which the teachers appeared to be unaware. For instance, in some cases the teacher tried to encourage attitudes towards the environment, yet evidence of environmental awareness was only reflected in the

written work of several children, the rest of the class appearing interested in and displaying understanding of other areas of science. It seemed puzzling that the teachers were unaware of some of the attitudes observed in the children, since during interviews, teachers indicated that they were aware of children's attitudes to science.

Similarly, the Pre-school/Kindergarten teachers tended to emphasise knowledge of words and facts, while the children displayed curiosity and were interested in investigations. The Pre-school/Kindergarten teachers also appeared to be unaware that they were influencing the girls through longer and more detailed interactions and in some instances simply found them more responsive with a higher level of language than the boys.

In summary, it seems that each group in the study had well formed attitudes to science, although some of them were considerably less positive than others. It seemed that some members of each group influenced each other. The academics and exemplary teachers particularly attempted to influence other groups. There is also evidence that some teachers were strongly influenced by the academics who took their pre-service classes. Occasionally this influence was negative, but usually it was positive. Further, it seemed that children's positive responses to science were also able to have a positive influence on some of their teachers' attitudes to teaching science. All adult groups acknowledged that children generally seemed to enjoy science lessons but were often unaware of the range of the children's attitudes, or which attitudes were held by the children prior to learning about science, or ways of further developing their attitudes to science.

CHAPTER 7 SUMMARY, CONCLUSIONS AND IMPLICATIONS

Summary

The central interest of this study has been the consideration of the affective aspects of science education, as they have often been ignored by educators (Gardner, 1975a). The study attempted to present a picture of the attitudes and attitude influences on Early Childhood Science Education in order to provide information that may be used to improve the quantity and quality of science presented to young children. The study was guided by general research questions, which asked what are the affective factors that influence the teaching of science to young children? What affective attitudes to teaching science to young children are held and modelled by academics to pre-service teachers? What kinds of attitudes do pre-service and in-service teachers hold? Further, what kinds of attitudes to teaching science are modelled by teachers to children?

The data used in the study were gathered through qualitative and quantitative techniques which vindicated each other in respect to the information they provided (Lindlof, 1995). The methodology required obtaining data from four groups central to the study comprising academics, pre-service teachers, in-service teachers and children. Information about attitudes to science education was collected from the seven academics in the study through audio-recorded interviews. An instrument, called the Early Childhood Educators Attitude Scale was administered to a total of 227 pre-service teachers and 75 in-service teachers. Interviews, recorded in field notes were also conducted with 58 pre-service teachers and 46 in-service teachers. Data were collected from approximately 120 children through their written work and video-taped activities. These methods allowed the collection of a wide range of data about affective attitudes towards science, backgrounds in science, attitudes about teaching science to young children and attitudes towards science education taken at university.

On analysis, the data collected from the administration of ECEAS indicated that there was very little difference between the attitudes of pre-service teachers and in-service teachers. The responses of both groups also indicated that they were not confident

about teaching science. It was interesting to note that the responses of the pre-service teachers in the present study differed from the pre-service teachers initially tested by Coulson (1992), in that the pre-service teachers in the present study gave generally consistently less positive responses to science. There were a number of variables that could account for this result, including differences in background high school subjects, science experiences and variations in the selection criteria for Early Childhood pre-service courses between the two universities. However, the qualitative data collected suggested that all groups interviewed enjoyed some aspects of science, although apparently not enough to alter the attitudes measured by ECEAS. When Coulson (1992) originally described the term “enjoyment”, it was applied to first year pre-service teachers’ recollections of science at high school. However responses to open-ended test items and interviews revealed that after first year science education had commenced, the term enjoyment was used by participants to refer to the science taken at university and in later interviews, the term was also used to denote feelings associated with teaching science to children.

Information from Academics

Interviews of academic staff who taught science education indicated that they enjoyed science, found that it was personally meaningful, considered it to be relevant to children and felt confident in teaching it to pre-service teachers. These academics also recalled positive memories of science from childhood and beyond. Similarly, the academic staff who worked specifically at the Early Childhood Education Institute recalled positive experiences of science and all academics in the study contended that it was important for teachers (both pre-service and in-service) to teach science to young children. The science that the academics presented to teachers (pre-service and in-service) was hands-on and reflective of the theory of constructivism. The academics considered that they were providing pre-service teachers with the appropriate knowledge, methodology and attitudes to science to use with young children.

The academics from the Science Department attempted to influence the attitudes of pre-service teachers by establishing a healthy rapport, selecting suitable methodology and, in the case of the academics who taught Curriculum Science, providing simple ideas and activities that could be used with children. It seems that the academics influenced some pre-service teachers to rethink their attitudes to science and reinforced positive attitudes to science held by others. Although the academics who taught science education claimed to try to model or reflect positive attitudes to science, there was one major period in which they were more readily able to influence the attitudes of pre-service teachers. This occurred during Curriculum Science, when they presented

science education in a way that was directly related to teaching science to young children. Germann (1994) noted that students who normally did not value science responded with enjoyment to a new format, instructor, or experiences in science.

Information from Pre-service Teachers

The information obtained from pre-service teachers about attitudes to science indicated that the pre-service teachers had limited or negative experiences in science at high school, preferred the natural sciences over the physical sciences and sometimes felt they were influenced by academic staff. In addition, most pre-service teachers interviewed, suggested that they preferred learning about Curriculum Science rather than General Science and expressed a willingness to teach science by integrating it with other components of the curriculum. It is important to note however, that although the pre-service teachers appeared to enjoy and be willing to teach Curriculum Science, there was no evidence, particularly from the ECEAS, to suggest that overall their attitudes to science had changed.

The pre-service teachers who taught science during practicum were influenced by the direct responses of both supervisory teachers and children to the science lesson that they presented. As a result of such feedback the pre-service teachers interviewed indicated an increase in their confidence and enjoyment of teaching science and a willingness to teach more science. The kinds of science experiences that the pre-service teachers provided for young children were often based on Curriculum Science.

Information from In-service Teachers

In-service teachers in the study, with the notable exception of exemplary teachers, often reported negative experiences of science at high school, although some teachers recalled positive tertiary science experiences. They also indicated a preference for science related to the life sciences as they felt comfortable teaching it and believed it to be important for young children to understand. In addition, they perceived science to be hands-on and involving a degree of experimentation. The small number of in-service teachers who had experienced ideas that were new and relevant to them (either through being forced by circumstances to teach science or through attendance in a staff development program) became interested in and excited by teaching science. Their subsequent success in teaching science may be attributed partly to the children's positive responses to their lessons. Some in-service teachers were guided in their lesson presentation by their memories of tertiary science education.

The sub-group of exemplary teachers reported consistently positive experiences in science from their early years through to their present work. Like the academics they enjoyed and placed a considerable degree of importance on science in early childhood education. This sub-group was able to provide detailed descriptions of how a good teacher of science should behave.

The sub-group of exit teachers also reported enjoying teaching science and attributed their positive attitude to the Curriculum Science experienced at University and the responses of the children to science lessons.

Information from Children

The information collected from video-tapes and written work of children suggested that children were interested in and enjoyed science-related experiences. The data further indicated that the children felt curious and confident about their activities. Children were noted to be willing to handle equipment provided for them and to try ideas out for themselves. They exhibited interest in their results and tried to share their ideas with others. Although the Preschool children expressed vague ideas of what scientists did and didn't do, Junior Primary children appeared to have well formed ideas about scientists and indicated that science involved a degree of hands-on work. In general, it seemed that no matter how hard the teacher attempted to guide or influence the children, they tended to express and follow their own ideas and opinions rather than those of the teacher.

Attitude Influences of One Group on Another

The literature has documented that attitudes are complex in both their nature and the ways that they are expressed, similarly the ways in which the groups in the study influenced each other varied in depth and subtlety. The academics appeared to be able to influence pre-service teachers (and in some circumstances in-service teachers) by establishing a comfortable learning environment and providing simple, enjoyable hands on ideas in science which could later be used in the classroom.

Teachers (in-service, and to a degree, pre-service) influenced children through the learning activities and equipment they chose to provide for them as well as the way in which they responded to the children. The degree of influence that the teacher had on the attitudes of young children in the study is unclear but likely to be variable. Once the children had been given a task they appeared to explore it, guided by their own

attitudes of curiosity, interest and confidence in handling equipment, rather than closely attending to the directions of the teacher. Indeed the responses of children in the study to science very likely may have influenced in part the teacher's willingness to teach it. It was considered worth noting that although some teachers seemed aware that children enjoyed and were interested in science, they did not seem to be aware of any other attitudes that the children may have to science.

The term enjoyment has been frequently mentioned throughout this study. It appears that each group considered enjoyment to be a mitigating factor in the presentation of science. For instance, the academics who taught science to pre-service teachers put considerable effort into presenting science as an enjoyable experience for pre-service teachers. Indeed pre-service teachers often referred to science in terms of "like/dislike, enjoy/hate." Similarly, the responses of in-service teachers suggested that learning about and teaching science involved emotion of enjoyment or its opposite. It was further noted that children appeared to enjoy science. It may be possible that science will only be taught when a level of enjoyment is experienced.

There seemed to be several factors influencing the attitudes to science which were common to each adult group in the study. The first seemed to be the belief that science was supposed to hands-on and the second seemed to relate to the individual's past experiences of science. It appeared that memories of science in the past influenced the present attitudes to science. As indicated in Table 6.1 teachers with consistently negative experiences in science may be more unlikely to be willing to teach science, whereas teachers with some positive experiences may be more willing to teach it. This notion is consistent with Oskamp's 1977 model in which he suggests that past and present attitudes combined with new stimuli modify existing attitudes. Indeed the influences of attitudes in Early Childhood Science Education can be summarised in Figure 7.1 . This diagram suggests that present attitudes to teaching science are influenced both by memories of past experiences in science and by present experiences. For example, for pre-service teachers the present experiences may include tertiary science and science lessons taken while on practicum. It is important to note that the present experiences may be able to modify the effect of past experiences.

