Science and Mathematics Education Centre

A Case Study of Design and Technology in the Early Years of Schooling

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ABSTRACT

Design, make and appraise (DMA) activities form a major component of the relatively new primary curriculum area of technology education. This case study is a descriptive and interpretative account of one teacher's attempt at implementing a DMA program in a class of children in their first year of formal schooling. The study seeks to discover and explore some of the factors and structural and organisational issues that arise during the implementation of a DMA program. The research aims to expand the knowledge base of the DMA strand of technology education as the teacher attempted to grapple with the problem of translating the theoretical technology education curriculum statements into practical realities in the classroom. This study highlights the importance of the teacher, her organisation and planning and selection of appropriate teaching strategies. Group work, continuous assessment and the provision of adequate and appropriate resources were also found to be important contributing factors. Three further issues were found to emerge from the study. Firstly there was a weak link between the children's designing stage and their making and appraising stages. Secondly, DMA has the potential to assist schools to work towards a more gender-neutral curriculum in which both girls and boys have equal access. Special education children were found to be assisted by involvement in DMA activities. And thirdly, the setting of DMA tasks was seen to be an issue that could cause difficulties. Finally, a number of implications for teachers arose out of these findings and they have the potential to improve DMA teaching and learning.

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INTRODUCTION

1 PREAMBLE

The word *technology,* perhaps more than any other, best captures the spirit and essence of our modern world. Technology has a history as old as the human race and has been one of the special features distinguishing human beings from other forms of animal life. Early technology was simple, with basic tools being made from stone and wood. From these primitive beginnings technology has developed and today encompasses a wide range of diverse fields that represent important technological products and processes.

Simon Crean (1990), a former Federal Minister for Science and Technology, argued that technology is becoming increasingly important to Australia's economic and social development and that science and technology education underpins our future capability as a nation. Despite the pivotal role technology has played in the course of human development, it has rarely appeared as a major area of study in formal education. The final quarter of the twentieth century has provided a dawning realisation that the dearth of attention to technological education was a mistake (Tickle, 1996). Fortunately, this situation is now starting to change. Educational authorities around the world are now including technology as an area of study throughout the years of compulsory schooling. They are recognising the importance of technology education for national economic and social well-being, long-term employment prospects and even global futures. In Australia the recent introduction of the National Statements (Curriculum Corporation, 1994b) - which guide the development of curricula, and their accompanying National Profiles (Curriculum Corporation, 1994a), has seen technology education acquire recognition and status as a legitimate and mandatory area of the curriculum to be taught to all children during the compulsory years of schooling. However, most attempts to introduce technology education into the school curriculum have been marginal (Lewis, 1991). In many respects, as a component of the total school curriculum, it is contested terrain that is still in the process of creation (Donnelly, 1992). Yet technology as a component of general education can serve as a new thrust for curriculum renewal and relevance (Vohra, 1987).

Technology is the generic term which encompasses all the technologies people develop and use in their lives (Education Department of Western Australian, 1994). Four interdependent strands of learning in technology are described in *Technology - A statement on technology for Australian schools* (Curriculum Corporation, 1994b). They are:

- Designing, making and appraising (DMA)
- Information
- Materials
- Systems

According to the 1994 statement, all learning in technology involves the DMA strand in which students explore, apply and develop information, materials and systems. The relative emphasis on the other three strands varies according to the needs of students and the nature of the programs and activities. A more detailed definition of the DMA strand refers to those opportunities presented to students which develop technological capability through planning, developing and refining design concepts; selecting appropriate tools, materials and processes for particular design purposes; carrying designs through to completion; and appraising the outcomes (Education Department of South Australia, 1990).

In the past technology education in primary schools has received only minimal attention from educational researchers, although several have appeared in recent years (Jane, 1995; Jones, Mather & Carr, 1995; Ritchie & Hampson, 1996). Basic questions about the nature of technology and children's understanding of it during the early childhood years (pre-school, kindergarten and years one to three) and at the primary level is an area needing a concerted research effort (Fleer, 1991b, 1992a; Hardy, 1993). During the late 1970's, Dowdeswell (1979) observed in Britain that the study of technology hardly featured in school courses at any level. According to Anning, Driver, Jenkins, Kent, Layton and Medway (1992), there is a need for studies that focus on students' actual technological problem solving activities. When Brown (1989) began her study of the technological achievements of six to nine year old children in Britain, she believed that she was breaking new ground by embarking on relatively uncharted territory. There is a clear need for a greater research effort about the nature of technology education at the primary level (Hardy, 1993; Anning, 1994). According to Jenkins (1994), there is far too little known about how design and technology education is conceptualised in a variety of contexts, and about children's competences in, and attitudes towards, this aspect of their education.

This lack of research can be associated with the apparent perceived low status afforded education in the early years of schooling. For example, during the early 1980's, teachers and researchers with an interest in gender issues tended to neglect the early years of schooling (Weiner, 1991). It was assumed that there was not a problem at this level of schooling. It has been further claimed that teachers of younger children have often been seen as having less ability and therefore less status in education (Burn, 1989).

A lack of technological knowledge on the part of teachers has been isolated as an important variable contributing to the poor teaching of technology (Dowdeswell, 1979; Jeans & Farnsworth, 1992). It has been claimed that many Swedish primary teachers could be regarded as rather uneducated in technology (Lindblad, 1990). In addition, Page (1987) has asserted that many female primary teachers in England possessed little or no formal training in the handling of tools that are used as an integral part of the DMA curriculum. This could cause some of these teachers to shy away from implementing DMA in their classes because they may wrongly perceive that they are not very technologically competent. Closely linked with this potential for teachers to lack technological knowledge, is the teacher's perceptions of what is technology. Rennie and Jarvis (1995) believe that teachers are confused about what is meant about the term 'technology'. Because teachers have been found to possess a diversity of meanings of technology, this has resulted in confusion among teachers about both the content and pedagogy associated with technology education.

A lack of confidence has been shown by many primary teachers in the area of science. This has resulted in inadequate science programs (Jeans & Farnsworth, 1992; Jordan, 1992; Willis & Kenway, 1986). According to Browne (1991), some early years teachers are not convinced about the value of science education for their students. She suggested a possible explanation for this situation was that many of the early years teachers are women who were 'switched off' science at a relatively early age of their own schooling. As a result, many of these teachers became afraid of teaching science and were unclear about what it was that their children should be learning. Similar feelings of insecurity and lack of confidence have also been found in female teachers of young children with regard to their mathematics teaching (Walden & Walkerdine, 1982). According to Browne (1991), similar parallels can be applied to the teaching of science and technology in the early years. While working with many female early years teachers, Burn (1989) had seen them undervalue their teaching ability. A lack of background experience and confidence in teaching DMA can result in many early years teachers feeling that they do little if any of it in their classroom (Benson, 1990a). Teachers' negative beliefs can have profound effects on a young child's attitude towards the subject (Browne, 1991).

Another problem concerns the lack of adequate resources which can be an impediment to the introduction of technology to schools (Australian Academy of Science, 1991; Lewis, 1991; Za'rour, 1987). In their study of primary science education in three Australian states, Jeans and Farnsworth (1992) found that the availability of equipment (which they found was directly related to funding priorities) was a significant impediment to the teaching of science. Unfortunately, DMA in the primary school also appears to suffer from the allocation of insufficient resources. The apparent lack of facilities and the paucity of suitable teaching materials for DMA in primary schools have been acknowledged by Dowdeswell (1979), Lewis (1991), Page (1987) and Williams and Jenks (1985).

In their evaluation of curriculum materials for teaching technology as a design process, Rennie, Treagust and Kinnear (1992) highlighted the problem caused by the lack of clear-cut guidelines for primary teachers on the introduction of technology as a design process. In South Australia this situation appears to have been addressed with the release of documents such as *Introducing technology education R-7* (Department for Education and Children's Services, 1994) and *Using tools in the classroom: R-7 technology and science* (McLoughlin & Wright, 1994).

Another critical research issue in the area of DMA concerns the stage at which it is introduced and taught to children in primary schools. In Australia, the document *Technology - A statement on technology for Australian schools,* (Curriculum Corporation, 1994b) advocates that technology be taught to all children starting in year one. Other countries have also advocated teaching technology in the early years of schooling. For example, in the United Kingdom the National Curriculum Council has issued revised attainment targets and programs of study for technology, commencing with year one children (Anning, 1994). In the United States, Project 2061 (Rutherford, Ahlgren & Warren, 1989) has also set national benchmarks for science and technology beginning with level one for children commencing in elementary schools. In Sweden, the teaching and learning of technology begins in their nursery schools which cater for children up to seven years of age (Edlind, Granstam, Haggenstrom, Jarvinen, Kernell & Segerborg, 1987).

There are several gender issues that relate to teaching and learning DMA. Girls do not seem to have the same chance to develop the understandings of technological concepts that boys learn through their tinkering and playing with construction sets and mechanical toys (Brown, 1989, 1990; Peck & Dick, 1989). In early childhood settings, girls have been found to use construction toys less than boys and this tendency very quickly develops into a reluctance to take risks with construction toys and activities (Ross & Browne, 1993). In a toy survey conducted in an English junior school, it was found that boys were far more likely to have toys at home that developed spatial ability and that provided opportunities for problem solving (Burn, 1989). By the time that girls leave primary schools, most appear to have already developed the attitude that technology is not for them. Many appear to lack the confidence to readily participate in technological activities and thus inhibiting their chances of eventually competing in the work place against men for high status, highly paid, hitech occupations (Eke & Gardner, 1991; Jordan, 1992). Societal gender expectations through sex-role stereotyping seems to be unwitting and unconscious and is probably deeply embedded in the social life worlds in which the children are growing up (Smithers & Smithers, 1984).

A number of studies concerned with girls' under achievement and participation in science and technology in secondary schools have made recommendations for action in the primary school (Doherty, 1987; Johnson & Bell, 1987; Tall, 1985). These studies have argued that technological education should commence in the early years of schooling because positive attitudes towards the subject are more likely to be found at this age (Page, 1987).

In summary, it would appear that technology education has been a largely neglected area of the curriculum which is now beginning to emerge as an important key learning area. In fact, Eggleston (1992) asserts that design and technology is now one of the fastest growth areas of the contemporary curriculum. The teaching and learning of DMA in the early years of schooling has been shown to be an under researched field. In Australia the technology curriculum involves the DMA strand being taught through the content strands of information, materials and systems. In the past, DMA [also referred to as design and technology in this thesis] has not been well taught in many schools for a variety of reasons. Teachers have had a lack of technological knowledge and confused perceptions of technology education. A scarcity of resources may have also contributed to the poor uptake of technology in schools. Lastly, the difficulties encountered by many girls learning DMA has also been discussed. Thus the teaching and learning of DMA in the early years would seem to be an area of the curriculum worthy of further investigation.

2 PURPOSE OF THE STUDY

The main purpose of this proposed study will be to contribute to the knowledge base of design and technology education by observing a DMA program in an early years classroom. The study will attempt to gain a greater appreciation and a deeper understanding of the classroom environment in which a DMA curriculum is being implemented. The following three research questions will provide a starting point to guide the investigation:

1. What are some of the factors which influence the implementation of a DMA program in an early years classroom?

2. What are some of the structural and organisational issues which arise during the implementation of a DMA program in an early years classroom?
3. What are some of the implications for classroom teachers which arise out of these identified factors and issues?

The first research question will seek to identify those key elements of the DMA program which seem to contribute to successful learning outcomes for the children. In addition, the second research question will seek to identify any issues which may have the potential to cause difficulties during the DMA implementation process.

The focus in this study will be on one early years classroom, and any outcomes arising from the findings should initially benefit the participants, particularly the class teacher. The study will examine the factors at work during the implementation of a DMA program and so form richer understandings of pedagogical actions within an early years classroom. The study may reveal insights, ideas and suggestions that other teachers might be able to use for their own DMA programs. It may assist these teachers to further reflect on their own DMA teaching practices which in turn could lead to enhanced learning outcomes for the children in their classes. Given that there appears to be a paucity of case studies that focus on the early years of schooling, this study will therefore attempt to provide some new insights into this important key learning area of the curriculum.

3 METHODOLOGY

The following is a brief outline of the methodology to be used for the study. A more detailed description and rationale will be described in chapter 3. This study will focus on a single early years classroom in which a DMA curriculum is being implemented. In order to investigate the initial research questions a descriptive and interpretive case study (Peshkin, 1993) will be conducted. The initial research questions may undergo further modification and refinement as the data collection and interpretation process proceeds. A mainly qualitative approach will be followed although some quantitative data will be obtained in order to provide background information about the classroom and the children's initial level of awareness and exposure to technology. In order to achieve the latter, each child will be formally interviewed about their favourite toys, occupational aspirations and home computer exposure. In addition, the Draw a Scientist [Technologist] Test (DAST) (Chambers, 1983) will be administered to ascertain technological awareness and the children will be asked to explain the features of their DAST drawing during a follow-up interview.

A detailed observation of the DMA program will be undertaken in the classroom over two school terms. This will involve working as a participant observer in the classroom every Wednesday morning for a total of twenty weeks. These sessions will be in the period between morning recess and lunch time. A variety of data sources will be used including detailed field notes, debriefing sessions with the class teacher following each session, audio taping of all sessions and video tapes of some of the sessions during term three. Photographs will be taken of completed models and informal interviews will be conducted with the participants throughout the period of the study. From the assembled data a detailed written description of the implementation of the DMA program will be compiled. During the data collection process emerging factors and issues will be sought, some of which will lead to the need to acquire additional data. Throughout the data analysis process data sources will be rigorously cross-check these for consistencies. The identified factors and issues that emerge from the study will then be presented as a number of assertions.

Following an analysis and discussion of the factors and issues, some of the implications for classroom teachers will be presented.

4 AUDIENCE

The primary audience for this study will be the class teacher and hopefully a wider audience of teachers of young children. Teachers of older children in primary schools may also find many aspects of the study useful. The study will seek to provide a mirror for self-reflection and a stimulus for ideas and suggestions about implementing an effective DMA program within an early years class setting. Some recent research by Zeuli (1994), has found that teacher responses to various pieces of research writing were more favourable towards case studies.

Tertiary teacher educators could form a secondary audience for this study. They may wish to use the study as a case study to guide preservice student teachers (Doyle, 1990; Louden & Wallace, 1996). In addition, educational researchers could also make use of this study as a starting point to sharpen additional research questions about DMA pedagogy.

5 OUTLINE OF THESIS

This study will seek to explore in detail what happens in an early years classroom where a DMA program is being implemented. To guide the investigation, three initial research questions have been posed. The next chapter will provide a dialogue with the literature of previous research in the field of technology education and in particular the DMA strand. It will therefore serve as a platform for the rest of the study by identifying possible gaps in the literature as well as identifying potential areas to focus on during the subsequent classroom observations. Chapter three will provide a rationale for the methodology to be used in this study, a description of the methods to be used to collect and analyse the data as well as a description of the measures to be taken to enhance the trustworthiness of the findings. Some background information about my training, experience and broad philosophical orientation will be given in chapter four together with some background material about the contextual setting for the study. This will include a description of the school, parents, classroom (both physical and pyscho-social features), teacher and children. This will be followed by the next chapter where a detailed narrative description of the DMA program in this early years classroom will be given. In chapter six an analysis and discussion of the program will be presented. Some of the factors and underlying classroom structural and organisational issues that emerged will be discussed. These factors and issues will both be presented as a number of assertions. In the last chapter the implications for classroom teachers that will have arisen from the study will be raised. Finally, some of the limitations of the study will be mentioned as well as suggestions for further research.

CHAPTER 2

LITERATURE REVIEW

This literature review will aim to first provide an overview of the field of DMA teaching and learning by clarifying what is meant by the term *technology education* and discuss the meaning of the terms of technological *capability* and technological *literacy*. The next section will place technology education within an historical context in order to understand how the DMA process has evolved to become an integral part of technology education. This background context will lead into an identification and exploration of some of the factors and emerging issues that may arise during the implementation of a DMA program in an early years classroom. Arising from an examination of the literature on DMA teaching and learning, a number of pedagogical aspects of the DMA process will be explored. Some of these pedagogical aspects include the design process; teacher and student perceptions of DMA; integration of DMA into the general school curriculum; early intervention and DMA; conceptual development of young children in relation to DMA; equal opportunities and DMA; and assessing children's progress in the DMA process. While examining these pedagogical aspects, I will attempt to discover any apparent gaps in understanding about the teaching and learning of DMA. These gaps and pedagogical aspects will then form a starting point to guide my subsequent investigation of the implementation of the DMA program in an early years class.

1 NATURE OF TECHNOLOGY EDUCATION

In order to address the question 'What is technology?' it is possible to frame answers in economic, anthropological, sociological, political or theological terms. Many of the conflicting definitions of technology can be either too technically restrictive or too all-embracing (Woolnough, 1975). Instead of attempting to capture the essence of technology in one definition, it is probably more appropriate to provide a cluster of definitions. Technology can be characterised as a form of human cultural activity that is grounded in purposeful human 'praxis' or action (Frey, 1989). Most definitions of technology in the literature focus on satisfying a recognised human need in a practical way (Clayfield & Hyatt, 1993; Gilbert, 1987; Harlen, 1985; Lever, 1990; Meday, 1989; Wisely, 1988). By contrast, Gardner, Penna and Brass (1990) assert that technology refers to actual artefacts as well as processes that may involve deep cognitive thought, aesthetic judgement and psycho-motor skills.

Because the concept of technology is a value-laden concept and has been associated with a wide variety of meanings, its introduction into the school curriculum has been fraught with a number of difficulties (Lewis, 1991). The concept of technology as part of general education is still fluid (Vohra, 1987) and so its definition has major implications for education. Whenever new money is allocated to a technology curriculum, a prize is up for grabs and the definitions become the battleground (Scriven, 1987). Dictionary definitions of technology tend to suggest that it is about the study of industrial applications of knowledge (Symington, 1987) while Medway (1989) believed that it is a multi-dimensional activity that extends far beyond what has been traditionally thought to encompass technical education. Technology is a dynamic concept in time, and across culture (Lewis, 1991).

A number of colloquial classifications have entered everyday speech by simply adding prefixes such as 'high', 'computer', 'information', and 'appropriate' (Symington, 1989). The clarification of meaning has been further compounded by the fact that the term 'technology' has often acquired a value-laden connotation, resulting in images of either good or evil, depending upon the context. The word 'technology' has been used to represent things, actions, processes, methods, systems, for important working procedures, to represent progress and has also symbolically been used as an epithet (Kline, 1985). The media has often used the word 'technology' in such a way as to link it with the more recent sophisticated developments such as lasers, computers, robots and medical techniques such as the in-vitro fertilisation programs (Symington, 1989). As a result, many teachers are likely to have been influenced by such popular usage of the term and have a narrow and distorted view of technology. They may wrongly assume that all technology invented is high technology. The technology involved in everyday activities such as using domestic tools, materials (as in cooking or sewing) and systems (routines), may be completely overlooked.

In attempting to arrive at a definition of technology, de Klerk Wolters and de Vries (1987) isolated a number of distinctive characteristics. They believed technology to be an inseparable human feature always related to changes in the form and/or place of matter, energy and information. They maintained that there is a mutual influence between science and technology and that the technical skills of designing, making and using technical products are involved. Lastly, they contended that there is a mutual influence between society and technology. With regard to this last characteristic, a number of writers in this area have linked technology to creating practical solutions to enhancing and improving our environment (Wisely, 1988; Vohra, 1987).

A broad view of technology education should encompass the three main themes of technological knowledge and understanding; comprehension and awareness of the interrelationship between technology and society; and technological capability (Jones & Carr, 1992). In attempting to arrive at an operational definition of technology education, both Clayfield and Hyatt (1993) and Eckersall (1987) believed that it should engage students in problem solving. Teaching technology in classrooms should provide students with an effective model to demonstrate learning as a process. Each stage of the process is as important as the final product.

1.1 Technological capability

True technological activity encourages the development of capability (Edwards, 1987). The concept of 'technological capability', first developed by Black and Harrison (1986), has gained wide acceptance. Donnelly (1992) states that, in the UK, a systematic examination of the notion of technological capability has not been undertaken. According to Napper (1991), technological capability refers to the ability of a person to successfully work through the technological process of solving a problem and producing an artefact. Capability in DMA consists of two distinct aspects (Fisher & Garvey, 1994). It is to do with giving children the knowledge to be able to answer their own (and other's) needs within a given context or environment. It is also about developing a reflective understanding of issues related to how technology shapes and is shaped by society. The development of design and technology capability can be considered to be a way of thinking rather than as a subject with a fixed content (Benson, 1990b).

1.2 Technological Literacy

During the 1980's technological literacy was the buzz word in the US and quickly became a national agenda for the 1990's (Hayden, 1989). One of the priorities of technology education should be to educate citizens to cope with their present world. This means that the core of curriculum must include technological literacy together with the other basics of literacy (humanities) and numeracy (mathematics and science) (Wright, 1994). It has been argued by Archer (1986) that 'design' is distinct from the two cultures of science and humanities and that it represents a third fundamental area of education. The term *technacy* has been used by Warren (1995) to describe this third area of basic skills. This technacy, which according to Roy (1990) remains a poorly specified concept subject to a variety of meanings, seems to hinge on fundamental literacy. It refers to the capability to be intelligently critical about technology and to use intelligently facts of technology that are part of everyday existence.

Associated with this concept is an element of societal awareness in which technacy contributes to an understanding of the nature of advanced technological society (Crawford, 1988; Solomon, 1988). The technologically literate individual would appear to be socially vigilant, where issues pertaining to technology are concerned (Lewis, 1991). Empowerment in one's culture is the key result of literacy. It enables us to move beyond our culture to create more powerful cultural forms by sponsoring new thoughts and imagination about viable alternatives. Such empowerment allows the technologically literate person to critically examine problems and issues of importance. This has been called 'socio-technology' (Fleming, 1989).

Technological literacy for all citizens can be acquired from an examination of the workings of everyday objects and experiences common to most human experiences of eating, getting dressed and going to work (and school). At each successive age level these objects and experiences can be explored at increasing depth and sophistication (Roy, 1990).

Design languages are all part of our wider language and have an infinite variety of connections with verbal and written forms of expression, though they do have a strong visual aspect. We should therefore be directing students towards a design literacy that will stimulate their awareness of how richly design-thinking and design-talk permeate the whole of our language. The syntactic and semantic aspects of design language can be considered by thinking of the design activity in terms of its vocabulary. This acts as an aid to developing more effective teaching strategies and also helps both the teacher and student to more effectively meet the challenge of using design and technology in more meaningful, creative and useful ways (Liddament, 1991).

1.3 Relationship between technology and science

The distinction between science and technology is often blurred (Newton & Newton, 1990). According to Fensham (1990) technology is about multiple concepts that may be related to materials, structures, energy and control. Science, on the other hand, concerns itself with single concepts. Gardner (1994) believes that it is possible to deduce four possible positions concerning the relationship between technology and science. He maintains that none of these positions necessarily hold true for all situations over all historical periods. These positions are as follows:

Technology as applied science

In this position science precedes technology, and that technological capability arises out of scientific knowledge. Technology as the application of science to the making of artefacts is a widely held, persistent and influential view. Such a dominant view has strongly influenced how many science teachers treat technology in their science curricula. Science and technology teachers who subscribe to this position, tend to keep scientific knowledge and practical skills as separate entities. (Gardner, 1994). However, Gardner (1992) has argued that such a position is historically and ontologically inaccurate because it fails to recognise the contribution of non-scientific factors to technology. It also neglects the reverse contribution of technology to science and tends to offer only a superficial account of the process of application.

Technology and science are independent

This demarcationist position asserts that science and technology are independent of each other. It has been argued by Scriven (1987) that technology is neither dependent on science nor an application of science. Technology and science have different histories, goals, products and methods.

Technology precedes science

For this position, technology is considered to come before science. Technology and science are not conceived to be in the same hierarchical plane in human learning. Technology tends to integrate science's results with other inputs in order to reach a goal. As such, technology leads to science more often than science leads to technology (Roy, 1990). In this view, technology has 'historical seniority' since it functioned independently long before science came into being. While both involve rational enquiry, science aims primarily at generating ideas, explanations and understanding. Technology on the other hand makes use of ideas to produce artefacts as solutions to every day practical problems (Gardner et al., 1990). In Australia, science has traditionally been accorded a higher status than technology as a result of an inheritance of a British cultural norm (Ellyard, 1995).

Technology and science are mutually dependent

In this fourth position, technologists and scientists learn from each other. The links between technology and science are close. Technology needs to be recognised as an autonomous coequal branch of science (Layton, 1988). This technology - science relationship has been portrayed as being different but equal (Gardner et al., 1990). Science and technology are recognised as being on a par with each other (Barnes, 1982). This mutually dependent position has been termed by Gardner (1994) as 'interactionist'. While technology and science are different from one another in some respects, they can not be separated and divorced within the context of the primary school (Richards, 1990a). Both science and technology include a number of common characteristics. They both involve the generation of ideas and then testing these ideas in action. Both involve the process of thinking as well as doing and both include an important place for creativity (Harlen, 1986). Technology can draw upon existing science as well as existing technology. Technology's form of cognition is seen as creative and constructive, similar to that of science (Barnes, 1982). As a result of this position, Lewis (1991) contends that contemporary technology may have forfeited its distinct character since it appears unable to find its definition outside a scientific framework.

According to this position, technology is not considered subordinate to science. The relationship between technology and science is symbiotic, egalitarian and interactive in a mutually beneficial way characteristic of symbiotic relationships. In a recent study of technology teaching and learning in a Victorian year five primary class, the relationship between science and technology was explored (Jane, 1995). This study used a blend of qualitative methods and data to record the experiences of the children as they carried out the DMA technological tasks. The children had to design, make and appraise a bird feeder, bridge and toy or gadget. They also made an animal catcher and house. In this study it was found that the children's learning of science and technology interacted in a symbiotic way. Given that this current study is similar to Jane's, it will therefore be important to take note whether the children's science and technology learning interacts in a similar fashion.

There appears to be a number of 'common threads' running through the technology and science relationship. An example of this is practical problem solving (Wiffen, 1988). Harlen (1986) had found it useful to use problem solving as a basis for distinguishing between technology and science. Technology seemed to be concerned with problem solving (and problem creation) related to human needs by designing and making artefacts. Imagination and creativity are important ingredients in this process. In contrast, she considered that science has been concerned with understanding things in the world through interacting with them.

Although there are significant areas of overlap between technology and science, they can usually be distinguished by their purposes (Malcolm, 1988; Skamp, 1986) and outcomes (Gardner, 1990). One of the main purposes of technology is to make practical applications and achievements in order to satisfy human needs. The purpose of science can be considered to enhance understanding through knowledge and explanation. Technology seems to emphasise an external tangible product, while science emphasises an internal manipulation of ideas (Wiffen, 1988).

1.4 Relationship between technology and society

Technology education can encourage students to explore the synthesis of ideas and practices, and the effects of technology on societies and environments (Western Australian Education Department, 1994). It is concerned with answering human needs by the use of available knowledge to create solutions to enhance and improve one's environment (Wisely, 1988). In the past, too little attention has been paid to the place of technology in society (Dowdeswell, 1979). Therefore the introduction of technology as a component of general education, can serve as a new thrust for curriculum change and renewal. It is able to contribute to the overall development of individuals and nations, and can provide for sensitivity and creativity, encourage the formation of positive value and attitudes, and assist students towards taking responsibility in dealing with their environment (Vohra, 1987).

Perhaps the best example of teaching technology within the context of existing science programs is by the use of the Science-Technology-Society (STS) approach (Lewis, 1991). According to Cross (1990), STS courses offer students a convenient way to connect science with the social, technological and political forces that shape science. Gardner (1994) warns that during teaching STS, technology should not simply be treated as a black box. Consideration needs to be given to the human context. A survey of teachers from three Australian states, found that teachers strongly believed that STS was an important area of the curriculum and should be taught to students (Jeans & Farnsworth, 1992). These courses are typically taught by science teachers whose task is to try to infuse technology applications into their programs. Whether science teachers are able, because of their training, to move on to the open-ended, problem-solving modes of the technologist is debatable (Lewis, 1991).

It could therefore be argued that during the teaching of DMA, considerations of the relationship between the technology (such as the artefacts made) and the society (including our physical environment) need to be made. In this study close attention will need to be paid as to whether the teacher and/or children focus on aspects of the relationship between DMA and society / environment.

2 HISTORICAL OVERVIEW

2.1 Origins of technology

According to Gardner et al. (1990) technology is very ancient. During the Pleistocene Age over a million years ago, *Homo erectus* first made use of existing objects such as pebbles, animal teeth and bones as tools and weapons. Much later *Homo sapiens* began to communicate and develop a cultural tradition in which tool-making began to replace the casual use of found objects. Gradually the quality and sophistication of hand tools developed. Early winches, wedges, catapults, presses, levers and hoists were chiefly used to amplify human or animal muscles (Toffler, 1980). During the Middle Ages (which lasted from 500 to 1500 AD), the foundations for industrialisation began to emerge as the transition of western civilisation from a predominantly rural society to an urban industrial society took place. Gradually technology became more complex as civilisation progressed through to the Industrial Revolution and machines gradually begun to emerge and replace the work previously performed by people or animals.

Prior to the establishment of schools, presumably children learned their tool-making skills through observing and copying. Technical knowledge and skills were transmitted to the younger generations by the elders of the village (or tribe). This technical knowledge or skill tended to be practical and directly related to the immediate local environment. However, this system of transmission eventually broke down with the onset of the Industrial Revolution and was replaced by mass education, one of the central structures of what Toffler (1980) termed 'Second Wave' societies. The family no longer worked together as a unit. To free workers for factory labour, key functions of the family (such as education and socialisation) were handed over to the new specialised institutions such as schools. Initially these schools tended to favour an academic approach by emphasising intellectual development (Vohra, 1987). Because of the perception that technology was associated with manual work, it was considered inferior to a higher status academic education.

Although the words *techne* and *logos* must have existed in the Greek language long before they found expression in literary form, they first appeared in the epics of Homer and Hesoid (Zargari & MacDonald, 1994). According to Foster and Kirkwood (1993), the founders of technology education were Frederick Gordon Bonser and Lois Coffey Mossman who claimed that technology education was the study of how people make changes in materials and of the problems that subsequently arise from such changes. McCulloch (1987) has provided a detailed historical guide to published sources of school science and technology in nineteenth and twentieth century England.

2.2 Technology education in Australia

Secondary schools

The introduction of technology education into Australian schools has had a shorter history and has been more fragmented than in England and Wales because curriculum has traditionally been a state rather than a federal responsibility (Rennie & Jarvis, 1995). In Australia, some states formed a two-tiered secondary education system comprising of high schools with an academic emphasis, and technical schools with an emphasis on vocational technical knowledge and skills. During the mid 1970's most Australian states eliminated this dichotomy so that all secondary schools became high schools incorporating a technology component as part of their curriculum. A noticeable exception was in Victoria where separate Technical High Schools remained. In the last few years some twenty eight specially designated Technology High Schools have been created in New South Wales where the philosophy of implementing technology across key learning areas has been adopted. In South Australia, a Technology School for the Future has been established (National Board of Employment, Education and Training, 1993a). It was during this transitional stage that the names of subjects such as woodwork and metalwork were changed to Technical Studies, and more recently grouped under the generic term 'technology'. As previously mentioned, technical education can be traced back to the origins of mass schooling. Yet the role of technology within a framework of only technical and vocational aspects may suggest that technology is merely a manual activity. Such a notion neglects not only the socio-environmental aspects but also the importance of technology as an educational tool in developing a person to live comfortably in an increasingly sophisticated technological world.

Primary schools

In primary schools, components of design and technology have always been part of the primary school curriculum, but it is only very recently that design and technology has been given any formal recognition (Donnelly, 1992). According to Layton, (1993), the structure of the timetable and style of working in primary schools can frequently provide a more hospitable environment for technological activities than many secondary schools. Some Australian states do not have up-to-date primary science and technology curriculum statements and supporting materials, covering both process and content, from the K to 6 level (Australian Academy of Science, 1991). In South Australia, the first official mention of primary design and technology appeared in the late 1980's as part of the Primary Art, Craft and Design curricula. During 1988 a Schools Technology Education Program (STEP) was formed and involved pilot schools in the metropolitan area (STEP, 1988). This was at about the same time as the release of the National Goals for Schooling in Australia (Education Department of South Australia, 1990) and the subsequent National Subject Statements (for example, *Technology - A statement on technology for Australian schools,* Curriculum Corporation, 1994b) and the accompanying eight draft National Subject Profiles (for example, *Technology - A curriculum profile for Australian schools*, Curriculum Corporation, 1994a).

Technology had finally emerged as a separate curriculum area in its own right as one of the eight key learning areas of study. The original rationale behind the release of the National Subject Statements and Profiles had been to work towards a national collaborative effort in curriculum development. It was hoped that this would minimise unnecessary differences in curricula between the states and territories and make best use of limited curriculum resources . Unfortunately, this was never achieved due possibly to changes of governments (both Federally and State) and interstate rivalry. However, these documents have since formed the basis for individual states and territories to plan their own technology curriculum.
Some states had previously released separate technology statements for the years of compulsory schooling (see for example, Crawford, 1988; New South Wales Department of Education, 1989). New South Wales subsequently decided to combine technology with their science statement - 'K-6 Science and Technology Syllabus' (Board of Studies, 1991). Because the ACT has school-based curriculum, each school there is responsible for formulating its own technology curriculum. In Western Australia they have opted to link the concept of *enterprise* with technology (Western Australian Education Department, 1994). At this stage, no other Australian state appears to have included enterprise as part of their technology curriculum. According to Ellyard (1995), a major goal of education for the twenty first century should be the creation of enterprising people. While referring to the nexus between practical capability and enterprise (entrepreneurship), Donnelly

(1992) warns of the dangers inherent in trying to balance between the demands of fulfilling individual potential, satisfying human needs and exploiting business opportunities. He also warns that an invalidated notion of generalised practical capability may be economically counter-productive.

2.3 Technology education in England and Wales

Technology in England has developed along four different lines, each with its own traditions and distinctive character (Kings, 1990). First there was an approach dominated by craft teachers. Next an approach that focused on hitech - such as computers and electronics. Then there was an approach in which students learnt engineering as a prerequisite to further tertiary courses. Finally, there was an approach where technology was considered to be a subject of science. Towards the end of the nineteenth century, separate schools were established for students who were unable to cope with a general academic education. The English education system was restructured in 1944 along tripartite lines with three different types of schools - grammar, technical and modern. From the mid 1960's onwards a comprehensive system of schooling in England and Wales was introduced which saw the transformation of the technical dimension of the secondary curriculum that had been inhabited by intellectually less able students (Allsop & Woolnough, 1990; Donnelly, 1992).

The formation of comprehensive schools saw the incorporation of design principles into the curriculum. A resultant emphasis was placed on planning processes at the expense of acquisition of constructional skills. The introduction of the National Curriculum in England and Wales emphasised the design cycle and resulted in technology frequently taught in terms of model making and other design and construction related activities (Rennie & Jarvis, 1995). Also at this time, a hitech approach began to emerge (Allsop & Woolnough, 1990). By the beginning of the 1980's the combination of these influences saw the introduction in England and Wales of a subject known as Craft, Design and Technology (CDT). Attempts to successfully coordinate the different aspects of the subject were mixed (Donnelly, 1992; Medway, 1989). Another variation that emerged from this confusion was the formation of a subject that became known as Science, Technology and Society (STS). This subject sought to link science and technology with solving societal problems by providing new information and designing programs based on new knowledge (Zargari & MacDonald, 1994). Thus technology education was not suddenly a new subject that had been invented, but rather the elevation of a set of slow moving ideas to formal recognition (Tickle, 1996).

2.4 Technology education in other countries

The place of technology in school curricula has been surveyed in several countries (Vohra, 1987) and it was found that there was a plethora of subjects and activities that are considered to be under the umbrella of 'technology'. There appears to be little consensus about how it can be or should be taught, with different countries adopting various approaches, organisation and emphases. Similar scenarios have occurred elsewhere around the world (Fensham, 1990). For example, New Zealand (Jones & Carr, 1992), Sweden (Lindblad, 1990) and Northern Ireland (King, 1994) have all defined technology as a separate compulsory area of the curriculum. The term 'technology' is often used to refer to computers in the United States (Etchison, 1994; Thode, 1996). In England and Wales, Information Technology has recently been defined as a separate new basic skill and is to be reported separately from Design Technology (Anning, 1994). This is contrary to the Association for Science Education Report that advocated information technology should not be taught as a separate subject but as an integral part of different subjects or as a tool for approaching particular tasks (Allsop & Woolnough, 1990).

A UNESCO (1983) survey of 37 countries looked at technology education as part of general education and found that the emphasis in Australia was on the development of positive attitudes towards making and doing rather than acquiring knowledge and following instructions. Emphasis was placed on increasing students' capability for solving practical problems through designing and technological means. This is consistent with the more recent National Technology Statement (Curriculum Corporation, 1994b) and Profile (Curriculum Corporation, 1994a) that emphasise a Design, Make and Appraise (DMA) approach.

3 PEDAGOGY OF DESIGN AND TECHNOLOGY

3.1 Design processes

There has been some dispute as to whether design includes technology or technology includes design, though Medway (1989) contends that there is a prevailing view that there are design activities that do not involve technology and aspects of technology that do not involve design. He has also argued that the production of design proposals is an artificial construction whose links to reality are tenuous and problematic (Medway, 1992). A number of characteristics of design and technology have been documented by Bentley and Campbell (1990a). These authors believe that it involves problem solving activities that are child centred and focused. Designing (or imaging) is a distinct activity that usually occurs as a pre-cursor to the problem solving activity that takes place within a particular context or environment. Design and technology is distinctly concerned with knowledge and skills concerning the form and function of materials, artefacts and systems. It is an activity that involves children in cooperative planning and practical application of various communication skills.

Design activities have the potential to offer rich and meaningful learning, and combined with technology, allow the creation of interesting design learning environments in schools. As an area of the curriculum, design education makes a unique contribution to children's cognitive, emotional, psycho-motor and social development. The act of designing can open the door to a wide range of real life situations that are of special interest to girls (Browne, 1991). Designing can make a contribution to child development that both complements and augments the effects of more traditional subject areas (Phillips, 1982). The act of design has been defined by Richards (1990a) as prescribing some form, structure, pattern or arrangement for a proposed thing, system or event. Design can also be described as a process that includes problem solving, problem finding and personal expression (Kafai, 1991). The difference between problem finding and problem solving has been pointed out by Schon (1983) who maintained that the former has tended to have been neglected in schools to its detriment.

In Jane's (1995) study, which has been mentioned previously, she found from a literature search that little has been reported about the design process as it relates directly to primary school children in Technology Studies. I have also discovered this to be the case and therefore in discussing design it is necessary to broaden the focus to explore related areas. One of these related areas concerns the techniques that children use to draw diagrams in science. In a study of grade two children in a Victorian primary school, it was found that these young children used a wide variety of techniques to aid the clarity of their drawings during science activities (Hayes & Symington, 1989). They were able to readily discriminate between various drawings even though they were given no direct teacher instruction on appropriate drawing techniques. In a more recent study of drawing during science activities, Hayes, Symington and Martin (1994) maintained that there has not been any comprehensive consideration given as to what are the actual purposes of involving children in drawing. After implementing a number of teaching strategies, they discovered that a range of objective and process purposes can be achieved in the early years of schooling. Despite the fact that drawing is a very common activity during science lessons in the primary school, it has received very little attention from curriculum developers and researchers (Medway, 1989).

Kafai (1994) has conducted extensive research in the US with elementary children engaged in design projects using computer software. I believe that many of her findings have relevance for design in the DMA context. She believed that there is no one 'right' way to start, continue and complete a design task. Children's mistakes are not seen as signs of failure but as sources of feedback. The unexpected is valued and unanticipated ideas from children actively encouraged (Medway, 1989). A similar sentiment is shared by Farely (1986), who also maintains that there is no absolutely right answer to a design problem, since any one of several creative and diverse solutions may be equally valid. Unfortunately it would appear that much of today's education seems to require responses to questions that only have so-called 'correct' or 'right' answers. Each of the new curriculum profiles (Curriculum Corporation, 1994a) attempt to categorise children's attainment levels in the eight key learning areas of the curriculum. Each statement (subject) strand has eight progressive levels of student achievement which are described as outcomes. Yet as has been argued above, it would seem that DMA activities tend to be more open-ended and do not readily lend themselves to be neatly categorised into levels. Solutions produced for DMA tasks can always be further refined and improved. As such, DMA activities can be one of the most intellectually demanding tasks that a child can experience at school (Farley, 1986). Primary schools are appropriate places for children to begin their DMA training, since young children tend to have limited inhibitions about discovering. A good deal of learning takes place through play in which children learn through trial and error (Bishop & Simpson, 1992).