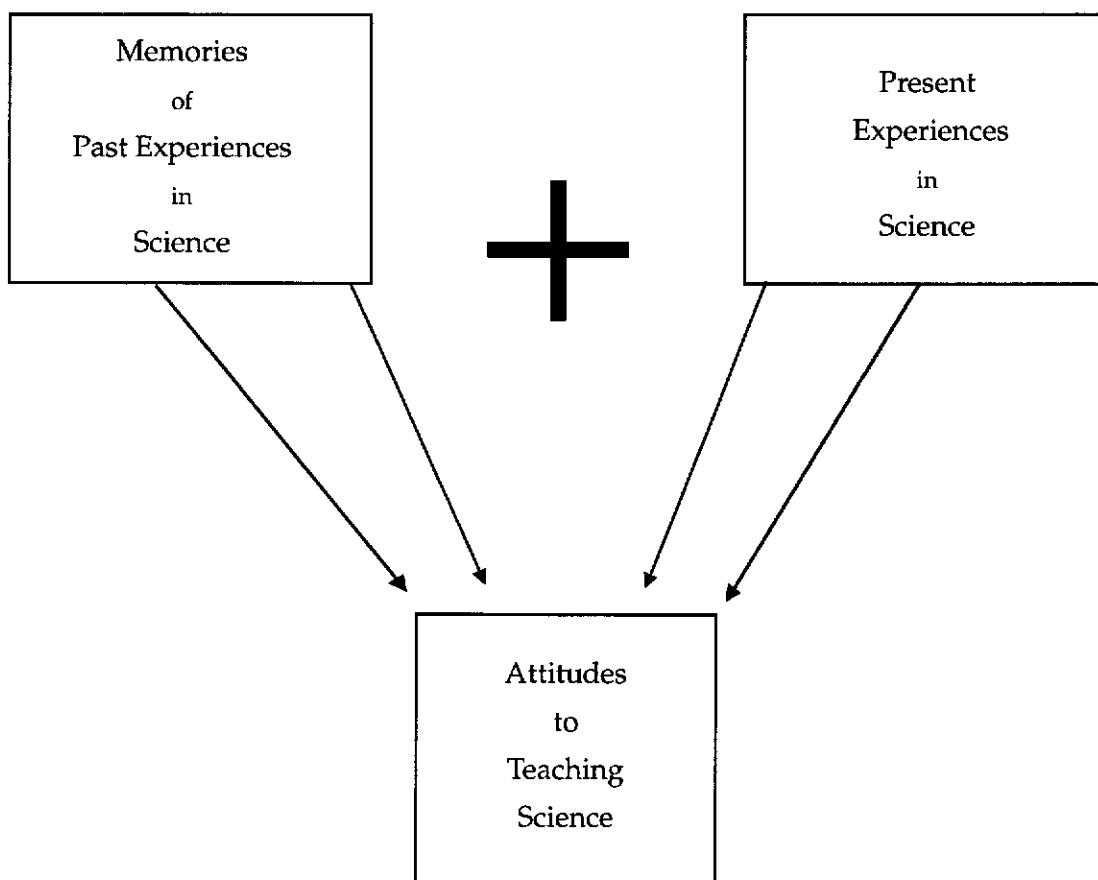


Figure 7.1 Diagram of influences on attitudes to teaching science.

Limitations

Although the study has been carried out on a relatively small sample, in a single geographical area, the results obtained are generally congruent with those described in literature. The fact that the study relied on the participants' willingness to partake in questionnaires and interview may also have influenced the study's outcome. However, once again the findings were consistent with the literature, and there was a degree of uniformity in the responses of the subjects who participated in interviews. Other studies have shown that the administration of an attitude instrument can also affect attitudes but the consistent results obtained would tend to negate the likelihood of this occurring here. Similarly, the repeated administration of ECEAS may also have influenced some cohorts, although it was found in other studies, such as PECSTEP, that repeated surveys did not influence the results. It should be noted that although the ECEAS was selected because it was designed specifically for Early Childhood Educators, and it was used successfully with them, it has the same limitations as all

pen and paper measures of attitude. Respondents can respond only to the statements presented. Thus there may be a lack of sensitivity in the sub-scales which contributed to the similarity of results across all the pre-service teacher groups. The third years who were interviewed often expressed quite positive attitudes, especially after they had taught science on their practicum. That this was not reflected in the ECEAS results may have been because only volunteers were interviewed, and they were possibly the most positive group, or a lack of sensitivity in the instrument.

It was considered desirable that the study should be longitudinal in design, unfortunately as already stated this proved impracticable. Nevertheless, detailed data were collected over a four-year time frame on the relationship between background and attitudes to science. It is also possible that the researcher may have unconsciously brought bias to the study, as she is a university academic, and may have affected the responses of the people from whom the data were sought. The problem of retaining confidentiality was addressed by assigning codes and pseudonyms to the participants on the completion of collecting data and then leaving a considerable time lapse between the collection of data and the writing up of results.

Conclusion

The academics who taught science education had positive backgrounds and attitudes to science but were untrained in Early Childhood Education and therefore were possibly unfamiliar with the culture and attitudes to children of Early Childhood Education pre-service teachers. Still, the academic staff who taught science attempted to influence positively the teachers (both pre-service and in-service) in Early Childhood Education. It also seems reasonable to suppose that different experiences in science education and tertiary qualifications, may explain in part some of the differences in attitudes between the academics who specialised in science education and those who specifically worked, and were trained, in Early Childhood Education.

The responses of pre-service teachers to ECEAS indicated that, overwhelmingly, they entered the University with negative affective attitudes towards science. The pre-service teachers expressed anxiety about their lack of knowledge of science and indicated that they disliked aspects of General Science. It was puzzling that although pre-service teachers had expressed a lack of confidence in their knowledge of science, they did not respond positively to the subject that was designed to partially remediate this problem. It was unfortunate that although the pre-service teachers enjoyed Curriculum Science, their lack of confidence may have prevented any overall potential

attitude change towards science, certainly as detected by the ECEAS. However, it is possible that the positive influence of Curriculum Science on pre-service teachers could in part be attributed to the fact that the subject was extremely child-centred and the science presented was practical and able to be understood without arousing feelings of anxiety in the pre-service teachers. In addition, the pre-service teachers' positive response to the subject may have been linked with their interest in teaching children, rather than a sudden development of interest in science per se. Once the pre-service teachers realised that children were likely to enjoy participating in science lessons they responded favourably to the subject as it could be seen to benefit children. The fact that during interview, some pre-service teachers claimed to enjoy Curriculum Science could be explained in the same manner, and so, having felt comfortable with the subject, they were prepared to express a willingness to teach it to children.

The attitudes of in-service teachers towards science education generally followed a similar trend to the pre-service teachers. In-service teachers had negative memories of science taken at high school while those that remembered the science taken at university closely associated it with the academic who presented it. In-service teachers' open-ended responses to ECEAS suggested that they derived some attitudes to science from memories of past experiences of science but were also influenced by the present responses of children to science.

Children brought with them to school attitudes that could be regarded as curiosity, enthusiasm, interest and enjoyment towards the science they encountered. Such attitudes were likely, in part, to have developed at home and, in the case of preschool children were still developing. The children's attitudes were evident in science lessons and influenced by the materials they were exploring, as well as some interactions with their teachers and each other. It was also possible that the attitudes of others influenced the children in respect to gender, equity and ability in science activities. As formal learning in general was a new and exciting experience to young children, it was likely that they were open to and receptive of any new idea, experience and influence.

Isolation of positive responses to science obtained from interviews, open-ended responses to ECEAS and video-tapes of children, suggested some common attitude influences on teachers (pre-service and in-service) and children. The attitude influences included successful exploration of ideas through hands-on learning activities and in some cases the establishment of a positive rapport between learner and teacher in an environment free from anxiety. It seems likely that positive attitudes to science are not developed solely from the opportunity to indulge in exploration during childhood,

as was claimed by some of the pre-service teachers from country areas. Rather, the opportunity to successfully explore ideas using hands-on activities can influence attitudes to science held by both teachers and children irrespective of where they reside.

It is possible that memory of past experiences in science influenced attitudes towards the teaching of science to young children. Although the memories of high school experiences in science dominated pre-service and in-service teachers' attitudes to science, when such memories were accompanied by some pleasant recollections, the individual was more likely to be prepared to review their attitudes towards science. For instance, exemplary teacher groups and academics had almost uniformly positive experiences and memories of science, which were reflected in the attitudes that they presently held. Of more interest, however, were teachers (pre-service and in-service) who recalled pleasant experiences in childhood, high school, or university, which they were able to incorporate into an attitude of willingness to teach science to children. In some instances, recollection of early positive science experiences in childhood seemed to help the teacher to override negative experiences encountered at high school.

It was also noted that although, overall, attitudes towards science as measured by the ECEAS remained unchanged, the pre-service teachers who reported enjoyment of science may have been influenced by multiple factors. For instance, the culture of pre-service teachers meant that they were predisposed to respond to the influence of the academics (information supported by Adler & Byrd, 1976) and it was easy to derive enjoyment from a form of Curriculum Science that was presented as fun. The additional information about science provided to pre-service teachers through Curriculum Science may have been sufficient to reduce anxiety towards science subjects, increase self esteem about the ability to learn a science subject and modify attitude components towards science. Moreover, the pre-service teachers may have depressed other less positive emotions towards science in order to help them to survive the subject. Since there was a general expectation that teachers should enjoy teaching and their teaching should be relevant to children, teachers may have experienced a form of 'cognitive dissonance' (as described by Festinger, 1957) from negative attitudes to science that were incompatible with these expectations. Therefore, teachers (pre-service and in-service) may have felt more comfortable with themselves if they were able to alter attitudes, which were incompatible with attitudes towards teaching. Since not all attitudes are active at one time (Augoustinos & Walker, 1995), it is also possible that the necessary stimuli for confronting attitudes to science were unavailable, or that the other attitudes were of too greater intensity to change, or were interlocked with a number of negative memories of science.

The study has described the affective attitudes that academics, pre-service teachers, in-service teachers and young children express towards science and noted with concern, the lack of confidence of pre-service and in-service teachers. It has also described the ways in which academics model science to pre-service teachers and it seems likely that at least some attempts made by academics to encourage the pre-service teachers to present science to young children were successful. However, if the results of the ECEAS are to be believed, overall they seemed to have little influence in changing pre-service teacher attitudes towards science.

The science that in-service teachers appeared to model to children involved hands-on learning activities. Although teachers were aware that children enjoyed science, they seemed unaware of any other attitudes to science that the children might hold. Further, they appeared to emphasise the development of science knowledge rather than affective attitudes. It was therefore likely that teachers considered the development of a body of knowledge to be of prime importance in the teaching of science to children. The teachers may have felt that it was sufficient for the children to show enjoyment when participating in science activities. It also seems that a combination of memories of science experiences coupled with present experiences influenced the teaching of science to young children.

Implications

To a large extent, the basis for the implications drawn from this study reflect Gorden's 1971 (p. 241) statement on attitude studies:

Rarely does (or should) an attitude study produce results, or may implications be drawn from it that are widely at variance with what common sense tells us about familiar populations.

It became very obvious during the course of the research that the groups in the study did not have a clear understanding of attitudes or the role that attitudes play in social life or science education. Evidence from pre-service and in-service teachers suggests that positive experiences in science may encourage positive attitudes to teaching science, which in the case of the exemplary teacher sub-group encouraged them to acquire a greater depth of knowledge about science and science teaching.

The following implications of the study are aimed at suggesting ways of influencing the development of positive attitudes towards Early Childhood Science Education. They are divided into two sections. The first, covering implications for practice considers how to improve the delivery of science education and the second,

implications for research, discusses the role of research in understanding the influence of attitudes on the teaching of science.

Implications for Practice

Fensham (1991) was critical of pre-service courses in Early Childhood Science Education and certainly some changes could be made in order to persuade pre-service and in-service teachers to teach science to young children. In order for academics to have a better chance of influencing the attitudes of pre-service teachers of science, a more concerted effort to influence attitudes may be required over a long period of time. Perhaps a subject in science education could entail the identification of attitudes held in science by pre-service teachers and through discussion heighten their awareness of their attitudes and the reasons why they may have developed. This may result in the development of ways of reducing anxiety towards science and ideas about building self esteem.

One way to promote and influence attitudes to science was suggested by O'Driscoll (1981) who advocated the use of Moreno's (1934) and Moreno and Moreno's (1959a, 1959b) techniques of using role play to change attitudes. Moreno encouraged participants to adopt an unfamiliar role, in order to gain insight into the attitudes and experiences of another. Although Moreno's work was originally intended for use in the field of psychodrama, it seems to be readily adapted to other areas. One way of modifying, or at least sensitising, the attitudes of academics and teachers might be to have them enact the role of a child learning science, or to re-enact high school experiences or to take on the role of an exemplary teacher. It seems more likely that attitudes to science may be changed through such a concentrated technique rather than by attempting to influence attitudes in a general way as well as teaching other aspects of science education.

There was very little positive response from pre-service teachers to General Science, yet the fact that the confidence of pre-service and in-service teachers remained low, coupled with the emphasis that in-service teachers placed on developing knowledge about science, tends to indicate a need for such a subject. However it seems that the method of presenting the subject and the year level at which is presented requires considerable review. An ideal model on which to base such a subject appeared to be the gender sensitive model from the WASTE project, advocated by Bearlin, et al. (1989) and used successfully with teachers by Kirkwood, et al. (1996). Perhaps before any extensive influence on the attitudes of pre-service teachers occurs, the pre-service

teachers (and in-service teachers) should be encouraged to feel positive about themselves as independent learners and their ability to understand science, an idea supported in a study by Rennie, et al. (1985) some time ago. For this to occur, it may be necessary to teach the pre-service teachers how to analyse the relationship between gender and science and develop techniques for making science more inclusive.

In order to build further on the confidence of pre-service teachers to teaching science to young children, subjects in science education should be linked more closely with teaching practicum. In addition, during practicum, pre-service teachers should be required to teach a series of science lessons as part of their practicum assessment. Such a step would emphasise the importance placed by the University on science education to both pre-service and in-service teachers alike. It would also provide the pre-service teachers with the opportunity to increase their confidence and skills in teaching science to young children. The evidence from interviews with pre-service teachers who had taught science during practicum provides support for this idea. Ideally a debriefing session or an assignment that allowed pre-service teachers to reflect on the results of their teaching should follow each practicum.

It may also be advantageous in terms of influencing attitudes to science, to provide two curriculum-based science subjects (followed by two periods of practicum to pre-school and then to school aged children). It is also conceivable that the pre-service teachers would see science as more useful if the methodology or organisational skills developed in science were noted by academic staff to be directly applicable to other subject areas.

The science staff in the study were not qualified in Early Childhood Education and possibly not familiar with expectations placed on the pre-service teachers. This situation could be remedied if the Early Childhood Department employed academic staff who could teach science education or if the science staff became involved in teaching supervision or attended some practicum-related tutorials. In this way, the academic staff who taught science may obtain more information about the attitudes and abilities of pre-service teachers in Early Childhood Education while simultaneously providing reflective feedback on the pre-service teachers' experiences in teaching science.

Academics should also be encouraged to examine how they influence attitudes, in view of the fact that the teacher interviews and open-ended ECEAS responses showed that the personality and style of the academic had a considerable and often long lasting effect on pre-service and in-service teachers (a point reinforced by Sundberg, Dini and Li, 1994). By becoming aware of the aspects of their personality which influence pre-

service teachers' attitudes to science, academics may use aspects of their personality and teaching style more effectively during lectures and work shops. Likewise, the methodology used by academics could be reviewed in order to document ways of influencing the attitudes of pre-service teachers.

The lack of confidence of both pre-service and in-service teachers to science warrants acute concern as it may limit both the quantity and quality of science lessons presented to children. Perhaps the most effective way of building the confidence of in-service teachers was through professional development. The few teachers who attended professional development programs spoke glowingly of them and indicated that the programs had considerable impact on their attitudes and approach to teaching science. The effectiveness of in-service programs on primary teachers has been effectively demonstrated by Napper, Crawford and Zeegers (1989).

Another way to increase the confidence of teachers is to improve the status of Early Childhood Education which would ultimately result in increasing the importance of young children and teachers. This in turn could at least highlight the importance of teaching young children and include the importance of teaching science.

The enthusiasm for science expressed by children in the study seems worthy of encouragement perhaps through funding programs aimed specifically at the early years of life. Given that children's perceptions of themselves as learners are well developed by the age of 6 years (Bloom, 1976), it seems logical to suggest that a heavy emphasis should be placed on providing experiences in both the development of positive attitudes in children towards themselves and learning in science. The literature further suggests that science programs for children should also involve parents, grand parents and the wider community, in order to raise awareness of the importance of allowing young children to have experiences in science, a point that was made by some Kindergarten Directors in the study.

A final implication of the study for practice can be directed at authors of science books and curricula designed to be used by teachers and children. It is common practice for the writers of classroom-oriented science materials to list the attitudes that children may develop over a given period. In the light of the present study, such a practice requires review to include the attitudes to science that young children are already likely to have. For instance, lists of attitudes that include encouraging a willingness to engage in scientific investigations or to foster curiosity may well be redundant if, as suggested in the study, they are already developed in the preschool. Instead, the already established attitudes held by children need to be widely published to heighten teacher awareness along with the need to develop them.

Implications for Research

The literature review indicated that there was room for many more studies on attitudes to Early Childhood Science. Interviews with pre-service teachers revealed that they were able to recall specific instances of negative attitudes towards science from their past. In light of this information, it is possible to build on the present study by investigating the effects of confronting attitudes of pre-service teachers to science with a view to developing a list of strategies for changing negative attitudes.

Although outside the parameters of the study, it became apparent from the data collected and the literature reviewed, that the science experienced at high school had a negative influence on many students and, in particular, those wishing to be Early Childhood educators. Such information could be used as a basis for further research examining the impact of negative attitudes to science on future career choice. It could also be of interest to develop a profile of Early Childhood pre-service teachers, which could be compared with tertiary students studying an arts degree or a degree in primary teaching. This could verify or refute the notion that pre-service teachers who select Early Childhood Education have negative attitudes towards science and this is why they opt for teaching young children.

In a more general sense, it is of concern that high school science has offered such negative experiences, and more research might be directed there to ascertain the reasons for this.

The instrument used in the present study revealed considerable information about the subjects being tested and consequently could be used on any sample of Early Childhood pre-service and in-service teachers. Indeed it would make an interesting comparison to describe the attitudes of teachers in Early Childhood Education in each State through the use of the instrument. In addition, there is room for an instrument to be developed to measure the attitudes to science of young children, possibly through drawing or noting verbal responses.

Lastly, the area of attitudes to science itself is open to research. There are few direct studies that highlight ways of influencing, modifying or changing attitudes to science, especially in the area of Early Childhood Education. Until researchers promote the importance of affective attitudes to learning and appreciating science, it is likely that educators will continue to disregard the importance of understanding of attitudes towards teaching science to young children.

Future Trends

The publication of the Australian Science, Technology and Engineering Council *Foundations for Australia's future: science and technology in primary schools* (ASTECC, 1997), warrants mention in this Chapter. In this report, ASTEC published updated information about the status of science and technology in primary education, and continued to acknowledge the findings of *The Discipline Review* (DEET, 1989a, 1989b, 1989c).