In her book on primary technology, Wisely (1988) lists the design process as consisting of eight main steps that for younger children can be simplified into three basic stages. The first stage consists of drawings and plans. The children are encouraged to be innovative and creative in their design of say an imaginary device. At the second stage, 3-D models of their design are created. These models are static as they only symbolically represent the components and structures. For the third stage a working model is made containing working parts that re-create the ways in which a full size version would operate. These three stages differ from the usual DMA process that can be considered to be essentially a cyclic process, in which feedback from each stage enables children to either modify ideas already generated, or move forward onto new ideas (Lever, 1990).

The act of design integrates different aspects of learning - the analytic and synthetic; the planning and tinkering; the detailed and the holistic; and the cognitive with the affective. The act of designing allows the learner to explore a particular subject from multiple perspectives and in different styles (Kafai, 1994). Design education can be used to help children think more flexibly and creatively by encouraging them to engage in exploratory and investigative behaviour towards objects in the environment. The act of designing assists in the functioning of the relatively neglected right hemisphere of the brain and can be used to encourage those aspects of thought and understanding concerned with more sensuous ways of knowing the world (Phillips, 1982).

When children are imaging (that is, running mental models through their mind's eye) the scaffolding provided by the teacher can greatly enrich this design process. This scaffolding takes place when the teacher provides visual stimuli of mental images which children can later access and so help them function at a much higher level in the design process (Anning, 1992). A note of caution has been made by Samuel (1991) who has advocated that teachers need to impose a range of constraints when giving young children design tasks. He believes that by providing young children with parameters in which to explore a design problem, they can be genuinely extended in both their thinking and designing skills. Such a controlled and structured approach also ensures that children are able to gain access to a full range of experiences offered by DMA activities.

Recent work by Stables (1997) examines the practice of allowing young children to draw a design on paper prior to making. Stables argues that the technology curriculum for young children should not be dominated by paradigms developed for use in secondary schools. She expresses reservations about the DMA practice of having young children first draw a design on paper before moving into the making stage. Her argument is supported by citing instances where there has been little resemblance of the designs drawn to what the young children make.

In a survey of twelve primary schools in England by Smits (1990), it was found that while technology was strong in aspects that drew on existing strengths in science and craft, it was weak in the area of individual designing and planning and the intellectually creative aspects. In this study it was discovered that the children tended not to design before making and failed to evaluate afterwards. This was also the experience of Brennan (1989) who noted that only occasionally children sketched their ideas first. In this current study it will therefore be interesting to observe the young children's behaviour during the design stage and relate it to the above findings and beliefs.

3.2 Teacher perceptions of DMA

A survey using one thousand questionnaires sent to Australian primary teachers drawn from three states revealed that teachers' general perception of technology in science education focused on consumer education involving such everyday items as bicycles, batteries, pumps and radios. Only a few teachers thought that primary science should include practical problem solving activities in which children are encouraged to design, make and appraise technological solutions to real world problems (Jeans & Farnsworth, 1992). In another survey conducted by Symington (1989), seventy experienced Victorian primary teachers were asked to complete a simple questionnaire. In this sample it was found that the teachers held a wide range of views about what constitutes technology. Some believed that technology only referred to items involving modern sophisticated hardware, while in sharp contrast other teachers operated with a much broader definition of technology. A similar investigation was made of the perceptions of technology of senior secondary teachers in Western Australia (Rennie, 1987). This investigation revealed that many of the teachers had a somewhat restricted view of technology that tended to consider technology as being dependent upon science. Such a view fails to take cognisance of the historical aspects and societal influences on science and technology.

The Leverhulme Primary Project (located at the University of Exeter) surveyed a national UK sample of nine hundred primary teachers to see how competent they felt to teach the new National Curriculum. It was found that only one in seven felt competent to teach technology (Anning, 1992). In another study conducted in New South Wales, one hundred and seventy eight preservice and forty practising teachers were compared with respect to their knowledge and confidence of the new Science and Technology key learning area. The study found that both groups of teachers were less confident to teach the technology-oriented content areas. This had obvious implications for preservice and inservice professional development courses for teachers. Teachers in the survey also claimed that their confidence about their knowledge of science and technology topic areas improved after actually teaching those topics to children (Skamp, 1991).

In order to effectively teach design and technology, existing teachers need to make significant shifts that involve diversification in their pedagogical strategies and knowledge (Donnelly, 1992). They need to adopt a critical and humane stance rather than a merely economic or instrumental understanding of technology. While mainly referring to secondary schools, Gardner et al. (1990) predict that in the foreseeable future, technology education will be taught by teachers possessing widely varying qualifications and experience. These authors also suggest that schools may need to foster team approaches to technology teaching in schools. The difficulty of obtaining sufficient numbers of teachers willing and able to teach design and technology is particularly acute in the primary sector. Key requirements for primary teachers include extended and continuous exposure to practical problem solving activity on a cross-curricula basis (Hawkey, 1987).

The *Times Education Supplement* (TES, 1991) devoted sixteen pages to reviewing what was happening in technology education at both the national level and at selected schools throughout Great Britain. A common feature of most of the articles was the difficulty being experienced by many teachers in coming to terms with the meaning of technology and the subsequent implementation of technology education. An obvious strategy to improve the supply of competent design and technology teachers is to provide inservice training and development so as to develop appropriate technological knowledge and technological skills of designing, making, appraising and communicating (Cole, 1987).

Hardy, Bearlin and Kirkwood (1990) describe a project conducted in Canberra that aimed to improve the teaching and learning in early childhood and primary science and technology. The project was based on an interactive model of teaching that included systematically linking gender with teaching and learning of science and technology. A part of the project involved a year-long inservice program in which teachers developed a science unit with their schools. Support networks for teachers were fostered and preservice - inservice programs were linked. As a consequence of participating in the program, there was found to be a significant increase in the inservice teacher's level of interest in science and technology, in their perception of their background knowledge for teaching in both science and technology and in their sense of their own competence in teaching science and technology. Another interesting finding to arise from this project was that preservice teachers' interest in technology did not increase significantly nor did their belief in the importance of teaching technology. Any inservice program needs to include a planned progression and have a whole school emphasis involving all teachers in the school (Richardson, 1988). It is claimed by Duffee and Aikenhead (1992) that in-service programs must provide teachers with a dramatically memorable experience in order for the programs to compete with deep rooted, well established elements of teacher practical knowledge. Webb's (1993) survey of ninety seven primary teachers (from the Sydney Metropolitan West region) indicated that teachers had a preference for traditional models of inservice for the K-6 Science and Technology Syllabus. He concluded that this belief may result in unrealistic expectations that may not bring about significant changes.

3.3 Student perceptions of DMA

Students hold alternative frameworks about technology. It has been found that they are more likely to think of the product-side (equipment and machines) of technology rather than the process-side of DMA (de Klerk Wolters & de Vries, 1987). An international study called Pupils' Attitude to Technology (PATT) revealed that children found it hard to describe technology and were unaware of the important role played by creativity and design (Medway, 1989). From a survey conducted in Perth it was found that many pupils have no idea that technology includes the design and manufacture of common household appliances (Rennie, 1987). A national survey of one thousand four hundred and sixty nine year three students in New Zealand, conducted by Burns (1992), found that although the children had poor concepts of technology they generally had positive attitudes towards technology. Another study of one thousand six hundred and seventy five pupils in South Wales explored children's perceptions of the subject of design and technology (Hendley & Lyle, 1996). The findings also indicated that children were positive about key aspects of design and technology. A similar finding in Australia arose out of a study commissioned by the National Board of Employment, Education and Training (1993b). This study found that children entering secondary school have a very positive attitude towards science and technology, both as a school subject and as part of their everyday life. The authors of this study concluded that these children's views of science and technology were mainly formed by television and other outside influences as opposed to their science and technology experiences at school.

Rennie and Jarvis (1995) describe a cross-national study comparing primary children's perceptions about technology in Australia and England. The children's perceptions were measured using a writing/drawing activity, a picture quiz for the younger children and a questionnaire for the older children. A sample of approximately eight hundred children in each country was used. It was found that the primary school children held a multi-dimensional view of technology. Many children only associated technology with computers and modern appliances. The older children tended to have more complex and coherent ideas about technology, although they tended to express less interest in technology than the younger children. The high profile of DMA given in the English and Wales National Curriculum was reflected in the English children's emphasis on model making which was generally ignored by the Australian children in the sample. The diverse understandings and perceptions of technology found to be held by the children in the study suggest that teachers need to organise and plan their classroom design and technology instruction accordingly. Rennie and Jarvis (1994) have provided teachers with a practical strategy for finding out what students think about technology as well as ideas and suggested activities to enhance their understanding of technology. An earlier study of Western Australian secondary students in year eight also found a wide variation in their understanding and beliefs about the nature of technology (Rennie & Sillitto, 1988).

3.4 Integration of curriculum

In the DMA process, attempts are made to fuse the cognitive and process skills that are involved in designing and making, craft and problem solving into one cross-curricular capability to operate creatively in the made world (Bentley & Campbell, 1990a). It has been strongly advocated that the teaching of DMA should be viewed as a cross-curricula activity (Bosanko, 1990; Jinks, 1984; Joseph, 1994; Milloy, 1990; Montgomery, 1988; Nuckley & Wolman, 1988; Richards, 1990b; Seaward, 1996; Wallace, Adersley & Allen, 1988; Wesley, 1996). In fact, according to Woolnough (1975), the introduction of technology as a separate subject in the timetable is positively harmful. Students involved in the technological process can make considerable gains in understanding and skill development if technology is presented as part of an integrated curriculum (Jane, 1993; Jane & Smith, 1992). Just as with other areas of the primary curriculum, technology can be approached through an integrated plan (Eaton, 1991) since it draws on the skills and inventiveness latent in all subjects (Hodgkin, 1990). Design as a process should not just be concerned with technological projects but should permeate the whole curriculum, because design puts children in a situation in which they have to be inventive, creative and to solve problems (Wisely, 1988). Design and technology has wide application across traditional curricular boundaries. It relies not so much on a narrow content but on the process of doing through activity. Its essential features involve child centred activity, active-learning, problem solving as well as knowledge and skill acquisition (Lever, 1990).

In her study involving two Victorian primary school classes, Jane (1993) described technological activities that related to particular themes. Such an approach encouraged the children to make links between the various discipline areas. Another example of one teacher's attempt at providing year two children with an integrated approach to technology was provided by Braddock (1989a). In a junior primary class in Adelaide, children were given the problem of designing and constructing a vehicle large enough to carry a person. The children worked in groups to design, make and appraise their vehicles. Parental assistance was used throughout the activity that also incorporated children using mathematics and written language. Another interesting example of integrating the teaching of DMA has been provided by Pace and Larson (1992) who describe robot making in a first grade classroom in Oregon. Design and technology were combined in a meaningful and enjoyable way with language learning and imaginative problem-solving (Clayfield & Hyatt, 1993). Other examples of combining literature and technology in the kindergarten class are provided by Mahlke (1993), Moorcroft (1993), Newton and Newton (1992a) and Sittig (1992). In constructing a response through language or art/craft, it is claimed that the child can relate, connect, remember, relearn, monitor, problem solve and perform all those other powerful mental activities that help children and adults to adapt and create new solutions (Clay, 1986).

In a study of thirty New Zealand primary and secondary teacher's perceptions of technology education, it was found that primary school teachers did not want to see technology introduced as a separate subject (Jones & Carr, 1992). Yet Lewis (1991), has argued that technology in the curriculum needs to have its own space and own teachers who are trained in its particular methodologies. In his paper Lewis was mainly referring to the secondary context, though others have argued for it to be treated separately in primary schools. The formation of a separate science / technology centre in a primary school has been discussed by Fitzgerald, Fagone, Ritter and Beechy (1989). Treagust and Mather (1990) have described an approach to technology education that was successfully integrated with all subjects taught in a secondary school context. It would therefore appear that the issue of treating technology as a separate entity can be contested and therefore will be an area worthy for consideration during this current study.

3.5 Early intervention and DMA

There appears to be no 'right' age at which to introduce children to technology and the earlier they start the sooner they will develop skills (Legg, 1991). A number of authors all agree that the most appropriate point at which to commence design and technology education is in the primary school (Brown, 1989; Harlen, 1985; Page, 1987; Richardson, 1984; Stoker & Green, 1983). It is at this stage young children tend to have few inhibitions about discovery through experimentation (Farely, 1986). Their attitudes towards new technologies are established early in life and later seem to become resistant to change, since they become enmeshed in broader socio-political ideologies (Breakwell, Fife-Schaw & Lee, 1985). It is the stimulation of early technological experiences that is more effective than implementing remedial measures later on at the secondary level (Donnelly, 1992).

Some interesting work associated with teaching technology has been conducted in nursery schools with children in the three to five year old age range (Edlind, Granstam, Haggenstrom, Jarvinen, Kernell & Segerborg, 1987; Fleer, 1991a, 1991b, 1992a; Matusiak, 1990). It is at this early stage that nursery teachers are able to provide young children with a diverse array of ideas for in career choices that are not necessarily pre-determined on the basis of gender or through lack of experiences in particular areas of the early childhood curriculum (Jordan, 1992). Young children entering formal educational settings already possess inquiring minds and possess expertise in problem solving, manipulating objects, making choices and finding meanings in their surroundings (Makiya & Rogers, 1992). To some extent the capabilities of young children are continually underestimated and it is especially important that young children are provided with the opportunity to develop the skills of communication and independent thought and the attitudes of cooperation and perseverance (Benson, 1990a). The role of the teacher in the early years is to build on children's design and technological capabilities as well as introduce them to a variety of new techniques and skills that will extend and broaden these experiences (Makiya & Rogers, 1992).

3.6 Conceptual development of young children.

An Australian study of early childhood science classrooms was conducted by Fleer (1990b) and investigated children's scientific understandings and conceptual change that occurs during the teaching of science. This study found that when the teachers' role was not clearly defined, the range of child-teacher interactions varied enormously and the subsequent learning outcomes for children were quite different. Specifically focused child-teacher interactions were found to lead to conceptual development in young children (Fleer & Beasley, 1991). With regard to young children's understanding of scientific phenomena, it was found that not all children hold alternative views to those generally recognised by the scientific community. In many cases children did not hold views about the phenomena being investigated. The teacher was found to be the crucial factor in developing children's conceptual understanding, and not the cognitive-conflict scenario that tends to be advocated in the literature (Fleer, 1991b).

In another study conducted by Fleer (1991a), young children in a child-care centre were involved in the introduction of the concept of electricity. According to Fleer, the success of the study was attributed to the fact that the teaching about electricity followed a socially constructed approach to learning. It was found that when child-teacher interactions are less procedurally focused, concept development occurs more readily. On the other hand, conceptually focused child-teacher interactions were found to result in young children creating destructive frameworks when working with technology related tasks (Fleer, 1995).

In this section of the review of literature associated with pedagogical aspects of DMA teaching and learning, several potentially significant areas suitable for focussing appear to have emerged. In the DMA investigation to follow, particular attention will need to be paid to the designing stage and whether the DMA activities are integrated with other curriculum areas.

4 EQUAL OPPORTUNITIES

4.1 Gender

Gender differences are the focus of much of the research which deals with children's technological abilities (Bolton, Mow & Skamp, 1989; Cawthorne, 1988; Edlind, et al., 1987; Fleer, 1990a; Greenberg, 1986; Harding, Hildebrand & Klainin, 1988; Harlen, 1985; Kinnear, Treagust & Rennie, 1991; Morgan, 1986; Pickford, 1992; Rogers, 1986; Ryan, 1993; Zarins, 1996). The perspective provided by technology is especially suited to the study of gender (Layton, 1987). According to Hill and Wheeler (1991) two of the most significant areas for research in science and technological education in the 1980's were constructivism and gender. In the early years of schooling gender appears to be a contested issue. For example, Browne (1991) argues that gender differences in science and technology are most evident in nurseries and infant schools. The effects of unequal treatment and gender-role stereotyping are already evident when children enter primary school (Eccles, 1989). On the other hand, Weiner (1991) believes that gender differences are not very visible in the early years. During the investigation of the DMA implementation process that follows, attention can be given as to whether gender differences are present in the early years class.

Much of the gender research has focused on girls' social contexts by examining the way in which science and technology is portrayed through the media, school practices and text books and by surveying the relative proportions of males and females in various educational programs and types of employment. The support papers *Access to science* (Education Department of South Australia, 1989), although targeted mainly at a secondary teacher audience, contain valuable insights into a range of classroom gender issues, which are equally applicable to the early years of schooling where it has been argued that the gender difference is not very visible (Weiner, 1991). Some of the topics included in the support papers are the male dominance in access to classroom resources; male images portrayed through text books and resource materials; preferred learning styles for girls; types of assessment methods used (competitive or non-competitive); socio economic class; and cultural and racial differences.

For some students, their lack of experience with some areas of technology may need to be addressed through the implementation of special measures that are sometimes referred to as affirmative actions (Braddock, 1989b; Curriculum Corporation, 1994a, 1994b). It has been claimed that girls do not seem to have the same chance to develop understandings of technological concepts that boys learn through their tinkering and playing with construction sets and mechanical toys (Brown, 1989, 1990; Browne, 1991). It would seem that girls do not have the same opportunity to develop some of the understandings of systems and machines that boys learn through playing and tinkering with mechanical toys (Eke & Gardner, 1991). Yet boys are more likely to have had prior experience with constructional toys and using tools and resistant materials to make models and objects (Bindon & Cole, 1991). They play more intensively with construction toys than girls (Doornekamp, 1991; Humphreys, 1996; Ross & Browne, 1993). Also, boys tend to be more interested in the physical and technological aspects of the world, while girls appear to be more interested in the human and natural aspects (Smail & Kelly, 1984b).

Because many girls initially appear to be less adept than boys at constructing activities, Stokes (1989) suggests that they need to be provided with additional catch-up time to enable them to gain confidence and to feel comfortable to freely express their ideas. This notion is supported by Claire (1992) who believes that girls need a lot more teacher support in construction activities and DMA than they currently receive. Special measures may also be needed for boys who may be unfamiliar with technology associated with child care, textiles and food preparation (Curriculum Corporation, 1994b). These special intervention measures (or affirmative actions) need to be supported on a whole school basis (Browne, 1991).

From a toy survey conducted in junior classes in four English primary schools, it was found that boys were far more likely to have toys at home that develop spatial ability and provide opportunities for problem solving (Burn, 1989). According to Medway (1989), differences between boys and girls spatial abilities have been consistently found in studies. The lack of opportunities for developing spatial awareness at this crucial early stage can lead to difficulties in later years of school (Bishop & Simpson, 1992). An English study that used over two thousand eleven year old children, found that boys did markedly better than girls on tests of spatial ability and mechanical reasoning. The boys were found to have had greater prior experience in tinkering activities and this led the researchers to conclude that sex differences in play activities and hobbies produced this sex difference in mechanical reasoning (Smail & Kelly, 1984a). The claim that girls have fewer opportunities to develop spatial visualisation and mechanical reasoning than boys has also been supported by Cattan (1988).

In order to function effectively in present day society, all students need to be scientifically and technologically literate. It is important that girls, as well as boys, are encouraged to achieve their full potential in design and technology so as to help them increase the degree of control that they have over their own lives (Browne, 1991). From a study involving four and five year old children in Melbourne, Coulson (1991) discovered that many had already formed distinct patterns of interest in science that paralleled those seen in older children. Both girls and boys were found to be very similar in their overall patterns of choice for science and non-science items. Because of the symbiotic relationship of science and technology, it is therefore possible to assume that these findings would also apply to technology. By the time they are in years five or six, many girls are already convinced that science (and technology) is not for them (Jones & Wheatley, 1988). Many appear to lack the confidence to readily participate in technological activities and thus inhibit their chances of eventually competing in the work place against men for high status, highly paid, hitech occupations (Eke & Gardner, 1991; Jordan, 1992). By the time that many girls leave primary schools, most appear to have already developed a negative attitude towards technology.

Attitudes towards new technologies are multi-dimensional and differentiated (Breakwell et al., 1985). In a large study of five thousand thirteen year old students conducted in the Netherlands, it was found that boys had a better concept and appreciation of the relationship between technology and the quality of life as well as a more positive attitude towards the consequences of technology for daily life than girls. Girls were more inclined to think of the product-side of technology (equipment, machines) than of the process-side (designing, making and using things) (de Klerk Wolters & De Vries, 1987). Similar findings were made by Rennie (1987) in Western Australia, where she found that boys were generally more aware, interested and had a broader knowledge of technology than girls. These differences in awareness and attitudes towards technological activities can be directly linked to the differences in experiences that girls and boys have had in their home environments (Bindon & Cole, 1991; Breakwell et al., 1985).