Although ASTEC (1997) did not refer specifically to Early Childhood Education, the area of Junior Primary was included as part of Primary Education, consequently the report was of some relevance to the study. The terms of reference of the report allowed a review of learning and teaching of science and technology and assessment of the ways schools foster the development of confidence in science and technology to equip students for future responsibilities. The report placed importance on the "development of curiosity, attitudes and skills in problem solving" (ASTECC, 1997, p. vii). It also considered the identification of opportunities that enhanced science and technology along with appropriate steps to develop such opportunities.

It was interesting to note that the report found that community attitudes gave less status to science and technology than to reading, writing and mathematics. It was also found that beginning teachers and experienced teachers alike lacked confidence in teaching science and technology. ASTEC (1997) suggested that the lack of confidence in teachers could be counteracted through revised pre-service education programmes and extensive in-service teacher professional development, a suggestion which concurs with the findings of the present study. The report also found that although many teachers expressed interest in science and technology, and in particular technology, these subjects received less curriculum time than other traditional areas of learning.

The report further indicated that children's attitudes to science and technology were positive in that "children demonstrate a great eagerness to learn science and technology and given the opportunity can learn effectively in these two areas" (ASTECC, 1997, p. 5).

ASTECC also referred to the impact of the *National Statement and Profiles* (Curriculum Corporation, 1994a, 1994b, 1994c) on teaching science and technology. However it should be noted that teachers were not required to report on the assessment of science until 1997 and therefore teachers were still likely to be coming to terms with all of the requirements of this curriculum document at the time the report was written.

There are also other influences that may affect the teaching of science in future years, for instance, the *Primary Investigations* Programme has been introduced to a number of schools and seems to be particularly well accepted in Western Australia. Such a curriculum package ensures that science is taught for set periods at regular intervals throughout the school. In addition, South Australia has introduced mandatory testing of science in years 3 and 5. The purpose of the testing is to assess and monitor the overall progress of students in science. It is possible that by heightening teacher awareness of the importance of science through such processes, levels of teacher awareness of Primary and Junior Primary science will increase.

It is difficult to tell whether the findings of the report (ASTECC, 1997) reflect a gradually evolving community interest in science and technology or a gradually increasing response to recognising the need to teach science and technology. The latter would reflect a response to the development of the National Statement on Science and the Statement on Technology and their respective profiles of assessment. It is, however, interesting to note that very little mention was made of Early Childhood in the ASTECC report, and that the National Statements refer only to school age children. A similar point can be made in respect to *Primary Investigations*. Although South Australia has begun testing children in science at the end of their Junior Primary years, the testing appears to be aimed mainly at identifying skills in the area. It is yet to be determined how children's results in science tests will impact, if at all, on the science presented to young children.

According to ASTECC (1997), some attitudes to science and particularly technology education are becoming more positive than was reported in *The Discipline Review* (DEET, 1989a). Although attitudes to primary science (and technology) have received more attention, there is little mention of Early Childhood Science Education, much less than it received in 1989. ASTECC (1997) also found that there was little change in teacher levels of confidence towards science. If this trend continues it seems unlikely to expect that teacher attitudes to teaching science will alter greatly. Indeed it seems most unlikely that the attitudes of Early Childhood Educators to science will change as the area continues to be largely ignored by researchers and curriculum writers.

One encouraging trend however does emerge. It seems that children have continued to maintain a healthy curiosity, enjoyment and enthusiasm for science and there is no reason to suggest that young children's positive attitudes to science will adversely change. Whether or not the increasing time in teaching science as required by the Statement and Profiles and recommended by the ASTECC report will influence teacher attitudes towards science, and in particular, increase confidence in teaching science, remains a point of conjecture outside the realm of this study.

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APPENDIX 3.1 TIME LINE

Year	Summary of Information
1992	
February	Checked methods of data collection.
March - July	Assessed a number of attitude scales. Selected ECEAS questionnaire
August	Commenced interviews with academic staff from Science Department. Obtained verbal permission to administer questionnaire and interview pre-service teachers.
October	Obtained permission to administer ECEAS questionnaire from its author.
October	Administered questionnaire to 1st, 2nd and 3rd year pre-service teachers.
November	Interviewed subjects from each of cohorts.
1993	
March	Met with Principals and Regional Coordinators.
April	Visited JP schools, where third year preservice teachers were on practicum.
May - June	Administered ECEAS questionnaires to third year pre-service teacher and interviewed a sample of the subjects.
June	Commenced interviews with in-service and exemplary teachers.
July	Administered ECEAS questionnaire to beginning students commencing a compulsory science education subject.
July	Interviewed preschool children at university.
July	Obtained permission from university registry to survey entrance scores of preservice teachers.
August	Obtained permission from Department of Education to administer ECEAS questionnaire to JP schools and preschools. Sent ECEAS questionnaire to schools and kindergartens.

APPENDIX 3.1 TIME LINE Continued.

Year	Summary of Information
September	Commenced interviews with kindergarten and JP inservice teachers. Collected children's recordings about science from teachers.
September	Administered ECEAS questionnaire to second year students and interviewed subjects.
October	Contacted 'exiting' third year in-service teachers by letter.
1994	
May	Administered third year ECAES questionnaire to in-service teachers.
July	Analysed data.
August	Administered ECEAS questionnaire to 1st and 2nd year in-service teachers. Data was not used.
September	Additional interviews from exemplary teachers and an academic staff member from early childhood education.
September	Collected additional material from children's recordings.
October	Completed transcribing interviews.
1995	
January	Analyses of data, continued through year
December	Organised and carried out video taping at preschool location 3
1996-8	Draft and revision of Thesis
1999	Final Draft Thesis Completion of Thesis

Appendix 3.2 ECEAS

Note: For copyright reasons Appendix 3.2(pp161-3 of this thesis) containing the following has not been reproduced.

Science Opinion Survey, designed by Ruth Coulson, School of Early Childhood Studies University of Melbourne.

(Co-ordinator, ADT Project (Retrospective), Curtin University of Technology, 4.12.02)

APPENDIX 3.3 EXAMPLE OF INTERVIEW TRANSCRIPT

INTERVIEW WITH TOM (September, 1994)

Sharon Before we get to talking about attitudes, I'd like to find out a bit about your background.

Can you recall much about science at school?

Tom Well, I took Physics and Chemistry to Matric.

The only thing I can remember about Primary School science is growing carrot and onion tops, watching the roots go down and seeing stuff grow on cotton wool.

However, it was an isolated rural school and all the kids were naturally science oriented - we knew about rainfall, super phosphate and machinery. We were free to roam, we played and explored all over the place.

I've thought about it a lot in terms of my interest in maths and I think it's because I already saw their practical applications.

I didn't enjoy chemistry because I'm colour blind and I could not see any changes occurring. In hindsight, it was the wrong choice of subject.

To me chemistry is abstract. Physics - this might be my background as well - relates to practical things, such as automatic transmission and tone.

Sharon How did you become a teacher?

Tom Well, I left school with no intention of being a teacher. I'd thought I'd get a job as there were plenty about. Having done physics, chem, maths 1 and maths 2 I thought I'd be a lab technician; but I couldn't get employed because I was color-blind. So I worked in the Muses, selling magazines and stuff, when the new Arcade had only just opened. After six months I really hated it and thought there had to be more to life than this. I had some friends at teachers' college and I thought - if they could get there so could I.

I got there by default, with no great passion for teaching. It didn't occur to me to go to university as I was the first person in my family to complete secondary education and uni. was too expensive. So I went to teachers' college for 2 years and got offered a third year. After 2 weeks into the third year I thought I've got to do something practical so resigned and went teaching.

I taught primary for 3 years then joined the permanent relieving staff and became a state-wide reliever. Thought it would be a good opportunity to see schools. It boosted my confidence, it showed off my skills and allowed me to make comparisons with people who

APPENDIX 3.3 EXAMPLE OF INTERVIEW TRANSCRIPT Continued

were going on stress. I picked up enormous messes. Found them very easy to fix. Usually the kids just needed a bit of structure and someone to listen to.

Got married, settled down. Went to Regional Country Centres for 10 years. I was also a language arts adviser, would you believe that? I also became a tutor to Aboriginal students learning to become kindergarten teachers. Then, on the spur of the moment, because I was on a year's parenting leave - I was asked to apply for a position to coordinate Aboriginal Ed. on Campus and I accepted it, then was later awarded tenure, because I was the only one who had supervised students on kindergarten teaching practicals.

Sharon What are your feelings about science and maths?

Tom I think they're exciting, wonderful subjects, but at the moment there is too much fuss about English as a second language. I think the general feeling in the community is, and I was talking to some teachers about this the other night, is that it's a body of knowledge that can be learnt. Maths and Science can be popped in anywhere and taught. I don't know how to get people to realise that some of the strategies to teaching language, also can be used across the curriculum. People are in instant horror of physics and maths.

Sharon Have you noticed this out on teaching supervision too?

Tom In child care - not much more than growing carrot tops. It's at a superficial level - let's see what happens. Same in kindergarten. They think it's not necessary to plan science, it's hit and miss. The children who are interested probably get it from elsewhere. It gets so integrated with other stuff that it doesn't exist.

Sharon Reasons for this?

Tom It's a way of hiding or justifying your lack of knowledge and points a way around the subject. In the junior primary there must be some brilliant teachers of science, but mostly they seem to be people working recipe book science - Opposite extreme to kindergarten. Science needs to be put into a context of learning. Without students in the maths half of science, there would probably be a fifty-fifty split, when you wander around and talk to them, between those who enjoy it; and those that moan about why we're doing it; and that it seems like a separate subject. In maths I only know of 3 who have had a change of attitude. The best group though were the ones that have science and maths all muddled up in order (reference to transition students). Probably because the first years are operating in a vacuum, they have a lack of curriculum knowledge and understanding and their own attitudes can impact on it.

APPENDIX 3.3 EXAMPLE OF INTERVIEW TRANSCRIPT Continued

Generally teachers don't feel confident and avoid it (science) or integrate it, or follow a recipe book, which they think is good because it's written by an expert.

Our students also hit barriers during teaching practice. The teachers tell them that our theory is impractical. They have a poor perception of what we do.