A study of gender differentiation, involving almost one hundred children, was conducted in four junior primary classrooms in Northern Ireland over a four month period (Morgan & Dunn, 1988). The study found contrasting styles of interaction and tentatively identified two types of children which they called *visible* and *invisible.* It was found that the visible children demanded a considerable amount of time and attention from teachers and peers. In contrast, the invisible children often passed unnoticed for considerable periods of time. Morgan and Dunn's study found that the visible child was highly likely to be a boy while the invisible child was highly likely to be a girl. Within the secondary school context, Tobin (1993) has used a series of studies from Australia and the United States to focus on what he has termed *target* students. He found that most of these target students were male.

The Leverhulme Primary project which has been previously mentioned, found that there are differences between female and male teachers when asked to provide preferences for subjects. The choices emerged along traditional stereotypical gender lines with women teachers expressing higher self-ratings for music and the humanities while men tended to rate themselves higher for science and technology (Anning, 1992). Australian studies of female primary school teachers have also found low perceptions of their own science background and knowledge, particularly in the physical science areas (Parker, 1987). Female teachers can and should act as good role models for the girls they teach (Carter & Carre, 1991). It is essential that girls feel that they can have equal roles and choices in a technological society in which men seemed to have predominated in science and technological activities in both education and industry (Bindon & Cole, 1991).

Because many primary teachers feel insecure about teaching science and technology, Stokes (1989) advocates that it might be useful for teachers to take time out to actually play with commercially available construction materials. A group of female junior primary teachers in England conducted an action research project involving girls and construction kits. The teachers found that on the whole the girls did not choose to play with the kits during free play. When they did use them, their play differed markedly from the boys. Throughout the children's use of construction kits the teachers continually questioned their current teaching strategies and outcomes. The questioning of existing practices often led to changes and these in turn were monitored. The ultimate aim of the project was for the teachers and their students to become technologically literate (Beat, 1991).

In Western Australia it was found that positive effects on women teachers resulted when gender issues were integrated with inservice science professional development (Rennie, Parker & Hutchinson, 1985). According to Makiya and Rogers (1992) primary women teachers have a duty and responsibility to fully participate in inservice technology training and development. Such active participation helps to avoid gender stereotyping and tackles sexist prejudices and practices. Inservice training and development enables female teachers to acquire hands-on capability themselves by exploring and trying out science and technology activities (Brown, 1991).

The issue of gender inclusive curriculum materials has been addressed in a case study about the development of technology materials for primary schools (Kinnear, Treagust & Rennie, 1991). The study found that an awareness of gender bias needs to be present from the earliest stages of developing inclusive technology curriculum materials. Technology teaching materials need to be attractive and effective for both girls and boys. The fact that different students have different interests and all student's possess existing knowledge are important considerations when planning technology courses (Jones & Carr, 1992). The National Curriculum for Technology in England and Wales states that all children during their compulsory years of schooling, must engage in design and technology activities requiring the use of a range of materials that encompass food, fabrics, construction materials and graphic media. The use of such a broad range of materials should help overcome some of the restrictive traditional views about which aspects of technology are appropriate for boys and which are for girls (Bindon & Cole, 1991).

In a study of sex-role differentiation among six and seven year old children in England, it was found that much of their sex-role stereotyping and training is likely to be unwitting and unconscious. The researchers concluded that young children acquire typical sex-role behaviour at a very early age and exaggerated views of what is appropriate for the sexes. This they believe is probably deeply embedded in the social worlds in which children are growing up (Smithers & Smithers, 1984). Gender specific and narrow technology programs tend to exclude many students from acquiring important skills and knowledge resulting in restricted post-school options, undervalued technologies that are used by women and caused a lack of participation by men (Curriculum Corporation, 1994a, 1994b).

4.2 Culture / race

Eggleston (1992), has asserted that the National Curriculum for Technology in the UK is devoid of gender stereotypes and is sensitive to cultural differences. Design and technology education should reflect multi-cultural contributions and achievements (Makiya & Rogers, 1992), and the variety of cultural backgrounds of students can broaden the insights they all have into the range of appropriate and alternative solutions to perceived problems. Such rich opportunities demonstrate that no one culture has a monopoly of achievement in design and technology. Benson (1990b) believed that teachers need to seek opportunities to develop design and technology activities that are not necessarily embedded in a white European setting, yet at the same time avoiding hidden agendas that may suggest a condescending attitude to 'Third World Technology'. The process whereby children become acclimatised to our culture (sometimes referred to as acculturation) can gradually produce inhibitors to their early eclectic use of drawing (Atkinson, 1991). A number of case studies have been conducted in which children have worked in mixed racial and gender groups and children's personality was found to play a greater role than both gender and race (Lever, 1990).

4.3 Children with special needs

According to Benson (1990b), children with special needs also includes the so called 'gifted' child who should be allowed to develop to her/his full potential. To a greater or lesser extent, all children can achieve success in design and technology activities (Lever, 1990). Over the last decade or so, there have been increasing efforts to ensure that children with special needs (such as physical, mental or emotional handicaps) are not excluded from participating in the technology curriculum (Donnelly, 1992). Practical activities which form part of the design and technology curriculum are able to provide special needs students with valuable skills in the areas of communication and language, numeracy, vocational and motor skills (Rodbard, 1989) and enhancement of self-image (Lund, 1986). Design and technology can also provide extension and enrichment activities to help foster gifted and talented children (Stoker & Green, 1983).

Coleman (1981) and Stevens (1988) both describe the successful implementation of a technology curriculum within their classes of special needs students in England. An example from England of a special school teacher's initiative, has been documented by Davidson and Gaster (1985). A wheelchair bound student with only limited arm and hand movement had become increasingly frustrated with the fact that most of his 3-D creative work was limited to clay and plasticine. The teacher was able to fit a vice onto the arm of a wheelchair and project it across the front of the child at an appropriate height. By careful selection of work, materials and tools, the student's learning horizons were considerably expanded.

Two areas where children with special needs may encounter difficulties are with communication and the 'making' aspects of the design and technology curriculum (Benson, 1990a). To help address the problems associated with communication, strategies such as collaborative writing, tape recording, photographic recording and pictorial representation have been suggested. To assist special needs students with making things, teachers may need to adapt the work accordingly and to encourage children to share their expertise and deficiencies in sensitively selected groups (Bindon & Cole, 1991). Physical help may be necessary to help students with disabilities engage in tasks such as designing, building, modelling, drawing, sorting and collecting. For some students, specialised equipment (e.g. computers, voice synthesiser, braille, templates, magnification aids) and specialised languages (e.g. signed English, Auslan) may be appropriate (Curriculum Corporation, 1994a, 1994b).

It has been argued that design, design awareness, craftwork and home economics could form the 'core' of the curriculum for children with special needs (Jones, 1983). Design and technology provides the motivation for many special needs students, and as a result they often perform in a manner contrary to class teacher expectations (Lever, 1990; Lund, 1986). Finally, the training and skills developed in design and technology can provide children with special needs the means for more constructively occupying the long hours of enforced leisure time that will inevitably be the pattern of their adult life (Coleman, 1981; Jones, 1983).

From this literature review, the issue of equal opportunity and DMA appears to be an area that may warrant attention during the class observations which follow. I will need to include in my focus on whether there are any differences between the working habits and attitudes of the girls and boys. I will also need to try and observe if the curriculum materials used are gender inclusive and whether there are any effects caused by different cultures / race of any of the children. Lastly, attention will also need to be given to any identified special education children that may be in the class.

5 ASSESSMENT

The design and technology process provides an example of an alternative assessment model in which a complex and significant task is accomplished, prior knowledge is utilised and an authentic problem is solved (Mahlke, 1993). There are two important principles to be considered in assessing children's performance in design and technology. They are that teaching, learning and assessment is (or should be) interrelated and that the curriculum should lead the assessment and not vice versa (Bentley & Campbell, 1990b). Carr (1990) has contradicted this assertion by claiming that assessment procedures drive the learning process and the curriculum. In this current study it will therefore be interesting to observe the place of assessment within the DMA process.

Assessment throughout a design and technology project should be a continuous and on-going cyclic process (Bindon & Cole, 1991; Gilbert, 1987). As part of this cyclic process, feedback from each stage allows the student to modify ideas already generated or move forward onto new ideas (Lever, 1990). Also, assessment is an integral part of the education process and provides a framework for promoting children's learning. It lies at the heart of promoting children's learning. It is a holist concept and is a part of normal classroom activities (Bentley & Campbell, 1990b). Assessment in design and technology needs to be based on clear expectations and recognise process as well as product. Students need to be involved in assessment and should be given credit for acceptable unintended learning. In addition, the importance of context in which the assessment occurs needs to be recognised (Crawford, 1988).

Assessment of student learning in technology can employ many sources of information (Curriculum Corporation, 1994b). Anecdotal records, checklists, teacher observations, portfolios of student work (Mahlke, 1993) and prepared proformas (Wisely, 1988) can be compiled to provide a performance assessment of the DMA process. Pupil profiling has been advocated as another assessment strategy by Donnelly (1992) while Montgomery (1988) has suggested dividing the curriculum into twenty six fields of study to form a mock 'brick wall' to facilitate continuous assessment and recording of achievement.

According to Ellyard (1995), all assessment should begin with student self-assessment, with the teacher assessing the student's self-assessment, and not the student's work directly. Student self-assessment has an important role in DMA learning (Donnelly, 1992) and children need to learn the skills of self-evaluation (Anning, 1992). With young children, a framework needs to be employed which continually stresses the child's own individual experiences within the task (Bishop & Simpson, 1992). Children need to share their insights within a climate of critical friends and feed their ideas directly back into subsequent phases (Anning, 1992). The design process encourages the self-evaluative skills that children need to obtain, and fosters both an aesthetic awareness and an atmosphere of constructive criticism (Wisely, 1988).

The key to children's self-assessment appears to be recording (Lever, 1990). Children can be directed to record their results, predictions and interpretations at any stage of the process. This recording can be in written form or may be verbal answers. Humphreys (1996) found in her action research study of her year six class, that the children were reluctant to make any judgements about their own DMA work. They were quite happy to show others their models and how they worked but would not be drawn into making any judgemental comments about it. She tentatively hypothesised that the reason for children's reluctance to make self-judgements, was linked to society's demands and expectations whereby success tends to be respected, but boasting about one's achievements is deemed socially unacceptable. Likewise failure is looked down upon and not seen as a chance to learn and improve. It will be interesting in the current study to compare the younger children's behaviour with regard to self-assessing with these older children from England.

Assessment (or appraisal) should be built into the processes of designing and making (Anning, 1992) and should centre on class observation of the child's ability to plan, choose materials and discuss designs with both peers and adults (Bishop & Simpson, 1992). Evaluation needs to permeate the whole iterative cycle of designing and making and not be conceived as a bolt on process added at the end (Anning, 1992). Teachers need to assess and evaluate children's construction skills and the development of particular concepts (Wisely, 1988).

Whole school program assessment can provide a process that can be used to improve existing practices or assist in the development of new programs (Wisely, 1988). Curriculum materials, teaching strategies, resources used and overall student performance can all be assessed as part of this process. It can be invaluable if the teachers evaluate their school technology policy against its implementation in practice (Gilbert, 1987). In a Canadian study of secondary science, technology and society teachers, it was found that their assessment practices were a reflection of their own personal understanding of the assessment process and had evolved over time from their own personal experiences (Duffee & Aikenhead, 1992).

One of the areas of concern for many primary teachers implementing DMA curriculum is progression (Smith, 1995). Most primary teachers have only a limited understanding of how children make progress in and through practical work (Anning, 1994). It is important to recognise and record children's progress in DMA tasks (Richards, 1990a). The national profiles (Curriculum Corporation, 1994b) are written to show the typical progression in achieving learning outcomes. Smith (1995) contends that both progression and assessment need to be linked by teachers continuously monitoring what they teach and what is being learned by the students. Two of the key areas of progression are skill development and the acquisition of a bank of knowledge and understanding. A progressive approach can be taken to building a pyramid of skills and knowledge. The base of the pyramid needs to be broad and strongly reinforced so as to form a solid foundation on which to build.

Four unresolved assessment issues for teachers have been identified by Bentley and Campbell (1990b). These include lack of teacher time; confusion caused by curriculum overlap; establishing realistic baselines; and the advisability of having

DMA coordinators in schools to assist class teachers with assessment procedures. The British Assessment Performance Unit conducted the single largest attempt to assess DMA performance (Donnelly, 1992). Both holistic and atomistic assessment methodologies were used. A heavy emphasis was placed on the imaging and modelling aspect of technology. A multi-faceted attack was made on the problem by using both short purpose-built and procedural-focused instruments and naturalistic studies of pupils' longer term work. The results revealed that, under some circumstances, overall performance can be assessed more reliably than that on only part of a design task. Interestingly, the findings also demonstrated that a highly structured approach to pupils' work can result in improved performance. This can have implications for the long standing ideological framework of technology education.

A number of other aspects of the pedagogical framework of DMA present particular problems in the field of assessment (Donnelly, 1992). When children work as members of a team on a DMA task, certain difficulties arise when it comes to individual assessment (Lever, 1990). Sometimes it is not possible to easily distinguish between when children are planning, making or evaluating (Bindon & Cole, 1991). It is important that the criteria used in assessing students cover a number of learning experiences common in DMA activities (Crawford, 1988). The assessment objectives should be sufficiently flexible to cater for individual responses to tasks (Donnelly, 1992). In the current study which follows, attention will need to be paid to assessment aspects such as those mentioned in this section.

6 SUMMARY

This review of the literature of design and technology education, has provided the platform on which to build the study to follow. The nature of technology education has been explored. It has been found that the process of DMA is an integral and interdependent strand of technology education. The terms technological *capability* and *literacy* are also inextricably linked with DMA activities. It was found that technology has close relationships with science and also society and the environment. DMA within a primary school context was found to have gradually evolved from technology education in the secondary sector. DMA in Australian primary schools now forms a major part of the technology curriculum that is one of the eight key learning areas of study that must be taught to all children during their compulsory years of schooling.

In the study which is to follow, an attempt will be made to reveal some of the factors and issues that are involved during the implementation of a DMA program in an early years classroom. This literature review has highlighted a number of potential factors and issues that can serve as starting points to guide the subsequent observations. Some of these factors and issues which I will need to focus upon include the relationship between the DMA activities and science as well as the relationship between DMA and society / environment. Pedagogical aspects which I can start to focus on include the designing stage and whether the DMA activities are integrated with other curriculum areas. From the literature it was revealed that the place of the design stage in the DMA process can be problematic and will therefore need to be observed in the study. The review of the literature has also revealed that the design stage with young children has not received much attention from the research community. The literature on gender aspects associated with DMA has indicated that I will need to focus on whether there are any gender differences present in the class by paying attention to the teacher's behaviour and children's attitudes and working habits. During my observations I will also need to take note of any differences in DMA outcomes that may be due to culture / race of the children in the class. The effect of the DMA program on any identified special education children will also be noted. Special attention will need to be paid to the area of assessment and whether the materials used during the program are gender inclusive. As mentioned earlier, each of these potential factors and issues revealed from the review of the literature on DMA teaching and learning will form starting points for my focus. Additional factors and issues will no doubt emerge during the conduct of the study. The research method to be selected will therefore need to be sufficiently open-ended to allow this to occur.

CHAPTER 3

METHODOLOGY

1 STUDY DESIGN

1.1 Qualitative research

The term 'qualitative research' has been broadly defined to refer to any research that produces findings that are not arrived at by using statistical procedures or other means of quantification (Strauss & Corbin, 1990). There are several considerations that need to be taken into account when deciding to adopt a qualitative research methodology. Strauss and Corbin (1990) claim that qualitative methods can best be used to better understand any phenomenon about which little is known. These authors also claim that qualitative methodology can be used to gain new perspectives on familiar occurrences, or to gain more in-depth information that may be difficult to obtain quantitatively. In this study the initial research questions sought to uncover the factors and issues involved in the implementation of a DMA program, and were framed as open-ended questions that sought to discover new information. Qualitative data has the potential to more fully describe a phenomenon not only from the researcher's perspective, but also from the reader's perspective. Thus qualitative research, which usually provides information in the form in which readers are familiar, can result in a greater understanding of the phenomena being investigated (Lincoln & Guba, 1985). A similar point has been made by Stake (1978) when he asserts that qualitative research reports are usually rich with details and insights into participants' experiences of the world that are more meaningful, since they may be epistemologically in harmony with the reader's experience.

In order to investigate the factors and underlying structural and organisational issues which contribute to the implementation of a DMA program in an early years classroom, the most appropriate mode of disciplined inquiry (Shulman, 1988) was to develop a qualitative case study (Denzin, 1988; Stake, 1978; Yin, 1989). According to Erickson (1986), the central issue of selecting an appropriate research method is to bring the research questions and data collection into a consistent and evolving relationship. Qualitative case study research uses natural settings as it seeks to describe and understand relationships without attempting to manipulate variables (Gloeckner & Gerst, 1994). To advance the knowledge base of DMA curriculum, the case study has the potential to provide a holistic account of the phenomenon by offering insights and illuminated meanings that are able to expand the reader's own experiences (Merriam, 1988). Thus the qualitative genre is able to offer richer and fuller understandings of education (Jacob, 1987) and as a consequence may result in improved practice.

1.2 Characteristics of case study research

Patton (1990) has pointed out that there are no absolute characteristics of qualitative inquiry, but rather a number of strategic ideals that are able to provide a direction and framework for developing specific designs and concrete data collection strategies. A number of writers have identified what they consider to be salient features of qualitative, or naturalistic case study research (see for example: Denzin, 1988; Eisner, 1991; Lincoln & Guba, 1985; Patton, 1990; Stake, 1978; Yin, 1989). The following list represents a synthesis of what these authors believe to be the main identifying characteristics of qualitative case study research:

1. Case studies make use of natural settings as the source of data description and interpretation.
2. The researcher acts as the (human) primary instrument of data collection.
3. Case study researchers predominantly use inductive data analysis.
4. Case studies are normally in the form of descriptive narratives and are concerned with the particular as a means of understanding the general.
5. Case studies have an interpretive character aimed at discovering the meaning events have for the individuals who experience them, and the interpretations of those meanings by the researcher.
6. Case study researchers attempt to pay attention to the idiosyncratic as well as the pervasive, seeking the uniqueness of each case.
7. Case studies have an emergent (as opposed to a predetermined) design in which the researcher seeks to observe and interpret meanings in context.
8. Case studies are judged using special criteria for trustworthiness. Judgements about the usefulness and credibility are left to the researcher and the reader.

The case study in this thesis was both descriptive (of the classroom setting and situation) and interpretive (Peshkin, 1993). The case study was enhanced by the inclusion of some quantitative data. Fetterman (1988), Patton (1990) and Strauss and Corbin (1990) agree that qualitative and quantitative approaches can be effectively combined in the same research project although Fraser (1991) claims that such an approach has been only applied in a limited way. In their study of the use of technology-based materials in a primary classroom, Russek and Weinberg (1993) claim that the use of both qualitative and quantitative data provided insights that neither type of analysis could have provide if used alone.

Because case studies are holistic, they attempt to portray the interplay of different features and forces (Wilson, 1979). A case study helps understand the complexity of the teacher and student claims, concerns and issues (Guba & Lincoln, 1989) involved in the implementation of a DMA program in the early years of schooling. Case studies allow the interpretation of events within a real-life context (Yin, 1989).

1.3 Advantages of case studies

Case studies are able to take the reader to sites that may not normally be accessible. Readers of case studies are able to expand their own experiences through the vicarious sharing of other people's experiences. Readers benefit by having perspectives presented by others who are able to observe, probe and analyse (Wilson, 1979). According to Donmoyer (1990), one of the purposes of case studies is to expand the range of available interpretations and so expand the reader's cognitive structures. Because case studies are usually full of rich detail, they enable the reader to enter the portrayal and to feel what it must have been like to have been present at the site at the time of the study. The case study approach is particularly suited to curriculum research because it provides an integrated way of describing aspects of classroom learning and practice (Jane & Jobling, 1995).

Another advantage of case study as a method of research is that it enables readers to see the world through the researcher's eyes and in the process, see things that otherwise may not have been seen or considered. Donmoyer (1990) contends that case studies need to contain what he refers to as sufficient 'medium-rare' data, so that the reader is able to enrich her/his understanding of an ideal type by accommodating the novelty of the particular case. Donmoyer uses the term 'medium-rare' to describe data which has been effected by the researcher's language and anticipatory schema. This is in contrast to raw data which by definition has been uncontaminated by the researcher. The provision of sufficient medium-rare data in a case study can result in a reader who starts from a different theoretical orientation to the researcher's, interpreting the researcher's narrative in a significantly different way. This can add depth and dimension to theoretical understanding.

The vicarious experience provided by case studies can assist readers to screen out disquieting and psychologically threatening aspects of direct experience that make them feel uncomfortable (Donmoyer, 1990). For example, a teacher reading a narrative description of a particular pedagogical phenomena that is occurring in another teacher's classroom, is likely to feel less threatened than if initially asked to confront the particular phenomena in their own classroom. The self-analysis is initially at a distance and therefore the teacher's initial defensiveness will be less. This self-analysis by the teacher will need to eventually lead to action if the teacher's pedagogical repertoire is to change and improve.

The case study research approach can also be useful in highlighting relationships that can be further studied in other ways. Suggestions for more tightly controlled research can very often be extracted from intensive case studies. And vice versa, research conducted in tightly controlled artificial circumstances can sometimes produce findings that may then need to be subjected to carefully designed case studies (Mason & Bramble, 1989). In addition, case studies have the potential to generate questions to guide future investigative research.

1.4 Limitations of case studies

There are a number of limitations associated with the use of case studies as a research method. Because the case study approach uses only a small sample, generalisation of findings to other cases can often be hazardous (Mason & Bramble, 1989). It has been argued by Eisner (1991) that the conventional criteria commonly used for making generalisations are not appropriate for qualitative studies. Donmoyer (1990) prefers the use of personal, idiosyncratic experience as a source of generalisation. As the practice of education is revealed in classrooms, it ultimately becomes focused on individual children rather than groups of children. Hence a teacher reading a qualitative case study must always adjust and fine tune any generalisations that may be relevant to a particular context or situation.

Generalisations revealed in the narrative of a case study emerge as a form of personal knowledge and are referred to as *naturalistic generalisations* that arise from personal experience (Stake, 1978). This is in contrast to other types of formal generalisations that emerge from the use of the quantitative research paradigm.

The usefulness and appropriateness of a case study needs to be judged in relation to the specific circumstances of practice in a practitioner's own setting (Erickson, 1986). The generalisability of the findings of the study resides with the reader rather than the researcher (Wilson, 1979). The process of naturalistic generalisation is an expansion of one's experience and provides the power and sensitivity to guide action outcomes (Stake, 1978). The reader needs to examine the circumstances of the case to determine the ways in which the case fits the circumstances of her / his own situation. Practitioners are able to learn from a case study even if the circumstances of the case do not exactly match those of their own situation. For this to be achieved, the case needs to possess adequate specificity in the data collection and reporting processes. Some case studies fail to achieve this requirement.

The problems associated with bias are frequently mentioned in the literature. One of the classic research problems according to Walker (1984) concerns how to produce a record that is unbiased, representative and reliable. A case study can be biased because of the heavy reliance on humans as the primary instrument of data collection and analysis. The open-ended nature of case study methodology can also lead to researcher bias. The lack of rules for case study research leaves open the possibility for real and imagined abuse (MacDonald & Walker, 1977). In addition, a researcher may select a case to study in which the findings can be fairly dependably predicted. In this study I have provided some background information about myself to help the reader identify any potential biases that I may have. Such an approach has been suggested by Stake (1995) to assist in the validation of naturalistic generalisation. Although bias is a natural part of human endeavour, our understanding of events is actually constructed through the preconceptions that we bring to them. The most appropriate strategy is to be aware of these preconceptions and to make explicit the researcher's preconceptions (Wallace & Louden, 1997).

2 DATA GATHERING TECHNIQUES

According to Stake (1978, 1988a), case study methods are usually more suited to expansionist rather than reductionist pursuits. The case study proliferates rather than narrows and one is usually left with more to pay attention to rather than less - more questions raised than answers found. In this study use was made of continuous focusing (Erickson, 1986) in which attention was progressively moved from the class as a whole to groups of children, then to pairs and finally to individual children. In field research, observing, data processing and analysis are dynamic interrelated activities (Babbie, 1975). New observations often reveal new patterns and may result in revisions to the initial observational strategy. As the data gathering and analysis occurred in this study, I was able to extend beyond the initial research questions and explored a number of additional but related areas of further claims, concerns and issues that impinged on the DMA curriculum implementation processes.

Case study methods are rarely described in advance, except in the most general terms (MacDonald & Walker, 1977). There are no set rules or rigid procedures (Burgess, 1985). The approaches selected for obtaining the data in this study were wide and varied in order to generate a comprehensive data pool. Thus I was able to generate a rich description of the DMA program. According to Lincoln and Guba (1985) before commencing a qualitative case study, a researcher needs to do three things. First, she / he must adopt the stance suggested by the characteristics of the naturalist paradigm. Second, the researcher must develop the level of skill appropriate for a human instrument acting as a vehicle through which data will be collected and interpreted. Finally, the researcher must prepare a research design that utilises accepted strategies for naturalistic inquiry. In addition, Burgess (1985) recommends that the case study researcher continually poses questions; records observations with as much detail as possible; and regularly reviews and cross - checks observations so that themes and patterns may be developed and in turn linked to theoretical perspectives.

The three main prevailing forms of data gathering techniques associated with qualitative case study are participant observation, interviews and examining documents and each of these were used in this study.

2.1 Participant observation

The classic form of data collection in naturalistic research is the observation of participants in the context of a natural setting, which in this study was the classroom. There are a number of ways that a researcher may act as an observer at the site. Both Schatzman and Strauss (1973) and Burgess (1985) have discussed a variety of observation strategies ranging from the researcher watching from outside of the site without being observed; the researcher maintaining a passive presence by being as unobtrusive as possible and not interacting with participants; the researcher engaging in only limited interaction, intervening only when further clarification of actions is needed; and the researcher acting as a full participant in the situation, with either a hidden or known identity. Each of these different types of observation strategies have specific advantages, disadvantages and concerns that need to be taken into consideration by a qualitative researcher prior to selecting an approach to take in the field. In this study I made use of the latter approach in which I fully participated in the DMA sessions.

Participant observation is one of the most powerful tools available to the qualitative case study researcher, who acts as the sole primary instrument of measurement and data collection (Russek & Weinberg, 1993). It has been claimed that this technique is very difficult to do well because the researcher must be both an objective observer while simultaneously fully participate in the setting (Mason & Bramble, 1989). In this study the observational data that was collected was used to describe the setting, activities, children and teacher, and the meanings of what was observed. Observations may lead to deeper understandings than can be obtained from utilising interviews alone, because they provide a knowledge of the context in which events are occurring, and may enable the researcher to see things that participants themselves may not be fully aware of, or that they are unwilling to discuss (Patton, 1990).

I would typically arrive at the school during the morning recess break and make my way straight to the classroom. The teacher invariably would still be in the staff room and the children out playing in the school yard. At the beginning of each session I would set up the tape recorder at the back of the classroom together with the video camera. As a participant observer in the classroom I joined in the various activities as appropriate, assisting the children as they worked on their various DMA activities. During the sessions I interacted informally with the teacher. I had a good rapport and working relationship with her. Almost as important as the act of observation was the need to keep an open mind about what I saw (Jackson, 1968). The observations and any notes made in the classroom were written up as detailed field notes immediately following each DMA session. Lofland and Lofland (1984), while acknowledging the difficulty of writing extensive field notes during an observation, recommend jotting down notes that will serve as a memory aid when full notes are constructed. This should happen as soon as possible after the observation, preferably the same day. My field notes became running descriptions of the setting, the children, the teacher and all of the various activities occurring. In the initial stages of writing my field notes I deliberately recorded as much detail as possible. These initial observations were then able to serve as a basic guide to provide me a background for subsequent observations. I also included notes on my self-analysis and personal reflections. Maykut and Morehouse (1994) have suggested the use of brackets to distinguish between objective observations and personal reflections / comments and I was able to employ this technique in my field notes (See Appendices 1 & 4). All observations were regularly reviewed and cross-referenced with the observations made in previous sessions so that any emerging themes and patterns could be extracted. These then formed the basis for my formulation of tentative assertions.

Extensive use was made of electronic recordings of the sessions to assist me to recall critical incidents. All sessions during term three were audio-taped and some videotaped. The audio-tapes of the sessions were used to assist me as I attempted to recall and write up my field notes (and comments) after each session. In those sessions where I used the video camera, I set up the tripod and camera in the back corner of the classroom, on the corridor side of the room. In order to record individuals, pairs or small groups of children working on the DMA tasks, I would focus the camera on a particular table that I had decided I would like to re-observe later when I viewed the video. At an appropriate time I would switch on the camera and leave it on record. It appeared to me that the children seemed quite unaware that this recording was occurring. Coloured photographs (Figures 5.6, 5.7, 5.8 and 5.9) and videos were taken of some of the models produced by the children as additional records (Brown, 1989; Walker, 1984).

It has been argued that research should properly use the 'interpretive categories of teachers' to understand the contexts and processes of schools (Carr & Kemmis, 1986). In an endeavour to allow this to occur, my observations in the classroom were supplemented by self-reflections on the sessions and regular debriefings with the teacher following each of the sessions. I debriefed with the teacher by clarifying and discussing critical teaching incidents that occurred during the preceding session. During these debriefing sessions I was able to refer to my field notes. In addition, the teacher was asked to read drafts of the thesis and make comments and responses when appropriate. Such a process ensured that any obvious misinterpretations or misunderstandings were corrected. Comments and ideas gained from this process were included as part of my field notes. Participants in educational processes have a central role to play in developing new practices and need to become, not objects for external researchers to investigate and relate in causal models to input and output variables, but agents in the research process itself (National Board of Employment, Education and Training, 1992).

2.2 Interviews

A second method of data collection used in case study research is the use of interviews which Burgess (1985) refers to as 'conversations with a purpose'. Interviews can be used to complement participant observations. Patton (1990) discussed three types of qualitative interviewing strategies. First there are the informal / conversational interviews. Secondly, there are semi-structured interviews and thirdly there are standardised, open-ended interviews. In this study I used mainly the first type of unstructured interviews that took the form of extended conversations. This was because of the very young age of the children and also because I wished to conduct the study with only minimum disruptions to the normal classroom routines. In addition, unstructured interviews (as recommended by Merriam, 1988; Patton, 1990) with selected students and the teacher were conducted informally throughout the conduct of the study. A formal interview with the school principal was conducted, and this provided me with background information about the school and its technology education curriculum. Use was made of a list of prepared questions and the interview was audio-taped and then transcribed. Information obtained from the unstructured interviews was used to complement the other two types of data collection strategies - participant observation and document examination.

Lincoln and Guba (1985) do not recommend recording interviews (except for unusual reasons) because of the intrusiveness of recording devices and the possibility of technical failure. Since they made this claim technological advances have greatly improved efficiency and effectiveness of electronic recording devices. I recorded the formal interview with the principal and made a transcription. (See Appendix 2).

2.3 Examination of documents

Additional data about the teacher and the school contextual features were obtained by searching various school and classroom documents including curriculum programs, lesson plans, school and class newsletters, parent handbook, student work-books, student work-sheets and materials on display in classrooms. The Education Review Report (see chapter 4 - section 5) was also consulted. In addition, the teacher was encouraged to keep a personal reflective journal, as advocated by Holly (1992). A journal is a personal document with the writer usually the only one who reads it. It can be used as a tool for professional development by allowing a teacher to explore ideas by writing reflectively about practice. Such a strategy may have assisted the teacher to clarify and sharpen issues that she later raised with me during our regular debriefing sessions.

2.4 Quantitative data

Some quantitative data about the classroom environment was obtained by the administration of the short form of the My Class Inventory (MCI) - (Fraser, 1993). This is a simplified five-scale instrument that was adapted from the original Learning Environment Inventory for use with eight to twelve year old primary students (Fisher & Fraser, 1981). It focuses on children's perceptions of their *actual* classroom environment and measures their levels of satisfaction, friction, competition, difficulty and cohesion in their classroom. Several research studies have successfully used the MCI with children in year one classes (Ciupryk & Malone, 1989; Fisher, Fraser & Bassett, 1995). Some of my own modifications of this instrument were necessary for its use with very young children. These include oral administration to individuals rather than using small groups or the whole class, and increasing the print-size of the forms. Because of the age of the children involved in this study, it was not felt appropriate to measure the perceptions of their *preferred* classroom environment. The MCI data obtained enabled me to expand the description of the classroom.

In order to gauge the current level of technological awareness of the children, the Draw a Scientist [Technologist] Test (DAST) - (Chambers, 1983) was administered to the children during term four. A structured interview with each child in the class was also undertaken during term four. During this interview further information was sought about the children's technology background by asking them to name their favourite toy; whether they had a computer at home (and if so, how they used it); vocational aspirations; and to clarify aspects of their DAST drawing. The collection of this data was used to assist me in formulating a broader profile of the children being observed in the study.

The study extended over the whole of the second semester (two terms) with the researcher working in the classroom every Wednesday. The implementation of the DMA program during term three formed the basis for the study. The time I spent in the classroom in term four enabled me to gather additional data. I was able to informally talk further with the teacher and children, conduct individual interviews with the children and administer the DAST and the MCI. It also enabled me to clarify and cross-check my observations, comments and perceptions made during the previous term three.

2.5 Theoretical sensitivity

Glaser and Strauss (1967) and Strauss and Corbin (1990) have each referred to what they call the 'theoretical sensitivity' of the researcher. This is a useful concept with which to evaluate a researcher's skill and readiness to attempt a qualitative inquiry. This theoretical sensitivity comes from a number of sources, including the reading of professional literature, personal and professional experiences. The credibility of a case study report relies fairly heavily on the confidence that readers have in the researcher's ability to be sensitive to the data and to make appropriate decisions in the field (Eisner, 1991; Patton, 1990).

Therefore in order to collect data appropriate for this study, the data collection strategies were driven by the following criteria. The data should:

- document pedagogical practices (e.g. discourse, tool use, problem solving) that occurred during the implementation of the DMA program.
- document resources (e.g. tools, products of children's work, concepts taught).
- follow some of the same students over a longer period of time.
- focus on children who represent the broad range of abilities, interests and attitudes present in the class.

These criteria, and local contingencies (such as children who finish early and absences) were used to determine my decisions about how, when, where, what and who to focus on to observe and record.

3 DATA ANALYSIS

Qualitative data analysis is a process that takes many forms, although it is basically a nonmathematical analytical procedure that involves examining the meaning of people's words and actions (Maykut & Morehouse, 1994). The process of qualitative data analysis has been described by Bogdan and Biklen (1982) as working with data by organising it; breaking it down into manageable units; synthesising it; searching for patterns; discovering what is important and what is to be learned; and deciding what it is that you wish to tell others. Qualitative researchers tend to use inductive analysis through which critical themes emerge out of the data (Patton, 1990). Qualitative analysis of data requires some creativity, for the challenge is to place the raw data into logical, meaningful categories; to examine them in a holistic fashion; and to find a way to communicate this interpretation to others.

Strauss and Corbin (1990) have categorised three broad approaches to analysing qualitative data. These three approaches can be conceptualised along a continuum ranging from low to high levels of interpretation and abstraction. The first low level approach involves researchers presenting their data without any analysis at all. The second approach involves some selection and interpretation of the data. Using this approach, the researcher weaves descriptions, interview and field note quotes together with their own interpretations into a rich and believable narrative.

The third approach to data analysis lies at the other end of the continuum where there is a high level of interpretation and abstraction from the data. This leads on to theory building that helps to explain the phenomena of interest. Glaser and Strauss (1967) developed the notion of 'grounded theory' to accommodate this data analysis strategy. In their classic text *Discovery of Grounded Theory,* Glaser and Strauss (1967) describe the generation of grounded theory to be more than description or theory testing. According to this view, theory is not a static perfect product but rather a dynamic ever-developing entity or process. Glaser and Strauss (1967) claim that one of the requisite properties of grounded theory is that it be sufficiently general so as to be applicable to a multitude of diverse situations within the substantive area. It could be argued that the grounded theory approach as described by Glaser and Strauss (1967) represents a somewhat extreme form of naturalistic inquiry. I maintain that it is not necessary to always insist that the product of qualitative inquiry necessarily be a theory that will apply in a multitude of diverse situations. Examples of a more flexible approach to qualitative inquiry can be gained from a number of sources. For example, both Patton (1990) and Guba (1978) maintain that naturalistic inquiry is always a matter of the extent to which the researcher influences responses and imposes categories on the data. The more 'pure' the naturalistic inquiry, the less reduction of data into categories has occurred.

In this study I have adopted Strauss and Corbin's (1990) second approach in which description and interpretation were combined. Although an emphasis has been placed upon an ethnographic description of the DMA program being implemented, no doubt elements of theory may be revealed in the narrative together with the accompanying interpretations.

Data analysis begins with the identification of themes (and patterns) emerging from the raw data, a process sometimes referred to as 'open coding' (Strauss & Corbin, 1990). During open coding, the researcher must identify and tentatively name the conceptual categories into which the phenomena observed will be grouped. The goal is to create a preliminary framework for analysis. Words, phrases or events that appear to be similar can be grouped into the same category. These categories may be gradually modified or replaced during the subsequent stages of analysis that follow.

The use of data displays has been suggested by Miles and Huberman (1984) as another strategy to organise information in order to assist in clarifying what is happening and draw tentative conclusions. A data display matrix can be used to help isolate those factors and issues that appear to be the most relevant for the implementation of the DMA program. I found that many factors and issues did emerge from the variety of data sources used during the conduct of this study. A data display matrix helped me to reduce the data into an organised form, and so expose those factors and issues that appeared to be the most pertinent to the DMA implementation process.

Data analysis can also involve the re-examination of the categories identified to determine how they are linked, a complex process that has been referred to as 'axial coding' (Strauss & Corbin, 1990). The discrete categories identified in open coding are compared and combined in new ways as the researcher begins to assemble the 'big picture'. The purpose of axial coding is to not only to describe, but more importantly, to acquire new understandings of the designated phenomena. Therefore, causal events contributing to the phenomena; descriptive details of the phenomena itself; and the ramifications of the phenomena under study must all be identified and explored. During axial coding the researcher is responsible for building a conceptual model and for determining whether sufficient data exists to support that interpretation.

As previously mentioned, both the tasks of data collection and analysis need to occur in a dynamic and interactive fashion. The collected data needs to be analysed according to implied strategies, hunches and themes. As the data collection phase drew to an end, the major analysis task was then be to reduce the amount of data by making summaries, identifying clusters and creating data displays.

Because a case study is a detailed examination of a bounded system in one particular setting, the process of interpreting meaning needs to be constructed by the reader (Abell & Roth, 1992). Rich descriptions of social forms and behaviours are in themselves quite inadequate and incomplete (Abbott-Chapman, 1993). The raw data needs to undergo processes of refinement, reduction, selection, focusing, simplification, abstraction and transformation. Such processes enable causality to be assessed and fruitful explanations to be derived as the analysis moves beyond the initial framework and pre conceptions. During the data analysis process, the researcher deliberately seeks confirming and disconfirming evidence from the multiple data sources (Erickson, 1986; Stake, 1988b; and Yin, 1989). This process can be assisted by employing inductive analysis (Abell & Roth, 1992) in which repeated examinations of field notes, audio and video tapes, interview transcripts and documents can lead to the development of categories for organising the data in order to report the findings.

During the analysis of the data in this study, an iterative process was used to develop explanations and examine them in conjunction with the literature (Strauss & Corbin, 1990). The identified factors and emerging issues were then presented as a series of tentative assertions from which eventually I was able to draw some implications for teachers. Stake (1995) has referred to these assertions as being the researcher's 'propositional generalisations'.

Some aspects of the data analysis was conducted collaboratively with the class teacher who was the focal informant (Abell & Roth, 1992). The class teacher was asked to read drafts of this case study and to make critical comments about the contents. The quantitative classroom environment data together with the qualitative information obtained was cross-validated by checking the various data for consistency (Wiersma, 1991). This enabled greater credibility to be placed on the findings, because they have emerged consistently from the data obtained using a wide range of data collection methods (Fraser, 1994; Fraser & Tobin, 1991).

According to Abell and Roth (1992), case studies tend to seek to describe specific configurations of events and then establish theoretically valid inferences. To be externally valid, the case need not necessarily represent the average. The reliability of this study - that is, the probability of its findings being confirmed by replication, were significantly enhanced by engaging in a continuous process of cross-checking and negotiation. The data for the case study has been deliberately sought from as wide a source as possible using a variety of qualitative and quantitative data gathering techniques, thus ensuring that they had some combined validity.

In summary, the data analysis process that I used in this study involved a combination of both 'open' and 'axial coding'. From this process I formulated an initial series of assertions that represented the identified factors and emerging issues. This was followed by inductive analysis that enabled me to further refine these assertions into their final form.