Interview terminated due to urgent call from student.
Tom shown transcript, November 1994.

APPENDIX 3.4 SAMPLE OF FIELD NOTES FROM PRE-SERVICE TEACHER
INTERVIEWS

INTERVIEWS WITH CURRICULUM SCIENCE THIRD YEAR STUDENTS, 1994

Third Year female 1

High School Memories

Physics - Felt it didn't relate to real life, all computations and formulas - like Maths which was a weaker/subject.

Chemistry - Interesting at times but yet again sulphuric acid etc. wouldn't help me in real life.

Biology - Enjoyed this, was realistic and easier to understand, therefore it got me better marks, and I felt more positive about it all.

Attitudes in general were:

1. that it was too difficult
2. it was boring
3. it was unrealistic
4. not enough hands on experiences
5. assignments one after the other - nothing different

Science 1st year ECE - found it to be a bit the same.

Science 2nd/3rd year - learnt it, is a subject easily taught and integrated with others.

Can be lots of fun with lots of hands on work activities are available.

Feel a lot more confident in the subject with a more positive attitude being created.

Third Year female 2

High School Memories

I found that year 8 provided a range of science topics which was a good idea for students to make comparisons and choices of senior science subjects. However, I found that Biology subjects interested me the most in years 8, 9 and 10. I found topics such as Chemistry and Physics difficult to understand and they were so boring and seemed irrelevant.

I therefore chose Biology for year 11 and 12. I really enjoyed this but I did find the tests

APPENDIX 3.4 SAMPLE OF FIELD NOTES FROM PRE-SERVICE TEACHER
INTERVIEWS Continued

were set out in unusual ways. We all found that what we learnt appeared quite different in the test. We learnt basic facts in the lessons while tests asked difficult questions applying knowledge to many areas we had not dealt with. We really needed more time in class to practise "applying" our knowledge to questions, problems which we found it hard just learning the facts not learning how to use the facts!!!

University

I found the 1st year of science quite boring. Mechanics was difficult to understand in some cases whereas I really enjoyed Chemistry. For the first time I found Chemistry relevant!!

2nd and 3rd year have been so much more practical. I have developed so many more ideas for teaching. I feel a lot more confident teaching science on Prac. than I ever thought I would. I know that you don't have to be a 'Scientist' to teach science. I have taught wonderful lessons! I go in with the idea that it is great to learn with the children too!

Science can be so much fun and it's a shame many teachers do not teach much! I feel that 1st year was good to refresh my knowledge (but at times boring). 2nd and 3rd year have been great - provided ideas and endless resources for children.

Thanks Sharon

Third Year female 3

High School Memories

Didn't take much notice of science

University

1st year - Some not relevant.

2nd year - More interesting.

3rd year - Excellent really relevant and interesting ways to introduce science to children.

Third Year female 4

High School Memories

- * hated Physics and Chemistry
- * enjoyed Biology did that in year 11/12.

APPENDIX 3.4 SAMPLE OF FIELD NOTES FROM PRE-SERVICE TEACHER
INTERVIEWS Continued

University

1st year - OK but 2nd and 3rd year have been a lot more useful.

2nd year

3rd year - For people who didn't do science in their last years at High School may have found 1st year a lot more useful.

My attitudes towards science have changed because we have to look at science from a child's perspective rather than an adult's.

You have proved that science can be fun. After 1st year I wasn't looking forward to 2nd and 3rd but it has been really interesting and at times rewarding. Both personally and professionally.

Third Year female 5

High School memories

Year 11 - I can remember doing a lot of book work which was only a matter of reading and answering questions. I saw science as a "bludge" because it was mainly the teacher standing out the front talking to us and chose to listen or not listen.

We had 2 lessons a week on science and probably every second week we did a hands on experiment. I remember this as a fun time, where we could muck around. There was not much hands on experience and the little we did do I can't remember meaning much.

The only part of science which I enjoyed and remember was Biology, because it related to animals (I remember a hopping chordata) and people.

Year 12 - Did not do any science.

APPENDIX 3.4 SAMPLE OF FIELD NOTES FROM PRE-SERVICE TEACHER
INTERVIEWS Continued

University

1st year - General Science was heaps of fun because it was completely different from any kind of science I had learnt before. It also dealt with many different topics and was constantly presenting new information to us.

Most importantly it was hands on and we learnt through doing, which was something I had not experienced before!

2nd year - I learnt a whole lot of new things this year. It became more specific and related more to our teaching. It still remained hands on and was still heaps of fun.

3rd year - Very exciting and heaps of fun because it's more hands on than any science we have done before. It relates directly to our teaching and I find there is more opportunity to learn from each other. Because we are working in a group situation we get ideas from each other. I have found that during my teaching practicum, I have used many ideas which I have collected from science.

Third year female 6

Curriculum Science has been of real value to me personally. It has provided me with practical ideas that I will be able to take to the classroom.

High School science was always great fun with the exception of Biology. I was really into Chemistry and was put in separate classes during year 10 and 11. I didn't do a science in year 12 because I wanted to do my more artsy subjects in hopeful preparation for ECE at Uni (I made it!!).

General Science was a big waste of time for me mainly because I had come to Uni to learn how to teach children and understand them and here I was playing with bikes and talking about clocks. These were all very interesting topics, but it gave me no ideas about what I could show 5 year olds about science.

Generally, Curriculum Science has been fantastic in regards to teaching and preparation of lessons. I have thoroughly enjoyed participating in the practical sessions and I can see how I could make science lessons more exciting and interesting for my classroom.

INTERVIEWS WITH SECOND YEAR STUDENTS, 1994

Female 1

I find Curriculum Science to be far more interesting than General Science.

In school I hated science and did not carry it through to my final year in High School. I dropped Biology and Chemistry at year 10 and Physics at year 11. My grades were OK but in year 11 my Physics attempts were disastrous. Since then I have had no interest in science at all.

APPENDIX 3.4 SAMPLE OF FIELD NOTES FROM PRE-SERVICE TEACHER INTERVIEWS Continued

When doing General Science I found parts of it were interesting while other parts were a real turn off. Those areas which paralleled my school experiences I paid little attention. The biological component lost me completely. I felt I was sinking, it held no interest. That was the worst component. The best I found was the last one where we looked at chemical properties. This was fun, enjoyable and practical. This did give me a better feeling towards science than my school experiences had.

Curriculum Science has given me a renewed interest in discovery and exploration. I now have a more positive feeling towards science. This year I have learnt how science with children can be fun and exciting. I don't have to teach boring things to them. Science can be made as fun and as exciting a subject as language and other such subjects. Curriculum Science I have also found to be practical and useful.

Mature aged female 2

For the first time in my life I feel quite excited about studying science, since being involved in science last year. The hands on approach and learning by experience is great as I've always found that to be the way I learn best.

General Science which I only studied for my first year at High School wasn't as much fun. All I can remember is a laboratory with test tubes and dissecting mice. At that stage I never considered science to be important for me to learn.

With Curriculum Science I can clearly see that science is a part of every day life integrated into all other areas.

I am looking forward to teaching science to young children and encouraging their natural curiosity and delight in exploring things.

I therefore feel that Curriculum Science is a very necessary part of a child's education programme and that the teacher needs to follow up interests of each child which could lead into other areas of research.

Overall I now believe that science is fun and stimulating as it causes one to think and problem solve.

APPENDIX 3.4 SAMPLE OF FIELD NOTES

INTERVIEW EXEMPLARY TEACHER 5

Background: Lived in inner metropolitan area, near a geological form. Loved to explore and find things. Collected rocks, lizards and went mushrooming. Enjoyed riding motor bikes. Encouraged to explore by parents. Can't remember primary school science.

Geography (no Geology offered) and Biology were taken until year 12.

Lack of choice of subject dampened aspirations to be a geologist. There was no career counselling. General perception from school and family seemed to encourage her to be a secretary, teacher, or nurse.

Chose teaching as she lacked the confidence and couldn't afford to go to university was expensive. Hated playing with children and felt that a career wouldn't really happen.

Tertiary Applied for kindergarten teaching but had to learn a musical instrument in order to be accepted, which she did not want to do. Went into Junior Primary teaching instead at a different teachers' college because it also paid more.

During an orientation camp at which an overview of all subjects was presented she decided to select drama as she liked acting and science because she liked the lecturer presenting the subject.

She studied general science in first year and particularly enjoyed the lecturer, and the biological and physiological underpinning.

In second year she also studied geology and in third year majored in science, specialising in Geology. Science became interesting because:

- a) of the personalities of the lecturers involved.
- b) it seemed applied and practical.
- c) there was considerable scope for individual projects.

The teacher applied for an advanced diploma but did not achieve high enough grades to receive it.

Teaching experiences

Felt devastated in her first country appointment. Attributed feeling to lack of preparation during field experience. Taught children by relying on instinct and past experiences.

Gained confidence over a 3 year period. Taught a big proportion of Aboriginal students. Enjoyed teaching informal science - tracking through sandhills - visiting local sheep stations.

Returned to the city and volunteered to teach non-contact science, PE, drama and language arts.

APPENDIX 3.4 SAMPLE OF FIELD NOTES Continued

Eventually specialised in science

In 1978 she received a release time scholarship to undertake a B.Ed. majoring in Science. Chose curriculum science because it was related to teaching a practical. Welcome member of a cohesive group comprising the original lecturer and five other students all of whom were encountered during orientation. All of the group became key teachers or science advisers and were founding members of the Primary Science Teachers' Association.

The teacher was appointed to schools in the South where she continued to teach science as a specialist subject. Emphases were always placed on Environmental Education, Outdoor Projects, Staff Inservice.

Attitudes to Science

The teacher suggests that some children just don't like science, due to external influences, or personal conflict with her. However, her research suggests that the majority of children enjoy the subject. Girls like to 'make' and 'do' activities.

Feels that her science is most effectively used as a specialised subject:

She uses a range of activities.

She models valuing science to children. Tries to make the lessons interesting and gives encouragement awards.

She suggests that teachers generally:
find science too hard
lack knowledge
lack time
don't enjoy science
make superficial changes to suit curriculum expectations
will teach science for profit
teach science through theme.

The teacher

is interested in science
prefers biology to physics
is proud of teaching
likes to work with local Nature centre
feels that parents value her work.

APPENDIX 3.5 EXAMPLE OF PRESCHOOL VIDEO TAPE TRANSCRIPTION

LOCATION 1. Group 2 Australian Animals. The teacher asks if the children would like to look more closely at a caterpillar in a container.....

T Can you see it.

Amy A black one. It's a real one.

T It's a real one is it? How do you know it's real?

Emily It's black.

T What else is it doing?

Amy There's leaves in there and bark.

T Leaves and bark. And it's dark in there.

Emily It's asleep.

T Is the caterpillar soft?

Joe Can I touch him?

T OK. Would you like to touch him Sam, you can. Would you like to touch, Emily?
You can touch the caterpillar.

Sam He bites.

T You can go and have a look and touch the caterpillar, he's quite friendly.

Emily Touch with our fingers?

T Yes.

Joe It's round there (name) look. It's a black caterpillar. See it.
Don't touch him.

Joe It's a cat (interrupted).

Sam Don't (name). Don't do it. Don't touch the caterpillar.

T Do you want to see the caterpillar. You can take him out if you want him in your hand. Would you like to do it.

Emily There he is.

Joe He's moved.

T Is he?

Sam Yes.

APPENDIX 3.5 EXAMPLE OF PRESCHOOL VIDEO TAPE TRANSCRIPTION
Continued

- T Do you know why? We've got a magnifying glass here. Would you like to use it to have a look with.
- Joe Yes. I'd like to have a look.
- T Hang on. (goes to get down magnifying glass)
- Sam Don't touch it.
- Joe Yes.
- T Is it still there? Is the caterpillar still there?
- Amy Yes.
- T Has he gone away? There you go. Let me have a look with the magnifying glass.
- Joe He's still there.
- T Is he. Let's have a look and see if he's bigger or smaller.
- Sam It's too deep.
- Amy Don't. Don't.
- T We're sharing. C'mon let's have a look.
(the children thumb at the caterpillar to make it move)
- Amy shake it.
- Emily It's grown big.
- T Is he coming out?
- B No.
- T Is he coming out?
- T Is he coming out?
- Joe No.
- Amy Don't. Don't. He's coming out.
- Joe See. He's all the way out.
- Amy Put him back in.
- T Has he come out?
- Joe Yes.

APPENDIX 3.5 EXAMPLE OF PRESCHOOL VIDEO TAPE TRANSCRIPTION
Continued

T Have a look through the magnifying glass Sam. Have a look, let's share. Here he is. He is black isn't he.

Sam Yes.

T Sharing.

Amy I've got two, too.

T Can you see two. Turn the magnifying glass.

Amy Yes.

T Oh.

Joe Give it to me.

Emily He's moving.

Amy Don't. Don't.

Joe I saw a big caterpillar.

T Did you where and with what?

Joe With this.

T What's that? Do you know what that's called.

Emily I don't.

T Have you used a magnifying glass?

Joe See there's only two big ones.

T You're so gentle.

Amy Don't. Don't. Don't.

Joe He's got that. Give him that.

Emily He's soft.

Sam Get off.

Amy You could get off.

Sam I'm here.

Amy Put him in here.

Sam No.

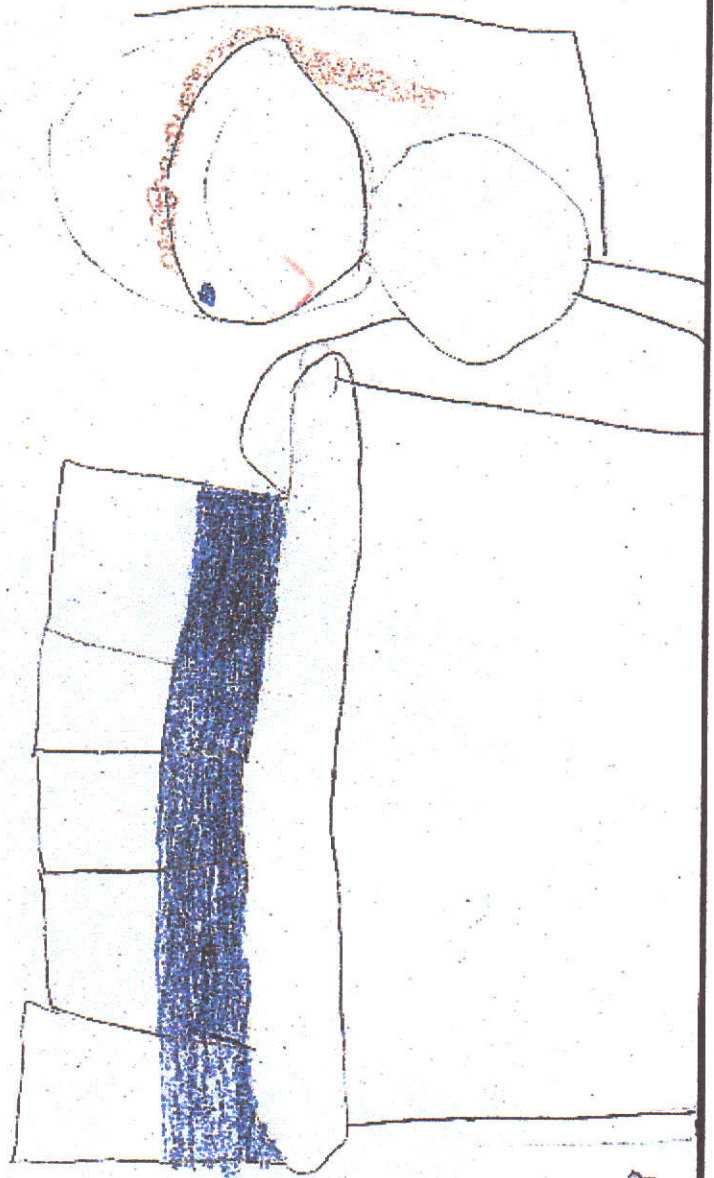
Emily Go on. Put it over the edge.

Amy Oh look it moved over my hand. (laughter)

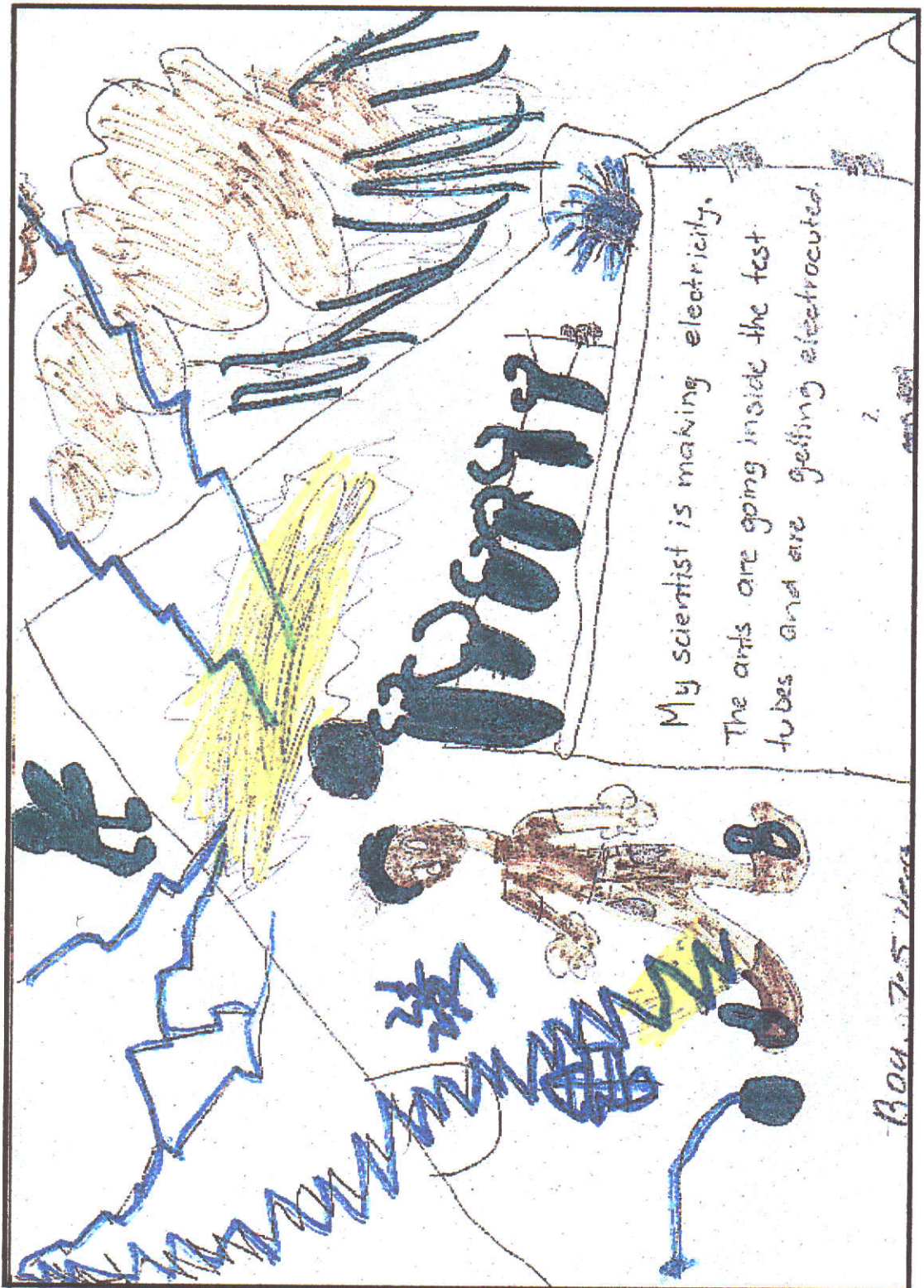
APPENDIX 3.5 EXAMPLE OF PRESCHOOL VIDEO TAPE TRANSCRIPTION
Continued

- T Be gentle, let Sam have a turn. It's Sam's turn now Amy. Can you share it with Sam? Good.
- Sam He's got furry.
- Amy Don't.
- T Perhaps if you give him a little tickle. You can pick him Emily, your turn. Emily's turn.
- Amy Don't.
- Sam Hurry, hurry.
- Joe Quick, quick we need the
- Amy Don't chew them.
- Sam I can.
- (pause)
- Emily Can't come.
- (pause)
- Sam You say, tree.
- Emily Two caterpillars.
- Amy I can touch him.
- T Have you all touched him. How about we put him back in here I think he'd like to go back home.
- T Leaves and bark. He needs his leaves and bark. Cover him up.
- Joe No. You can't. Bark. Bark. I'll do it.
- Sam I'll do it.
- Joe No. I'll do it.
- T Sharing children, sharing together, working together. Emily pop the lid on now. Good girl. Gently, safely shut the door.
- Amy I put caterpillar in because he was tired.