4 SELECTION OF SCHOOL AND GAINING ENTRY

Highfield junior primary was selected as the school to use for this case study because it was convenient and most importantly was receptive to participating in the proposed research. I had visited the school on several occasions during the previous year to administer the MCI in a year two class as part of a course work unit requirement. The initial contact with the school had been with the principal and when it was decided to use this school for this case study, the principal was once again approached with the proposal. According to Erickson (1986) negotiation of entry is an important yet complex process. It is at this critical stage that the researcher establishes the grounds for building the all important rapport and trust. At this preliminary interview with the principal I stressed that I would respect the confidentiality of the participants and that it was intended to write up the case study with the class teacher reacting to drafts of the thesis. Mention was also made of the types of data gathering methods to be used and a reassurance given that the release of any findings arising from the study would first be cleared with the teacher concerned.

5 SELECTION OF TEACHER AND CLASS

Following the initial approach about the possibility of using a class for this case study, the principal discussed the proposal with one of her teachers. The teacher, who I called Jill, willingly agreed to participate during the following school year. Jill's class was to be a reception class in the first year of formal schooling and she was to share the teaching load with a tandem teacher. I was pleased to be able to gain access to young children at the beginning of their school career and viewed the opportunity as a challenge. Because of the lack of a large number of studies involving very young children, it would appear that many educational researchers tend to avoid working with children of this age because maybe they believe that they are more difficult to study due to their limited exposure to school routines, flexible thought patterns (which seem to be constantly changing), and often short attention spans.

The principal recommended Jill because of her interest and previous work in the school on DMA education. I first met Jill at the beginning of the new school year and thanked her for agreeing to assist. At this initial meeting the proposals for conducting the case study were explained and a familiarisation visit to the class arranged for the end of term two prior to commencing the regular weekly visits to the class in terms three and four. At this stage it was agreed that I would be present in the classroom each Wednesday morning during terms three and four between morning recess and lunch time - the length of this period being one hour and twenty minutes.

6 ETHICAL CONSIDERATIONS

Confidentiality was a critical aspect of the study. The dignity, integrity and privacy of the participants needed to be respected at all times (Guba & Lincoln, 1989). Where qualitative research methods are used, the issue of informed consent can often be tangled and contested (Howe & Dougherty, 1993). Anonymity and confidentiality was accorded to all participants and pseudonyms were used throughout the study. As mentioned earlier, the teacher was encouraged to have a 'voice' in the data collection and analysis processes. Maykut and Morehouse (1994) believe that collaboration helps to reduce the power differential between researchers and participants. It has been suggested that the consent by the participants for a study needs to take place as an ongoing dialogue as the study unfolds (Howe & Dougherty, 1993). I attempted to achieve this during my study through my constant contact with the participants. As previously mentioned, the possible release of any material for publication was also negotiated with the teacher and the school involved.

7 RIGOR

MacDonald and Walker (1977) claim that case study is the examination of an instant in action. As such case studies are always only partial accounts that are usually conducted under constraints of time and resources. In qualitative research, the data collected and the resultant findings need to be consistent and dependable (Merriam, 1988). To ensure the trustworthiness of the study the following criteria were used:

prolonged engagement; persistent observation; and member check (Lincoln & Guba, 1987).

- *Prolonged engagement* Because the study was conducted over two terms of the school year, my substantial involvement in the classroom and the DMA program enabled me to establish a rapport with the participants and build the trust necessary to assist me to observe and understand the context of the site.
- *Persistent observation* In this study I was able to be persistent in my participant observations by fully immersing myself in the life of the classroom. The object of persistent observation, according to Guba and Lincoln (1989), is to add depth to the scope that prolonged engagement affords. It could be argued that the intensity and duration of observations contribute to the overall trustworthiness of this study.
- *Member check* During the study I debriefed and discussed with the teacher my initial observations and interpretations of critical teaching incidents observed in the classroom. This occurred at both a formal and informal level. At the formal level I debriefed with the teacher immediately after each session. I also checked with the teacher any preliminary categories of data that I formulated. These processes occurred continuously throughout the data collection, analysis and compilation of the case study.

A final criterion that I used to ensure the trustworthiness of the study was to employ the concept of triangulation. which according to Guba and Lincoln (1989) refers to the cross-checking of specific data items of a factual nature. Triangulation can also be considered to occur when multiple methods of data collection and analysis are used. As such, triangulation can be considered an approach that strengthens reliability as well as internal validity (Merriam, 1988). In this study I used a variety of data sources which included field notes, examination of documents, notes from interviews and debriefings and some quantitative data. During my analysis I cross-checked the collected data and used a variety of analysis methods which included open and axial coding to identify themes, patterns and categories which eventually led to my assertions.

8 SUMMARY

In order to address the first two research questions, a qualitative case study methodology was selected for this study because it is an approach that allows for both a description and interpretation of the implementation of the DMA program. During the course of the study I acted as a participant observer in the classroom. The data sources were varied and data was gained using a number of data gathering techniques. Some quantitative data was obtained in order to provide a broader overview of the case study site and its participants. Details of the rationale and criteria used for the selection of the school, teacher and class have been discussed. During the analysis stage, data from multiple sources was cross-checked for consistency and examined in relation to the findings from the literature. In addition, Jill the class teacher was asked to respond to drafts of the case study and provide feedback. Lastly, the three criteria of prolonged engagement, persistent observation and member checks were used to ensure the trustworthiness of the study.

CHAPTER 4

BACKGROUND TO CASE STUDY

1 INTRODUCTION

In providing some background information for this case study, I will first briefly outline my own training, experience and broad philosophical orientation. Some background material about the contextual setting for the study will follow and this will include descriptions of the school, parents, classroom (both physical and pyscho-social features), teacher and children.

2 MY BACKGROUND

Because the theoretical position of a researcher in a naturalistic study affects the questions that are asked, the observations made and the interpretations generated (Wolcott, 1975), it is therefore important to provide a brief summary of my own background. Such information will assist the reader to gain an appreciation of where I am coming from and so become aware of some of my possible biases that could emerge within the study.

My teaching career with the South Australian Education Department has spanned a period of twenty six years. Following my initial teacher training, appointments for the first five years were in one teacher schools, teaching children in all year levels from five year olds in reception through to twelve year olds in year seven. This was followed by a year of release-time study and then seventeen months secondment as a tertiary lecturer in the field of adaptive and remedial education. For the next four years I worked as a principal in the field of special education in mainstream primary schools and for the remaining thirteen years I was a principal in three different primary schools.

During the mid 1970's my first experience with educational research was with using the quantitative genre which at that time dominated the field. In 1975, as part of the requirements for an advanced diploma, I conducted a small-scale quantitative research project investigating factors that influenced the legibility of children's cursive handwriting. The educational research work that I have conducted since that time, as part of my on-going academic study program, has been in the qualitative paradigm. Such educational research has included the evaluation of a school's daily physical education program, a case study of a junior primary class's use of word processing and for my master's degree, a theoretical analysis of a school philosophy statement. This last study involved the use of questionnaires to obtain data from parents and teachers.

Over the years my interest and attention has progressively focused towards the early years of schooling. From my experience in special education, I soon discovered how difficult it was to rectify learning and attitudinal problems in upper primary students. I became firmly convinced that the first few years of a child's schooling are critical to later progress. I believe that it is important to lay a solid foundation of 'learning to learn' skills and that the technacy skills, such as those provided by the DMA process, are critical to ensuring that children have access to a balance of basic skills in order to enable them to maximise their future educational and vocational aspirations.

It has been predicted that up to 80% of children starting school today will be working in jobs that do not yet exist, with machines that have not yet been invented (Department for Education and Children's Services, 1996). Therefore, in schools we are unable to guide children towards specific destinations. What we can do is provide them with the means of integrating new technologies into their fabric of learning. I believe that DMA, one of the four strands of technology education, can help children successfully journey into the future with skills and experiences that provide them with the maximum flexibility and adaptability for employment and other aspects of their life.

3 FIRST IMPRESSIONS

First impressions of a school can often be quite lasting and revealing. I can distinctly recall that on my very first visit to Highfield junior primary school, I gained the distinct impression that this was a school that worked well. After walking into the front entrance foyer (which was brightly displayed with children's work), I was warmly greeted by one of the school support staff who introduced me to the principal. The principal immediately made me feel at ease as she ushered me into her office where we had a chat. When we had finished this introductory discussion, the principal accompanied me as we went to meet the teacher in her classroom. As we walked down the long corridor I could not help noticing the children's school bags all neatly hung on the pegs outside each classroom. These school bags were all the same colour and had the school logo on them in a darker colour. As I looked into the classrooms as we passed, I noticed that all the children were dressed in school uniforms. Having worked in state primary schools for all of my teaching career, I was not used to seeing what appeared to be nearly 100% of children wearing the school uniform. I could almost be forgiven for thinking that I was visiting an independent private school.

4 SCHOOL PROFILE

Highfield junior primary is a state school situated in a leafy, reasonably affluent suburb of Adelaide. The junior primary (reception to year two) and primary schools (years three to seven) share a common campus. (In South Australia, the majority of children commence their formal schooling soon after they turn five years of age and generally spend their first twelve months of school in a reception class before commencing year one.) The original primary school was opened in the 1920's and the separate junior primary school was later established and opened in the late 1950's. At the time of conducting this study there were three hundred and seven children enrolled in the junior primary school in reception through to year two. There were twelve classes, five of which were taught by tandem teachers sharing the same class. On the staff there were a total of twenty female teachers, which included specialist teachers in music, LOTE (Languages other than English - Chinese, Greek and Italian), and ESL (English as a second language) and Farsi (mother tongue program). The average age of the teachers was between 40 and 50 years. Approximately 16% of the students came from non-English speaking backgrounds and approximately 6% of the students were on what is called 'School Card' (that is, parents of limited income who are means tested to receive some State Government financial assistance).

Over the last ten years, enrolments at Highfield junior primary have fluctuated between two and three hundred children. In the past, the school had many children enrolled who did not reside within the local catchment area. Many of these children had parents who daily commuted from the hills to the city to work. Because the grounds are of limited size, expansion of the facilities was not feasible. To prevent enrolments increasing indefinitely, the two schools were zoned in the mid 1980's, restricting access to those children who resided within the local school catchment zone.

The two schools have excellent facilities in comparison with many other state schools. There are two swimming pools and a joint gymnasium and hall that is also utilised by many community groups. In the early 1990's the two libraries were amalgamated into a common R-7 Resource Centre with a teacher librarian who works with both schools. A canteen is accessible to all students from both schools. There is a combined School Council and associated sub-committees.

5 EDUCATION REVIEW REPORT

Several years ago the Education Review Unit (ERU) of the state Education Department, conducted an external review of both of the Highfield schools. The ERU review found that the junior primary staff identified the support of parents as a major strength of the school. The notion of parents as partners played an essential role in classroom activities. The staff also frequently mentioned the responsiveness and enthusiasm of students as a strength as well as the overall quality of education provided by the school.

In the ERU report, most parents cited the staff as a strength of Highfield junior primary school, together with the sense of a feeling of community within the school and the high standard of education provided. The parents described the junior primary staff as being experienced, committed, caring, professional and supportive of each other. Parents also mentioned the facilities as another strength of the school, with the swimming pools, grounds, bright classrooms, library and gym all receiving mention. The areas of achievement most frequently mentioned by parents were the improvements in the grounds such as the pergola, new play equipment and purchase of mathematics resources. In addition, a significant number of parents spoke highly of their child's personal development over the previous year.

6 TECHNOLOGY EDUCATION AT HIGHFIELD SCHOOLS

There are a small number of primary schools within the state that have been designated as focus schools for technology education. Highfield primary school was one of these and as a result received some minimal additional resources and a technology coordinator. This coordinator's role was to be involved with all four strands (DMA, information, materials and systems) of technology education. In return these focus schools were expected to provide technology support for neighbouring schools by hosting observation visits and conducting some staff training and development. (The junior primary school was not included as part of this project.)

During the year of the study the Highfield schools had spent a total of sixty four thousand dollars on establishing a computer room consisting of a network of sixteen Apple computers and four printers. (These replaced the old Commodore network.) The schools also had purchased a colour scanner and video camera to take pictures that are able to be transferred onto the computers. In addition, most classrooms had their own network compatible stand-alone units. The junior primary school had eight stand-alones for their twelve classrooms. All children had their own discs onto which they were taught how to save, reload and print data. Every class in the school was time-tabled for a weekly session in the computer room that was located adjacent to the school Resource Centre in the primary school section. As part of her role, the junior primary deputy principal assisted each of the junior primary class teachers with their classes in the computer room while in the primary school, the computer coordinator assisted their classes and teachers. (See Appendix 1)

The School Council had a separate Information Technology sub-committee in addition to the usual Education sub-committee. The junior primary principal was the chairperson of this sub-committee that included a number of interested and computer literate parents. During the year of the study, the sub-committee coordinated the purchase of the new computer network and developed an accompanying five year plan about computers within the total school curriculum. They were currently involved in conducting a sports car raffle in order to raise additional funds to enable the on going up-grade of the hardware and software. The proposal was to start progressively selling and replacing some of the computers after they became two years old. This subcommittee had also organised a successful

Information Technology night for parents during term three. The following year they planned to broaden their brief to include the DMA strand of technology.

During the course of this study I conducted an interview with the junior primary principal. (Appendix 2) She informed me that last year the school had a technology coordinator as a teacher leadership position. This year all class teachers taught technology to their children. (Apparently two years previously, science and technology had been taught by a specialist teacher during the class teacher's non instruction time.) The principal went on to say that:

> I think to be perfectly honest, junior primary teachers have probably been pretty good with technology for a long time, because we have always done things like junk construction. Maybe the way we do it is different now. We might get to use more wheels or glue guns, but I think that we have always had that component there. Maybe we are looking at it with a different emphasis?

This year the school had budgeted two thousand dollars for the on-going maintenance of the school's technology program to be spent mainly on consumables. In the previous year staff training and development had focused on the DMA strand of technology and a total of four thousand dollars had been spent.

7 PARENTS

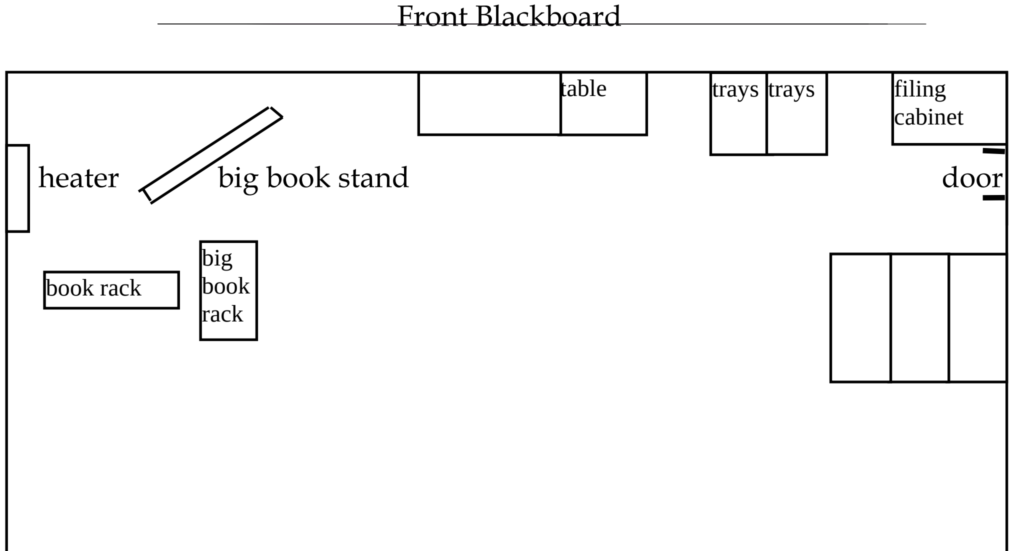
The Highfield community is predominantly middle-class. Parents tend to be generally well educated and many hold professional or managerial positions. There was a small group of children in the school from families of international students attending a nearby University campus. The parents at the school tend to have very high levels of expectations and interest in their children's educational development. (This was revealed in the previously mentioned ERU report.) Many parents requested that their child regularly take home three or four reader-type books each afternoon. At the parent-teacher night held during the study, most parents attended together with grandparents and friends. A few parents regularly came into the classroom at dismissal time and looked through their child's tray. This routine was then invariably repeated again the next morning. Jill was at a loss to know how the parents expected school work to be added to the trays during the night!

At the beginning of the year, a number of parents raised some concern about tandem teachers sharing a class of reception children. These parents felt that children in their first year of formal schooling may find it a little confusing trying to relate to two teachers. The school was able to reassure the parents of the benefits to be gained by their children having two tandem teachers.

8 CLASSROOM PHYSICAL ENVIRONMENT

The Highfield junior primary main red brick school building consisted of an entrance foyer, principal's office, staff room, clerical office and eight classrooms. (The remaining four transportable classrooms were situated at the rear of this main building.) The main building was L-shaped, with two classrooms across the front facing the street and the remaining six classrooms were located adjacent to a long corridor. Jill's classroom was situated at the end of this long corridor. Children's toilets and several small activity rooms were located on the opposite side of the corridor to Jill's classroom. (Figure 4.1)

The classroom itself gave the appearance of being light and airy. There was a solid wall at the back and front of the room and the other two sides of the room consisted mainly of windows. The windows that face south looked out onto a fence behind which were single-story home units. These windows were low so that the children were able to look out of them. The set of windows on the opposite side of the room faced into the corridor. These windows were mainly covered in charts and pictures with several gaps making it possible to look in (or out). The ceilings were high, contributing to a feeling of spaciousness.



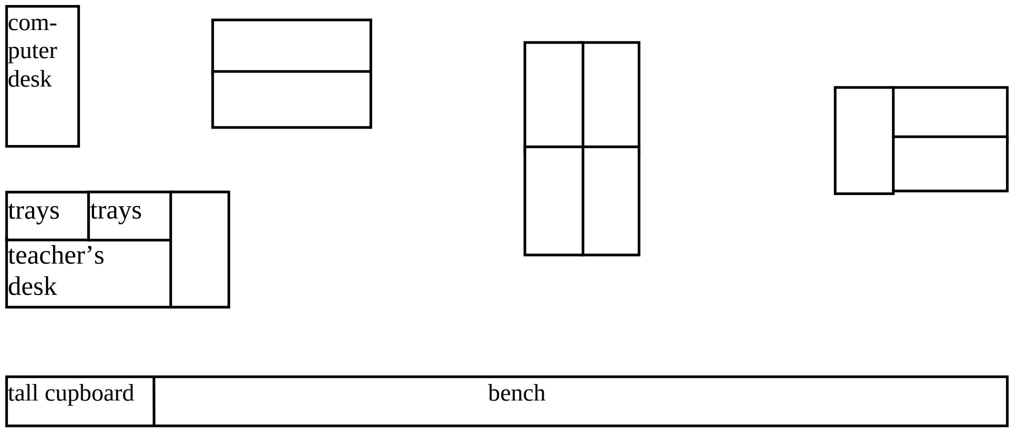


Figure 4.1 Plan of classroom.

Jill's classroom was colourful and attractive. There was a welcome sign on the entrance door together with the room number and the two teachers' names. Children's work was on display throughout the room, including examples of their work suspended from lines strung across the room; work neatly arranged on the various pin up boards around the room; and a range of children's models on bench top displays.

An interesting feature in the classroom was the widespread use of coloured photographs of the children. These were included in a display of a parent-school function held earlier in the year; photographs (with accompanying captions) of children on an excursion; the use of photographs of children (and captions) made into various charts and Big Books; and a number of photographs included in the Take Home Books that formed part of Jill's reporting to parents.

Also on display around the room were various teacher-made charts and rosters. These included a list of Class Rules and an associated set of consequences; a class monitor roster; a chart showing rules for using glue guns; a roster for using the cricket practice nets; days of the week; months of the year (together with children's birthdays); numerals; and alphabet letters. During term four, in place of the stand-alone Apple computer (which had to go to another classroom), the class had the use of a borrowed vivarium containing marsupial mice - Dunnarts and Spinifex Hopping Mice.

9 TEACHER

Jill had been teaching at Highfield junior primary school for the past four years and during this time had always been a half-time tandem teacher with Betty sharing the same classes. The year of this study was the third occasion that they had both taught a reception class of five-year-old children at this school. Jill taught on Mondays and Wednesdays and both taught on alternate Tuesdays to enable alternate attendance at the weekly staff meetings that were held on this day. Jill had previously taught in several country and city schools before taking time off to raise her family and she considered her participation in this study as an opportunity for professional growth and development. Jill mentioned in passing that she had never had a principal in her classroom to specifically observe her teaching. She enjoyed teaching and working with children and did not have any desire to aspire for school leadership positions. She possessed a warm and supportive rapport with the children in her class. From my conversations with her, it appeared that her interest in science and technology had been fostered by her father at an early age.