My scientist is a lady. She is doing an experiment
with water. She is seeing the things that float and the
things that don't float.



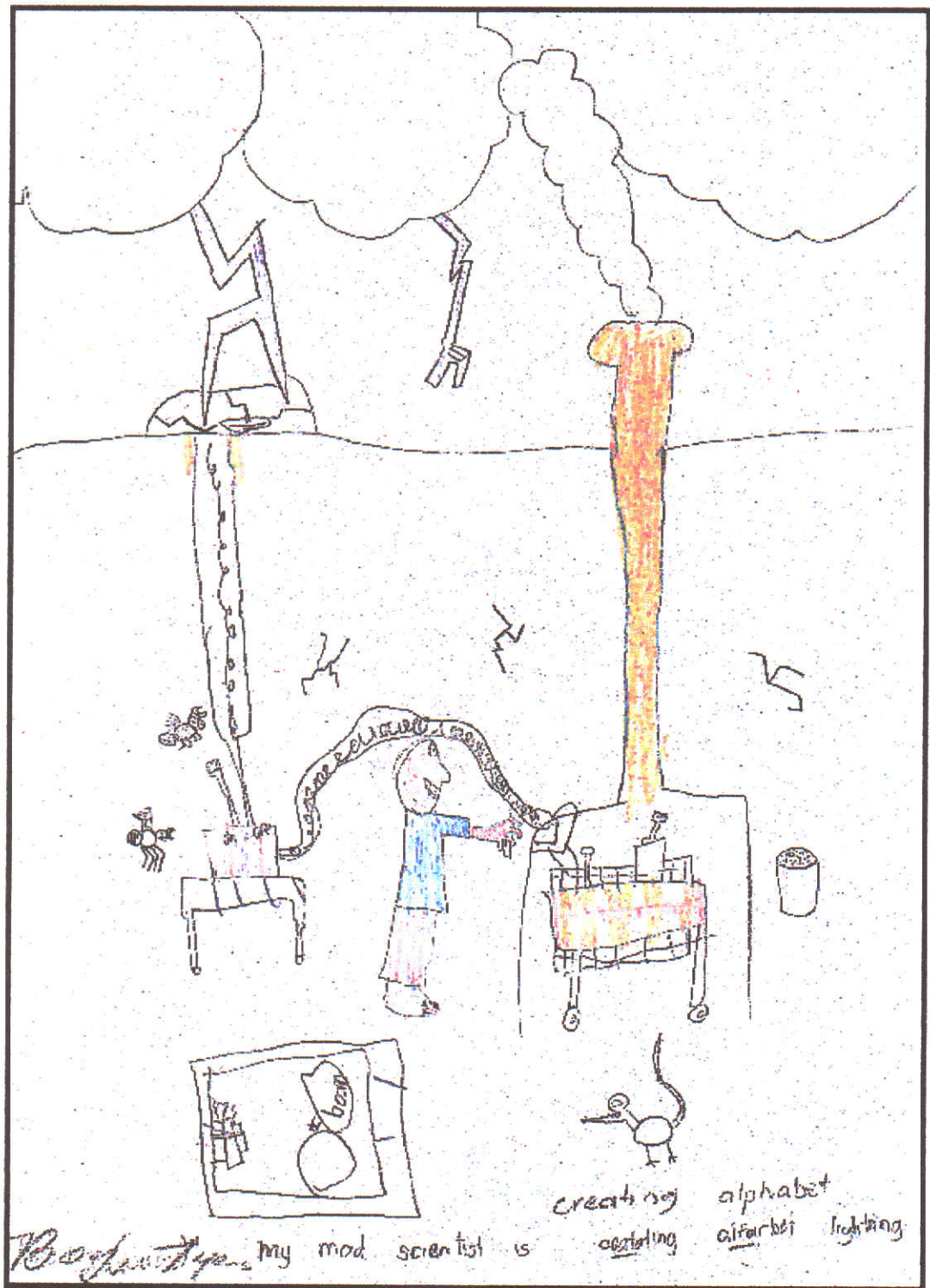
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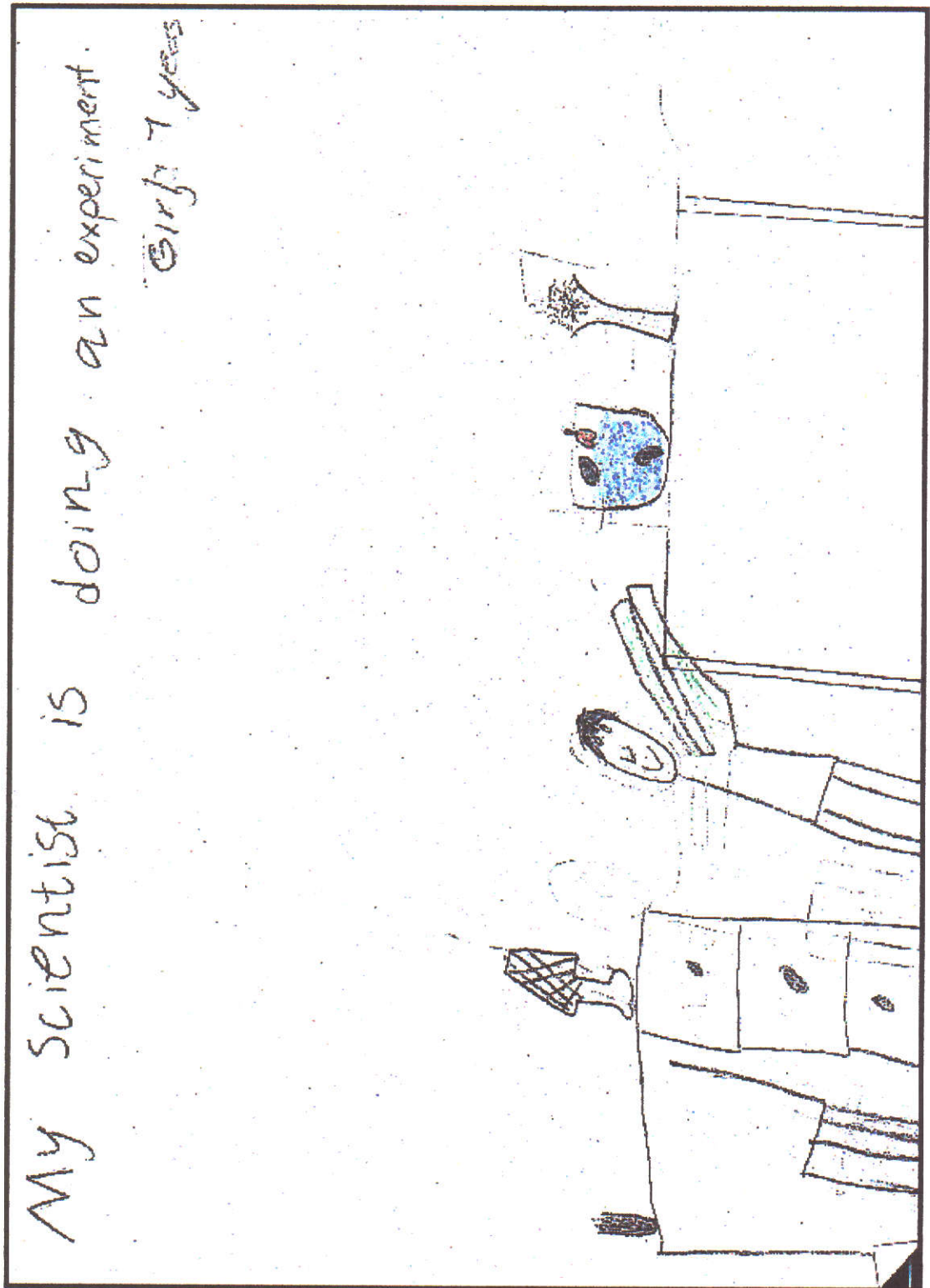


My scientist is working. He is writing about how the
energy in his legs make him walk.



Boy 7 years





APPENDIX 3.7 SAMPLES OF CORRESPONDENCE

21 April 1993

Dear

Thank you for the interest that you showed in curriculum science at the ECE field supervision meeting held at Campus on March 25th.

With your permission I would like to visit your school and spend approximately thirty minutes to enquire how your ECE student is feeling about science teaching. I am also interested to know your opinion as to what makes a good science teacher.

I am normally available to visit schools on Wednesday morning, and all day Thursday, but if this is unsuitable I will endeavour to be free another time. I will contact you by phone, early in Term 2 to make arrangements.

Sincerely

SHARON RUSSO

APPENDIX 3.7 SAMPLES OF CORRESPONDENCE

Note: For copyright reasons three of the four letters in Appendix 3.7(pp183-5 of this thesis) have not been reproduced.

(Co-ordinator, ADT Project (Retrospective), Curtin University of Technology, 4.12.02)

APPENDIX 4.1 OPEN ENDED RESPONSES TO ECEAS

Group1
 FIRST YEAR
 STUDENTS WHO HAD TAKEN
 GENERAL SCIENCE 1992, SEMESTER 2

Positive Responses	Negative Responses	Response to Practicals	Comments re Science Subjects
Need to learn more	Lacks confidence	Likes Experiments (3)	Prefer Biology (7)
Enjoyed (8)	Too difficult (3)	Likes practical approach (3)	Prefer Chem.
Gained confidence	Hates Science (2)		Confident Chem/Biol.
Relates to values (4)	Undecided		Disliked Chem equations
Interesting (10)			Dislikes Physics
Worthwhile (2)			Dislikes machines
Useful			Refers to high school science (2)
Seen as part of life			
Like science (2)			
Fun (1)			
OK (3)			
<hr/>			
Nil Response (61)			

The number of repeated responses received is shown in brackets beside the comment.

APPENDIX 4.1 OPEN ENDED RESPONSES TO ECEAS Continued

Group 2
SECOND YEAR
STUDENTS WHO HAD TAKEN
CURRICULUM SCIENCE 1992, SEMESTER 2

Positive Responses	Negative Responses	Response to Practicals	Comments on Science Subjects
Wants to learn more	Sense of failure from High School	Likes challenging (2)	Prefer Biology (5)
Enjoyed learning (7)	Not interested	Likes hands-on (7)	Prefer Chem.
Gained confidence (5)	Lack confidence	Likes experimenting	Prefer Physics
Confident to teach	Undecided		Prefer Genetics
Interesting (13)	Dislikes most science		Lacks confidence in Physics and Chem.
Helpful			Blamed High School experiences for problems, feelings in science (6)
Important (7)			
Seen as part of life (3)			
Fascinating			
Stimulating			
Fun (5)			
Useful			
Depends on how presented			
Not as scared as used to be			
Nil Response (7)			

The number of represented responses received is shown in brackets beside the comment.

APPENDIX 4.1 OPEN ENDED RESPONSES TO ECEAS Continued

Group 3
**THIRD YEAR TRANSITION STUDENTS
 WHO HAD TAKEN GENERAL SCIENCE AND
 CURRICULUM SCIENCE IN REVERSE ORDER
 1992, SEMESTER 2**

Positive Responses	Negative Responses	Response to Practicals	Comments re Science Subjects
Need for more Science (2)	Anxious re-teaching it	Enjoyed exploring	Prefer Biology (16)
Enjoyed learning Science (7)	Sense of failure from High School (4)	Likes challenge	Prefer Chem.
Developed confidence and knowledge	General Science difficult (3)	Liked hands-on (5)	Prefer Genetics
Enjoyed teaching it (5)	Did not like assessment	Practical (2)	Prefer Geology
Supports ideas re pedagogy (2)	Lack of confidence (4)	Liked experiments (3)	Confident Physics (2)
Interesting (6)	Hesitant		Lack of confidence in Physics/Chem (4)
Worthwhile	Lack of knowledge		Disliked High School Science (2)
Important	Mechanics difficult		
Enjoyed Curriculum Science	No use for General Science		
Seen as part of life (2)			
Comfortable to teach (3)			
Like Science			
Fun (2)			
H.S. should be taught			
Like Science Ed.			
<hr/>			
Nil response (3)			

The number of repeated responses received is shown in brackets beside the comment.

APPENDIX 4.1 OPEN ENDED RESPONSES TO ECEAS Continued

Goup 4
THIRD YEAR
CURRICULUM SCIENCE STUDENTS
1993

STUDENTS HAD COMPLETED GENERAL SCIENCE AND
TWO YEARS SEMESTERS OF CURRICULUM SCIENCE

Positive Responses	Negative Responses	Response to Practical	Comments on Science Subjects
Wants more philosophy	Lacks confidence but believes this can be overcome	Likes discovering and exploring	Prefer Biology (4)
Broadening Enjoyed learning (5)	General Science was a waste of time	Likes hands-on (6) Likes experimenting	Prefer Chemistry Finds Physics, electricity and sound difficult
Developed confidence (6) Enjoyed teaching it (9)			General Science valuable (2) Overcoming negative Pt. school experiences which had given feelings of 'dumbness' / failure (3)
Supports pedagogy Interesting (8) Very good (2) Important Comfortable to teach (9) Like science (3) Fun (2) Children love it			
Nil Responses (14)			

The number of repeated responses received are shown in brackets beside the comment.

APPENDIX 4.1 OPEN ENDED RESPONSES TO ECEAS Continued

Group 7
 A SUMMARY OF OPEN-ENDED RESPONSES FROM DATA - COLLECTED
 FROM ECEAS SURVEY TO PRE-SCHOOLS, SEMESTER 2, 1993

Positive Attitudes	Negative Attitudes	Statements Re Subject Preference
Hands-on Science	Some areas of science are difficult to discuss with preschool children	Staff need workshops on science curriculum with experiments to do with children
Important	Lack of confidence in teaching physical science	Enjoy astronomy, medical break-throughs, animal sciences, genetics
Helps to develop an inquiring mind	The word science is often misunderstood	Enjoyed physiology
Enjoys teaching it to children	Not my favourite subject but I enjoy some aspects of it	Science is part of our everyday life
Enjoys learning about activities to teach children	There is a need to be related to daily comments, practical comments leading to more abstract	There is a need to concentrate on Environmental Science
Like science on a simple, practical level	Lack of knowledge in some areas	Animals and plants are fun for young children
Fascinating	Keeps it at a lower level	Greater emphasis on natural science (living things). Feel that natural science is very important with young children.
Wonderment of discovery	I have not enough knowledge	Mainly environmental concerns
Essential, worthwhile curriculum area	Lacks confidence in teaching it. Would like more practical inservice on science topics.	Really enjoy life sciences: Biology, Botany, Genetics.
Children enjoy it as they are learning by doing		The idea of Physics exams still strikes terror in my heart.
Exciting		Very interested in all aspects of science - enjoy the physical and environmental aspects and am very interested in how chemicals effect us.
Can handle it at preschool levels		Has an extensive arts background. Very interested to know more about science.

APPENDIX 4.1 OPEN ENDED RESPONSES TO ECEAS Continued

Bikes, basic experimenting eg colour with very young children	I am very interested in the sciences - especially biological and environmental
I live with a family who live 'science' and enjoy showing what I've learnt and am learning to children and others.	Unsure about a number of aspects eg Physics and Chemistry.
Useful subject, interesting, varied, varied, important for children.	Found Physics difficult but enjoyed Biology and Chemistry.
Feels positive about science in general - but physical science more challenging to do with preschool children.	Enjoys natural science.
Interesting and good fun. Include it in an inclusive curriculum weekly.	
Can be challenging.	
Great with children.	
Some aspects are interesting and easy to do with preschoolers.	
Some topics are easier to teach than others.	
An important part of the preschool program. We grow things, make compost, breed worms as well as learning about light - magnets etc and making mud bricks.	
Every child I have worked with has found science an exciting and valuable part of our program.	
All aspects of science help children with problem solving skills for every day life.	
Interesting.	
Enthusiastic.	
Feels capable of teaching it.	
Feel more confident working with children.	

APPENDIX 4.1 OPEN ENDED RESPONSES TO ECEAS Continued

Group 8

A SUMMARY OF JUNIOR PRIMARY RESPONSES TO
OPEN ENDED QUESTIONS FROM ECAES QUESTIONNAIRE

Feelings about Science	Science subjects to Year 12			
	Biology	Physics	Chem.	Other
Loves science after being made to teach if for 2 years; finds it hard work. Believes she is giving many opportunities to students. Prior to this learnt science from memory, perceived lack of encouragement of High School		✓	✓	Maths
Science useful and exciting hands on approach. Participated in inservice program run by Investigator Science Centre.	✓			
Confident with young children. Dislikes aspects of physical science.	✓			
Positive, highly values, enjoys problem solving, learning about environment.	✓			
Important for problem solving.			✓	
Hands on science is great.	✓	✓	✓	
No comment.	✓			
Exciting, enjoys plant and animal topics.	✓			Geology/ Earth Science
No comment recorded.	✓			
Physics and Chemistry boring, hated learning formulae. Biology more interesting. Enjoyed feedback from Hands On Science with JP children.	✓	✓	✓	
No comment recorded.		✓	✓	
Not a classroom teacher, gradually gained confidence in hands-on activities. Supported by a specialist room, texts, equipment. Enjoy feedback from children. Would not have believed that 2 years ago as a classroom teacher she would ever teach science.	✓		✓	
High School science boring - felt put down by boys. finds JP science exciting and interesting. Encourages girls as much as possible.	✓			
Worthwhile subject as it increases skills in other areas. Problems experienced with lack of equipment.	✓		✓	

APPENDIX 4.1 OPEN ENDED RESPONSES TO ECEAS Continued

Feelings about Science	Science subjects to Year 12			
	Biology	Physics	Chem.	Other
Science is worthwhile as a problem solving subject as it promotes thinking and language. Needs to be taught across the curriculum. Has found input from Sci-Tech project valuable.	✓			
Interested. Enjoys Biology and Chemistry	✓	✓		
Worthwhile topic that involves all areas of the curriculum. Great for young children, when taught in a 'hands-on' way.	✓			
Feels disadvantaged by science taught at High School, in that she became afraid to take risks, wishes to remedy this with children. Science for young children is a part of life and can be integrated in many areas of curriculum.		✓	✓	
Became interested in science while at College. Now went on to further studies in science. Now teaches science as a specialist teacher. Proud to teach all aspects of science to 300 students.	✓			
Interesting.		✓	✓	
Love it - integrated in all subjects.		✓	✓	
Think it will become more important in future.	None			
Finds physical science more interesting.		✓	✓	
Strongly agrees with statements made in R-7 Guidelines. Encourages children to explore technology in science.		✓	✓	