Jill possessed a conscientious and professional approach to her teaching. She was keen to expand her pedagogical knowledge and skills by frequent attendance at conferences and courses in her own time. During terms two and three she attended weekly evening courses about using Claris Works in the classroom. These courses were an extension of a similar course she had attended the previous year. She willingly shared insights gained from such training and development experiences with her teaching colleagues at the school. During my interview with the principal, she mentioned that:

> Jill has continued to be our unofficial technology person this year. She has just offered to show all the teachers how to make light up Christmas cards with circuits and things. She is all into that now.

According to Tobin (1993), teacher's metaphors and images influence how they think and talk about teaching and what they do in their classroom. Jill used several expressions to describe herself as a teacher at different times. She said that at different times she thought of herself as a policewoman, negotiator, motivator, resource provider and mother hen. She stressed that she attempted to encourage learning that was hands on; having children take responsibility for their own learning; helping children become independent learners; and that she tried to cater for children's different learning styles.

10 CHILDREN

Although the majority of the twenty six children in Jill's class were in their first year of compulsory schooling, some had been at school longer than others. One boy Corrie, started school in May of the previous year. He had been identified as requiring special education and was on a negotiated curriculum. Ten of the children started in October of the previous year, at the beginning of term four. Another nine children commenced their schooling at the beginning of term one in the year of this study, while five children started at the beginning of term two in May. Pam had transferred into the class at the beginning of term three (July), although she had started school in Melbourne in February of the year of the study. Two children, Anne and Mohsen were from a non-English speaking background, both having fathers attending a local university campus as international students. There were a total of twelve girls and fourteen boys in the class.

Because I wanted an overview of the children's current level of science and technology awareness, I administered the Draw a Scientist [Technologist] Test (DAST). The children enjoyed drawing their pictures of a scientist. Eleven girls drew female scientists, while one girl drew a male scientist. A similar scenario occurred with the boys in which thirteen boys drew male scientists and one boy drew a female scientist. The example provided (Figure 4.2) was drawn by a boy from the class who was selected at random. It would therefore seem that the children in the class had not yet formed the usual male stereotypical images of scientists found to occur in the DAST results of older children (Chambers, 1983; Fort

Figure 4.2 Example of a scientist drawn by a boy.

& Varney, 1989; Hobden, 1993; Jannikos, 1995; Kahle, 1993; Newton & Newton, 1992b; O'Maoldomhnaigh & Hunt, 1988; Pickford, 1992; Schibeci, 1986).

In order to gain a broader picture of the children's technological awareness and exposure, I conducted interviews with each individual child. During these interviews I asked them four questions concerning their favourite toys, computer and video access at home and vocational aspirations. I also used the opportunity during the interview to ask them to explain any aspects of their DAST drawing that might have needed clarifying. I asked each child to name their favourite toys in order to discover any possible technological interest. Of the girls' responses, six named their teddy bears, four dolls and two animals. The boys' replies were more varied and tended to indicate a choice of toys that are generally more associated with technology. Four boys named their teddy bears, three animals, three transformers, two computer games and two cars.

Sixteen told me that they had at least one computer at home. Of those children with a computer at home, ten were boys and six were girls. Without exception they used them for games. Approximately one third of the class indicated that they owned a video camera.

I also asked the children what they would like to do for a job after they left school. The purpose of this question was to see how many had aspirations that involved hitech vocations. An interesting range of responses were given. The girls mentioned author, cleaner, doctor, nurse (2 girls), pilot, scientist, shopkeeper and vet (4 girls). The boys mentioned boxer, drawer, fireman, fisherman (2 boys), pilot, rocket person, school principal (2 boys), scooper driver, shopkeeper, taxi driver and vet. From these responses it would seem that the girls had chosen more occupations that could loosely be associated with aspects of hitech than the boys.

11 PYSCHO - SOCIAL ENVIRONMENT

As a final piece of background information about the class used in this study, I administered the My Class Inventory (MCI) *actual* short form in order to obtain an overview of some aspects of the psycho-social classroom environment. As mentioned in the previous chapter, the MCI is able to measure five different dimensions of the classroom climate. These five sub-scales measure the children's perceptions of satisfaction, friction, competitiveness, difficulty and cohesiveness in their classroom environment. The children's *actual* perceptions of their classroom learning environment is shown below in Figure 4.2 while the data obtained from the instrument is included in Appendix 3.

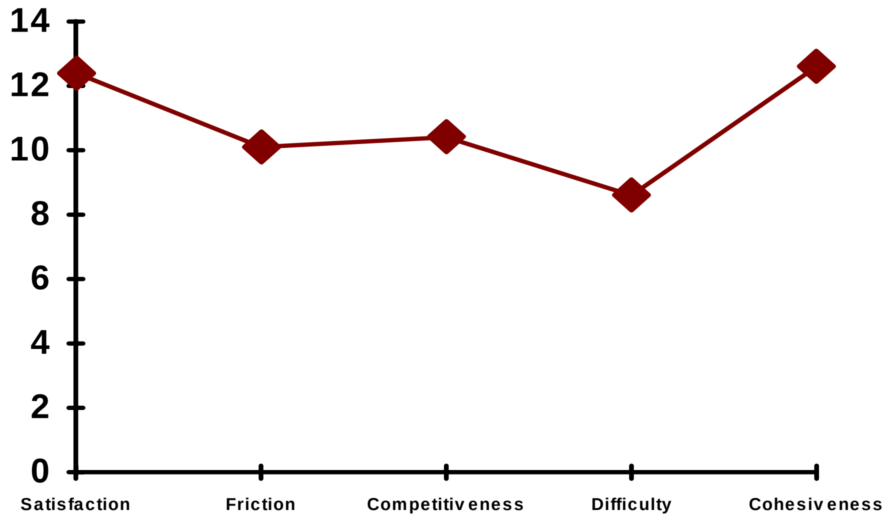


Figure 4.3 My Class Inventory (*actual)* for Jill's class.

The high satisfaction results obtained for Jill's class indicate that the children enjoyed their work in the classroom and regarded their peers as enjoying being in a fun filled and happy place in which to learn. The high cohesive score also suggests that the class was a tightly knit group in which there were many close friendships. The level of difficulty perceived by the children may indicate that many thought that the tasks set by Jill may not have been very challenging. Alternatively, because the children may have enjoyed what they were doing, they may not have perceived the set tasks as difficult. Both the amount of friction and competitiveness perceived by the children seem to be average when compared to results obtained in similar studies (Ciupryk & Malone, 1989; Fisher, Fraser & Bassett, 1995). Finally, it needs to be stressed that these results need to be interpreted with a good deal of caution, particularly since young children's perceptions are apt to change quite significantly even over a relatively short period of time.

12 SUMMARY

This chapter has attempted to lay the foundation for this study by providing some background information about me as the researcher; the school and its community; Jill the teacher; and the children in her classroom. From the information provided, it can be seen that Highfield junior primary school has an established interest and commitment to teaching technology. Information technology through the use of computers is particularly strong. The school had a technology coordinator in the year prior to the study and the staff training and development had focused on the DMA strand of technology. The DMA program is well supported by the school budget. Jill the teacher also has an interest and enthusiasm for computer use as well as the DMA strand of technology. The children's DAST results seemed to indicate that at this stage they do not have many of the stereotypical images of scientists commonly found with older children. From my interviews with the children, it would seem that many have access to home computers and video cameras. Finally, the results obtained using the MCI seemed to indicate that the pyscho-social learning environment of the classroom appeared to be similar to findings found in other early years classrooms, with strong perceived levels of satisfaction and cohesiveness.

CHAPTER 5

DESIGN, MAKE AND APPRAISE IN ACTION

1 INTRODUCTION

In order to reveal some of the factors and underlying structural and organisational issues involved in the implementation of a DMA program, this chapter will present a description of Jill's DMA program over the whole of term three. Each of the ten weekly sessions will be described in detail. In describing the implementation of Jill's DMA program, it was not possible to record everything that occurred. It is therefore necessary to provide a general overview of some parts of the program, and to progressively focus the description towards small groups of children, pairs and individuals. In selecting what to describe, I was guided by prior knowledge of some of the factors and issues gleaned from the review of the literature and open and axial coding of the collected data.

During the first three sessions, Jill's DMA program consisted of some initial teaching of science concepts. Jill believed that technology was best taught after the science concepts had first been introduced. These science concepts served as an introduction to the theme of making models with wheels, which was carried out over the next three weeks. The theme of playgrounds formed the final activity for the remaining weeks of the term.

2 TEACHING SCIENCE CONCEPTS

During the first three weekly sessions, Jill's technology program consisted of some initial teaching of science concepts before introducing the DMA topics. In the first week's session, Jill helped the children revise the class Big Book about tools that they had made earlier during term one. The children had learnt that tools were things that helped them do jobs. This concept about tools was used as an introduction to the idea of levers as being tools which also help them do jobs. The children were encouraged to explore a variety of everyday household utensils that demonstrated the lever principle. These utensils included items such as a can opener, cork lifter, cheese slicer, scoop, spatula, balance scales, tongs, meat scissors, egg slice, nut cracker and knife. Additional examples from a selection of library books were also provided to widen the children's exposure to everyday occurrences of levers. During the final part of the session the children made a page for a class Big Book about levers. Each child was asked to choose an example of a lever from the collection on the carpet, draw it on a work-sheet and then complete two short sentences about levers by adding appropriate words.

In the session for week two (Appendix 4), Jill first had the children revise the previous week's session on levers. During the remainder of the session the children explored the concepts of 'push' and 'pull'. Individuals and small groups of children demonstrated pushing and pulling using a skipping rope, removing and then redressing items of clothing such as shoes and jumpers, and various toys including a soccer game, tractor and Thomas the Tank Engine. Next the children were asked to record in their Science and Technology exercise books' examples of objects in the classroom which illustrated 'push' or 'pull'. Prepared labels containing these two words were then pasted alongside the appropriate drawings in their exercise books.

The session for week three examined inclined planes. After first revising the work covered in the previous week's session on 'pushes' and 'pulls', Jill divided the class into approximately equal groups of six children. A child in each group was assigned the task of recorder. Jill then carefully went through the directions for completing the task sheet (Figure 5.1).

	Predict	**Test**
With a slight slope.		
With a big slope.		
With a heavier car.		

Figure 5.1 A child's task sheet on inclined planes.

Each group was asked to make a prediction and then test a car when first the slope (inclined plane) was increased, and second when the car was made heavier. Each group was supplied with a large piece of thick plastic board and a toy car. In order to make the car heavier, Jill suggested that the children use plasticine. Jill then carefully explained each step again, paying particular attention to the meaning of the word 'predict'. Each group was also required to cut out and paste onto their group's task sheet either the word 'faster' or 'slower' for both their prediction and result obtained. Despite Jill's attempts at careful and detailed explanation, each group still required considerable assistance from either Jill or myself.

It soon became apparent that many groups had difficulty arriving at a group consensus, since the children's group work skills were still developing at this young age. Because Jill had allocated a group leader to each group, most other members of the group tended to step back and become non-participants, allowing the leader to do most things. At times some of the children's answers to Jill's questions showed a high level of creativity and innovativeness. When Jill asked what would happen if the slope of the incline plane was increased, one boy answered by using an invented word 'fastasonic'. Another boy, when asked the same question, was able to incorporate an elementary conception of gravity in his reply. A different boy asked Jill what would happen if the answer to the test result differed from the prediction. 'Do you want me to change it?' Jill was able to explain to him about the scientific method in which scientists test their ideas all the time and that there did not necessarily have to be the one so called 'correct' answer. Such a comment would help children appreciate from an early age a scientific approach where by one's ideas and theories are tested.

After the children had completed their group tasks, Jill conducted a class demonstration of other properties of inclined planes. Individual children were selected to roll a toy car down an inclined plane that had the same incline but different types of surfaces such as carpet, aluminium foil, vinyl floor tiles, plastic and water. Pam, one of the girls selected by Jill to release the toy car, accidentally placed the car backwards on the inclined plane. Although the rest of the class protested, Pam did not seem at all aware that she had the car around the wrong way. She could not understand what she had done wrong. It was obvious that she was not very familiar with handling toy cars or maybe she had difficulty in manipulating the variables of the task.

3 TEACHER-CHILD INTERACTIONS

During my time spent in the classroom I became interested in the balance of the teacher-child interactions. From my observations in session one, my initial impression was that Jill balanced her interactions fairly equally between the boys and girls. In order to gain some quantitative data about these interactions, I documented them over a number of sessions, along the lines advocated by Ryan (1993). From an analysis of the data obtained from the first session, it was found that the boys appeared to dominate the teacher-child interactions - 63% to the girls 37%. These results were then discussed with Jill during our debriefing following session one and in the subsequent sessions she made a conscious effort to redress this imbalance. I continued to monitor the teacher-child interactions in the remaining sessions and the gender interactions were found to average 50% each.

While recording the number of teacher-child interactions, I also made a careful note of the sex of the children that Jill selected to be demonstrators (in front of the class); to collect various items; and to run errands. I found that the sex balance in these situations was fairly even. Also, from an examination of the data of teacher-child interactions gained from the audio tapes of some of the sessions, it was possible to determine which children had significantly more interactions with the teacher than the rest of the class. These children have been called 'target students' by Tobin (1993). I found that in some sessions either girls or boys predominated as target students, while in some other sessions there was a mixture of boys and girls.

4 MODELS WITH WHEELS USING CONSTRUCTION KITS

The next three weekly sessions focused on wheels. In the session for week four, Jill first had the children add words to a list of everyday school and home objects that used wheels to make them move. She then introduced to them the notion that wheels were round and were usually attached to an axle (See Appendix 5). It was while Jill was explaining axles to the children that the unexpected happened. A child raised the alarm that some caterpillars had escaped from their box under the front blackboard. The resultant commotion brought the lesson to a sudden halt while all the escaped caterpillars were quickly collected and returned to their box. Following this slight distraction the children were allocated into small groups, and each issued with a container of commercial plastic construction materials. (Jill had borrowed most of these construction sets from other classrooms as well as bringing some from her home.) Each child was then asked to make their own model containing a 'wheel'.

From evidence obtained while viewing the video tape I recorded of the children working on their models, it became fairly obvious at the beginning of this part of the session, that many of the children simply wanted to 'play' with their plastic construction materials. This need to play especially applied to those who had not previously seen and manipulated their particular type of plastic construction materials. While the children were making their models they appeared to be totally involved in the activity. Both the girls and boys tackled the task with equal enthusiasm. All but two of the girl's and boy's models were 3-D solid structures with wheels. Two of the boy's models were 3-D hollow structures subdivided into sections. One of the girl's models was a 2-D structure (with wheels) while another girl's model consisted of several 3-D structures assembled into a complex whole. The final models varied in size and complexity and to some extent were determined by the type of construction materials used. They included a motor bike, a speed boat, a trailer, wheelbarrows, cranes, cars, aeroplanes, as well as a number of more creative models, the functions of which were eagerly described by their makers. There appeared to be no discernible difference between the types and complexity of the models made by the girls and boys.

At the end of this part of the session, individual completed models were video-taped, with each child providing an oral commentary to the class about their model, explaining how it worked. The following dialogue is an example of a child's presentation and illustrates how Jill attempted to link the previously taught science concept of levers with the current task:

T What is it Kym?
K It's a thing that helps people.
T It helps people. What does it do to help people?
K It lifts things up.
T It lifts things up. Good boy. And acts like a .....?
K Lever.
T Good boy. How about the front part? The other part?
K It helps too.
T Helps people too. And how many wheels on your machine?

K Four.

T Four. Good boy. How do they turn around?

(At this point part of the model falls to the floor)

T Never mind. Things fall apart when you hold them up, don't they? How do they turn around Kym? Show us.

(Child demonstrates)

T Good boy. O.K. Excellent.

Although Jill had asked the children to make their own individual model containing at least one wheel, one group of boys had decided to make a joint model. It was not until after the session had finished and I was reviewing the video of the children's completed models, that I realised some of the children's plastic construction kits did not contain wheels. Several children's models did not have conventional wheels. Obviously this had been an oversight by Jill and reinforces the need to pay particular attention to ensure that the wording for task setting is actually achievable. In this case, the original word 'wheel' could have easily been replaced by asking the children to make sure that their model contains something that turns or moves around.

For the final part of this session, Jill handed out a prepared blue worksheet on which each child was asked to draw their design of the model that they had made. Of the designs drawn by the children 50% were from the side-perspective (See Figures 5.2 and 5.3). The children were also required to write down the name of what they had made. Some children needed assistance with writing their word. A total of nine children's designs contained persons (See Figures 5.2 and 5.3). When they had finished, these sheets were then glued into the back of their Science and Technology exercise books.

Figure 5.2 Examples of designs drawn in session four by two girls - speed boat & car

Figure 5.3 Examples of designs drawn in session four by two boys - both of cranes.

5 DMA MODELS WITH WHEELS

The session for week five continued with the theme of wheels. Jill asked the children to think of objects that had wheels. She recorded their responses on a large chart. Next, the children revised another list of wheeled objects that the class had made earlier in the week. This activity was followed by each child being asked to read aloud their own page out of the class Big Book. (This Big Book had been made earlier in the week and had been shown to parents at the parent-teacher evening held the previous night.) Each child had drawn a picture onto which they had glued small white cardboard wheels. Jill had typed and printed off each child's sentence about their picture. These sentences had been pasted onto the page near their picture. A wide variety of pictures had been drawn, including a bat mobile, a paddle steamer, a tram, vans, bikes (some with trainer wheels), roller blades, aeroplanes, motor bikes, cars and a boat on a trailer.

Jill explained to the children how they were now going to work in pairs and jointly design a model of something that had wheels. She handed out a yellow work-sheet (Appendix 6) on which the children were asked to draw a picture which was to be the design of what they were going to make. To assist the children with this task, Jill showed them some ideas of objects with wheels, using photocopied sheets as well as some examples from a selection of library books.

Before the children went off to draw their designs, Jill went through some of the different types of materials they could utilise. She said to the children:

> I want you to think about the materials you are going to use. (These materials included plastic cups, big reels, plastic wheels, empty cardboard rolls, cotton reels, popsticks and an assortment of different sized cardboard wheels.). Think about what you are going to use and talk with your partner and draw a picture. I want you to think about all the materials that you are going to need. I am going to give one person at a time a partner and you are going to write their name on the top of your design sheet. You are both going to do a picture but first of all you have to plan together. Talk together and plan what you are going to do. So you will need to have two names. Maybe underline your name and write the other person's name too.

As the children were paired off they went back to their seats to begin their designing task. Jill reiterated to the children that this time, although they each had to draw their own design, they would only be making one model (containing wheels) between each pair. At this stage the children were not given any assistance on how to go about drawing a design.

After the children had been given sufficient time to draw their designs, Jill had all the children gather on the carpet. This time all of the designs drawn by the children were from a side-perspective and ranged from quite detailed through to less sophisticated. No plan view perspectives were drawn. Once again nine children including drawing a person in their design (See Figures 5.4 and 5.5).

With all the children sitting on the carpet Jill then proceeded to explain how to use the tools from the portable tool board. These included G-clamps, spring clamps, glue guns, bench hooks, cutting mats, hole punches, F-saws and hand drills (two of which were fitted to stands). The following is an extract of what she said to the children:

T What are these called?

A Snips.

T No, not snips.

D Clippers.

T No, not clippers.

N Spring clasps.

T Spring clasps. Good boy. What else does it look like? What is it? It's a......?

K A peg.

T It looks like a peg doesn't it? What is it acting as?

J A fish. When you open it up it looks like a fish.

A A crocodile.

T A bit like a crocodile mouth. Yes S?

S I forgot.

T It starts with an 'L'. We learnt about them at the beginning of the term.

J Levers.

T Levers. Good girl. It's a lever isn't it? What does that do? Everybody, what does that do?

C Holds wood.

T Holds wood so that we can saw. We have got some things here that we haven't used before. These are little mini pliers. We probably wont use these. What is this here?

C Glue gun.

T What do we have to remember? What are our safety rules when we are using a glue gun? A?

A Always wear white gloves.

T Always wear white gloves. D?

D On both hands.

T On both hands. Good girl. What else do we have to do A? Do we use it like a gun? Do we point it when it is hot at someone? No. We don't point it at anyone. We are not silly when we are using a glue gun. We must be very sensible. etc.

After Jill had finished explaining the safety aspects of the tools, the children quickly dispersed to collect the materials needed to make their designs. Jill had gathered together a wide collection of various recycled everyday household materials as well as commercial materials. The latter included a variety of plastic and cardboard wheels, wooden dowel and lengths of 1cm x 1cm wood. A few children went straight to the tools and began trying to use them. One boy seemed quite happy to spend considerable time trying to drill a hole in an empty plastic yogurt container even though it had nothing to do with the model he subsequently made. When most children had gathered together their materials, there was not a lot of time left in the session for them to engage in their 'making' activities.

Denise and Angela were assigned to work together as a pair. It was Denise who gathered together the materials and brought them back to their desk. She had collected four black plastic wheels, an empty food box and a 60cm length of thin dowel. Angela, who was clutching her teddy, was quite content to simply follow Denise around and watch her begin to make the model. After Denise sat down at the desk, the first thing she did was to snap the piece of dowel into half. Then, using copious amounts of clear adhesive tape, she attempted to stick the two pieces of dowel inside the box with the ends protruding. She then attached two of the black plastic wheels onto the sides of the box by once again using some of the tape. This was all she had time to do before Jill asked the class to stop work and pack up ready to go for lunch.

At the beginning of the session in week six, Jill used the model being made by Denise and Angela as an example of how improvements could be made to wheels so that they could turn around. (The wheels had been taped onto the sides of the girl's model.) She reintroduced the children to the concept of an axle and produced another model that she had made at home to illustrate how an axle could be used to help make the wheels turn. One of the pairs of wheels on Jill's model was deliberately located in the middle of the sides of the box to demonstrate how they were unable to turn. The following discussion took place about how the wheels could be more effectively positioned:

T What's going to happen now? What will happen if I keep moving that wheel around and around? K?

K Around and around.

T It will move and move. And what will happen to it eventually D?

D It will drive itself.

T It will drive itself. But what's going to happen if it keeps moving and wobbling? What's going to happen to the wheel? What's going to happen to the wheel N?

N It is going to fall off.

T It is going to fall off so what will I need to do to stop the wheel falling off?

The use of the low heat glue gun, split pins, clear adhesive tape and plasticine were all suggested by the children as possibilities.

Jill then spent some time revising the procedures for using various tools, continually stressing the need for safety. In turn she discussed the use of glue guns, F-saws, cutting boards, G-clamps and vice. A number of children were chosen to demonstrate to the class the use of selected tools. Jill also mentioned the need to place thick pieces of cardboard underneath objects being hand-drilled using the drill stands. (During the previous week's session one child had accidentally drilled a hole through the centre of a plastic wheel and on into the desk top.)

Figure 5.4 Examples of designs drawn in session five by two girls - truck (top) & car.

Figure 5.5 Examples of designs drawn in session five by a boy (car) and a girl (bus).

The yellow work-sheets (Appendix 6) containing the children's designs from the last session were distributed and the children moved off to gather their incomplete models from the previous week's session. During this session I noticed that there did not appear to be any evidence of children referring to their designs on the yellow sheets and Jill did not draw their attention to these sheets. While the children worked on their models, Jill and I moved around and assisted individual children. We helped a number of pairs of children to drill holes in their black plastic wheels using the drill stand. They were then able to attach these wheels to the thin pieces of wooden dowel for their axles.

The following interpretation of events are taken from the video I made of Denise and Angela as they continued to work on their model. The details of their movements are recorded as a running commentary as I interpreted them from the video. The following is a description of how the girls went about attaching the wheels to their model:

> Angela picked up the model off the desk while Denise gathered the four black plastic wheels and brought them over to where I was helping children to use the drill-stand to drill holes in their wheels. After drilling holes in their plastic wheels, they moved back to their desk with Angela carrying the model while Denise carried the wheels. While Denise went off to collect two pieces of dowel for the axles, and Angela was collecting a pair of scissors, a girl walked past the desk and paused to look at the model. After the girls had returned to the desk Angela tried to poke a hole through the side of the box with some scissors. Denise watched Angela and she then tried to poke a hole through the box even though Angela was still working on the other side of the box. When Angela finished making her second hole, Denise took a piece of dowel and poked it right through the box. She did not bother to measure the length first. Angela inserted a wheel on the axle and Denise went over to get some adhesive tape. Although Angela told Denise not to put the adhesive tape onto the wheel, she attached it anyway. Angela then inserted the other wheel onto the axle while Denise attached another piece of adhesive tape. Finally Denise poked through the other piece of dowel and attached the other two wheels. She then tried pushing the model back and forth on the top of the desk. While she was doing this Angela was busy watching two boys in front of her use a vice.

Denise and Angela's original model underwent considerable modification during the course of its construction. The wheels that were originally stuck onto the sides of the box with adhesive tape were modified to include axles that enabled them to turn. The original two protruding pieces of dowel that had empty cotton reels attached to their ends were eventually removed and were replaced by two pop sticks that crossed over each other to form a V-shape at the front of the model. The flaps of the box were attached at angles to form a front bonnet for the van. Cardboard cut-outs of Power Rangers were taped onto the top of the box and a cut out picture was attached to one side. Coloured streamers were taped across the back of the van and small pieces of cardboard off-cuts were placed inside the van as 'luggage'. (See Figure 5.6)

During the time when the two girls were engaged in making the model, there was not a lot of verbal interaction between them and yet they both seemed to know what to do. On a number of occasions other children came past to look and occasionally some spasmodic interaction took place. Mohsen was observed to spend most of this session (and also the previous session) wandering around the classroom as if he was not sure as to what he was meant to be doing. Jill spent considerable time during this session helping Pam make her model of a car.

Two boys finished their model well before most others had finished and they both seemed to be at a loose end. They showed me the car they had made and when they tried to push it along the floor it veered off to one side. I asked them why this was occurring and were able to solve the problem by realigning one of the crooked axles. Even after improving their car, they still had quite a long wait before most of the other pairs in the class had finished their models.

By the end of the session, all of the children had completed their models. Photographs were taken of each of the models so that the children could show their work to their parents and the rest of the class. As I was taking the photographs Jill challenged the children to think about how they could improve their prototypes.

Figure 5.6

VII.

Denise holding the model van.

Figure 5.7 Kylie with her 'wheeled vehicle' and written description.

The children were obviously very proud of their finished models and several of them wanted to know when they could take them home. The finished models reflected the children's creative imagination and their flair for colour and shape (see Figure 5.7). I noticed that Jill chose not to make use of the sections on the yellow design sheets (Appendix 6) which provided an opportunity for children to indicate the materials that they used and suggestions on how to improve their models. When I asked her about this later, she told me that she had forgotten to use it with the children.

6 DMA PLAYGROUND MODELS

Over the next three weeks, the sessions were devoted to having the children design, make and appraise pieces of play equipment for their group models of playgrounds. The task for the session held during week seven was for the children to begin work on designing and making a model playground. Initially Jill went through the word 'playground' by breaking the word down into its separate words and sounding out the syllables. She then used the brainstorm technique with the children to make up a list of different types of play equipment commonly found in playgrounds. This activity was followed by the class taking a walk around the school yard, observing and discussing the various pieces of play equipment.

Back in the classroom, Jill explained to the children that each group would get a large sheet of plastic board on which to mount their pieces of play equipment.

T This is also plastic isn't it and it is smooth and shiny. We need to attach all of those things (pieces of play equipment) to it. Don't touch it now - you'll have a chance to feel it in a minute. How could we join all of those things, that you are making separately, to our plastic? A?

A Sticky tape

T Sticky tape. You might need lots and lots of sticky tape. We could use sticky tape. J?

J Glue guns.

T We could glue gun it. What if this got really hot. What do you think might happen if it got hot? A?

A It could melt.

T It could melt couldn't it. So the other day some people used something special to put their wheels on the axles. Their wheels on the axles. Yes N?

N Some sticks.

T Some used sticks. Any other ideas? So that the wheels did not fall off what did we use? We used?

C Plasticine.

T We used plasticine. Some used plasticine. And A, plasticine might be a really good thing to attach our playground equipment to our plastic board.

Jill then went on to explain to the children that they would be working in groups of five or six children and that each child would be required to make an individual piece of play equipment for her/his group's playground. She also told them that for this week's session they would need to decide what they would like to make and then draw a design for it. Jill stressed the need for the children to discuss their proposed piece of play equipment with each other in the group so that no one would chose the same type of play equipment.

For this task the children had some free choice as to who would be in their group. After the groups had been formed, Jill went around and recorded the names of the group members and what piece of play equipment each child intended to make. In these groups the children had to first discuss with each other what piece of play equipment they proposed to make. In one group I observed that two boys both wanted to make a bike track. Each was determined to stay with their choice and neither was going to budge. By the time that Jill came to this group, one had reluctantly decided to backdown and proposed to make something else. After most children had finished drawing their designs, Jill called them back together and collected their design sheets. She then informed them that after lunch during their weekly computer session, they were going to use the 'pencil' on the *Kid Pix* computer program, to improve their designs by redrawing them.

As Jill collected their design sheets she made some comments about each design before allocating them into categories of play equipment. She asked the children to think during the coming week about what types of materials they might be able to use and how they might be able to get their models to move. One boy told Jill that he was going home to make a model first and if he got it 'wrong' he would not bring it back to school. Jill probed the child further and stressed that he could always improve the performance and appearance of his model. She referred back to the children's 'wheel' models (made in the previous sessions) and asked individual children how they could make their models even better. Most of their suggestions were for cosmetic changes and included adding a car cover, flowers, people, petrol caps and coloured wheels to their models.

At the beginning of the session in week eight, Jill went through with the whole class each child's computer generated piece of play-ground equipment design from the previous week. She showed the class what each child had drawn and provided feedback on each design. Jill retained these designs. She made the comment to me that the children generally found it easier to draw straight lines using the computer.

Jill also reminded the children of the need to keep their models reasonably small so that they would fit onto their group's piece of thick plastic-coated base board. She also asked the children to start to think of possible safety features that could be added to their playground models next week. After the children dispersed from the class group where they had been sitting on the carpet, many initially seemed a little confused and directionless as if they were not quite sure what to do next. Gradually they began to collect their materials and tools and set about to start their work.

What was most apparent with this session was the general busyness of most children in sharp contrast to some of the earlier sessions where only some children seemed to be fully occupied. When using the tools, many children tended to persevere. One of these was Corrie, a boy identified as having special education needs. He was fully engrossed at gluing rungs for his slippery dip ladder for at least twenty minutes. Because all of the children were busily involved in making their own models this session, the teacher and I were also kept fully engaged assisting individual children with the various tasks. Towards the end of the session, there seemed to be an increase in collaborative work, as many of the children placed their models of play-equipment on their group's board and verbally interacted with each other, discussing where to place their model in their group's playground. Some were content to simply play with their model of a piece of play equipment.

One group of boys decided to make their entire play ground out of plasticine. At the beginning of the session Jill had asked one of the boys from this group to collect the plasticine from the shelves at the back of the class room. This must have given him the idea of using plasticine. This group finished well before the rest of the class and it was necessary to spend time challenging them to think of other ways of improving their models. For example, the model swings kept sagging in the middle and so the boy who made them was asked to think of different ways to reinforce the cross beam. He eventually used some pop sticks but only with limited success.

At the beginning of the session in week nine, the children were very keen to complete their model making of playgrounds from the previous week. I noticed that the children's designs were distributed for this session. The following is part of Jill's discussion with the children at the beginning of the session:

T What could you do underneath to make it a softer place? J? Bark chips underneath it. Is that what you would do?

C Sand.

T Bark chips. If you look at playgrounds, council playgrounds, quite often there are a lot of bark chips. What does that do J?

J Helps. They are sharp.

T All right, so you have to be careful. You think that you need to put grass underneath. Well, I want you to think about what you would put underneath your playground. And also some playgrounds have very sensible things. What would they have around the edges to keep people in?

C A gate.

T A gate. And what else do you think that they have?

A A fence.

T Some playgrounds have fences all around them. Think about what things can make your playground safer.

Jill then produced a box containing small pieces of white polystyrene foam and she told the children that they could use these in their playgrounds instead of bark chips. Many of the children immediately gathered together some of these foam pieces as well as a variety of other materials to use on their models.

While the children were working on their models, Jill came around and spoke individually to each child. She checked what each was making against what she had originally recorded about their proposed models. Feedback was given to the children about their models including how they could be improved. While doing this she also made some more notes about their models alongside each child's name.

I became interested in what one of the girls called Helen was doing. She was engaged in making a model of a pair of swings. The previous week she had cut out the seats for the swings using two clear plastic biscuit containers. She had punched holes in the sides of these and tied short lengths of string. In this session she used a glue gun to join together the two upright pieces of wood to the cross beam. (These she had measured and cut in the previous session.) The four pieces of string were then secured to the top cross piece of wood, by once again using a glue gun. The finished model was then attached in the upright position on the group's plastic board by using pieces of plasticine. She appeared to be very pleased with her finished product as she spent some considerable time pushing her swings to test them (see Figure 5.8). I noticed a number of other children play with their models after they had finished them.

It was following the completion of Helen's model that a number of children in her group became involved in a minor incident involving some Power Ranger cards. Reviewing the video taken of the session, it appeared that one of the girls had gone over and told the teacher that one of the boys had taken her cards. The boy concerned was asked to give them back and then the girl was instructed to put them away. The children from the group continued talking about the cards for a considerable time after the teacher's intervention. It seemed that a number of children had apparently already finished making their models and had added their pieces of playground equipment to their group's board.

Jill sensed this restlessness, and asked the children to think about making some additional safety features which could be added to their playgrounds. As a result, a number of quite creative 'safety' additions appeared in the finished playgrounds such as lights, fences, safety houses and rubbish bins (see Figure 5.9).

Figure 5.8 Helen's playground with her swings in the background.

Figure 5.9 A playground with the added safety feature of a fence across the back

Towards the end of the session, Jill gathered the children together and conducted a class appraisal of the completed model playgrounds. Each of the groups presented their models to the class. The children were asked to show their peers how they made their piece of play equipment and how it worked. The following is an example of Jill's discussion with some of the children:

T One by one you are going to tell us what you've made. O.K. How you've made it. What you used to make it. And you can tell us about the play equipment. Maybe you can tell us how you can make it better next time too. O.K. Shall we start with J?

J These pieces are Power Rangers.

T You people just sit down so everyone can see. What else did you make J?

J The sand pit. (Pointing)

T And what else did you make J? Did you make the swings?

J No, Helen made them.

T So J you made the sand pit and the Power Rangers. O.K. D, can you tell us what you made darling?

D I made these lights.

T And why did you make the lights? I thought that was a good idea D.

D Because if a dog at night time. If a dog wants to walk, it can with the lights on.

T Terrific. So it can see where it is going with its owner. What else did you make D?

D We made a rubbish bin with rubbish in it.

T Right. Wonderful D. O.K. K can you tell us what you made darling?

7 EVALUATION OF TERM'S DMA PROGRAM

In the tenth and final session for the term the children were each asked to write the first draft of a sentence describing the piece of play equipment that they had made for their group's playground. Jill told them that she would redraft, type and then print their sentences over the forthcoming holidays. She informed the children that the sentences would then be used in a chart which would also include photographs of the finished playgrounds. The sentences that the children drafted were generally short and not complex.

Two examples of sentences written by children were:

For my playground I made a swing.

I made a slippery dip.

When the children had finished writing their sentence drafts, Jill read them out to the class before she proceeded to dismantle each group's playground. Each child was given an empty white plastic shopping bag into which they placed their own models of play equipment to take home.

The children were also asked to complete a teacher-prepared self-evaluation sheet about the technology sessions held during the term. Each child was asked to write inside a box on the sheet what they had enjoyed most about technology during the term. Most children said that what they enjoyed doing the best was making the playgrounds. A number of children also said that they had found making the models with wheels the most enjoyable. None of the children included any mention of the first three sessions in which science concepts were taught. Underneath the box for children's comments was another box for the teacher's comments. After Jill had filled in the comments boxes, these completed sheets were glued into each child's Take Home Book that formed part of the process of reporting to parents about their child's progress at school in all of the curriculum areas. And finally, Jill produced a class newsletter at the beginning of term four which included stories written by pairs of children using the *Kids Pix* computer program. Several of these stories were about the DMA work undertaken during term three.

8 SUMMARY

In this chapter, Jill's DMA program for term three has been described. The first three sessions served as an introduction to DMA and were used to teach the children some basic science concepts about levers; pushes and pulls; and inclined planes. The children were then introduced to DMA activities using plastic construction kits when they were asked to make, appraise and design models with wheels. They used various materials to design, make and appraise their own models with wheels. The final DMA task for the term involved the children designing, making and appraising pieces of play equipment to form part of their group's model of a playground. The last session for the term was devoted to evaluating the term's DMA program. Although the connection between the first three science lessons and the subsequent DMA sessions was not strongly apparent, I did notice on a number of occasions that Jill did try to link the two. This was evident in the examples of teacher - student interactions provided in this chapter where Jill refers to levers.

A number of factors appear to have contributed to the DMA learning outcomes achieved during the implementation of Jill's DMA program. In addition to these factors, there also are a number of underlying structural and organisational issues that appear to have emerged. It is these factors and issues that will be explored in detail in the next chapter.

CHAPTER 6

INTERPRETATIVE COMMENTARY

1 INTRODUCTION

This chapter will provide an interpretative commentary on the DMA program described in the last chapter. The commentary will attempt to answer the first two research questions that have underpinned this study. These questions are:

- What are some of the factors that influence the implementation of a DMA program in an early years classroom?
- What are some of the structural and organisational issues that arise during the implementation of a DMA program in an early years classroom?

The identified factors and issues will be presented as a number of assertions. The aim will be to provide insights that may assist in clarifying an understanding of the implementation of the DMA program. Arising out of the identified factors and issues will be a number of implications for classroom teachers and these will be addressed in the final chapter.

2 RESEARCH QUESTION 1: SIGNIFICANT FACTORS

The first research question sought to identify some of the factors that contributed to the successful implementation of the DMA program in Jill's classroom. Five main factors have emerged from an examination of the DMA program and each of these will be presented as an assertion.

ASSERTION 1.

Motivation, extension and enrichment, relevance of topics and time allocation were important aspects of the teacher's planning.

Early in the study it became obvious that Jill had spent time thinking about and documenting both her long and short term goals and objectives. She produced, using her lap-top computer, outlines of her DMA program for terms two and three.

As well, detailed lesson plans for the individual sessions were produced each week. At the beginning of the school year (during term one), the children were introduced to the topic of tools and had jointly produced a class Big Book. The topic of tools was reintroduced during this study and the children were able to build on this prior knowledge. During each session Jill made sure that work covered in previous sessions, as well as the current session, was revised. This overlearning / revision technique was a feature present in most of the sessions observed. Also, an effective system of classroom routines had previously been established by Jill prior to the study commencing. According to O'Grady (1996), such a strategy enables the class to operate confidently. The children knew when to stop their work to listen to Jill; when to assemble on the carpet; and when to pack up their work.

Motivation was a consistent feature of Jill's DMA sessions. She paid particular attention to planning the introductory segment of each of the sessions. During the sessions she incorporated strategies to ensure that the children's thinking was stimulated and challenged. For example, in the sessions where the children were given the task to make a model with wheels using a variety of materials, Jill provided a number of photo-copied sheets containing illustrations of models made by other children faced with a similar task. At the beginning of the session in week six, she showed the children a model that she had made at home in order to illustrate the construction and use of axles. The children were frequently referred to library books in the classroom book-rack as a source of additional ideas and suggestions. Wright (1996) contends that such a use of pictures can act as a valuable learning aid.

Jill's interpersonal skills when relating to individual children were such that she provided them with a source of encouragement and support. While acknowledging their efforts, she would also challenge them to think of ways to further improve their work. On a number of occasions, Jill was observed following up children's comments by exploring their ideas further. In order to delve deeper, Jill would ask the children additional questions or have them expand their comments further. The importance of teachers devoting time to discuss in detail children's work was found in the action research conducted by Cooke (1996). According to Rogers (1996), a class teacher's expectation of children's work can also be a force for raising standards of output. Jill had realistic expectations for the children's DMA work and as a result demanded high standards. For example, the group of boys who had hurriedly constructed all their pieces of playground equipment out of plasticine were challenged by Jill to improve their models. She was not prepared to accept work that had been produced with only minimum effort.

When necessary, Jill demonstrated her flexibility by introducing challenges and new ideas in a session. For example, in the session when the children were making playgrounds, it became apparent that a number of children were going to finish early, so she asked them to add some 'safety' features to their playgrounds. Many creative additions were added and as a result some of the models were greatly enhanced.

Jill sought to make the children's learning experiences relevant by trying to relate the concepts being taught to everyday examples. She produced an array of everyday household objects for the children to explore during the session on levers and encouraged the children to look for more examples when at home. She tried to relate her classroom discussions to objects surrounding the children in their immediate classroom environment. During the classroom observations it became apparent to me that the children were applying their knowledge to a wider field. Following the session on levers, a girl came up to Jill and told her that a toaster was an example of a lever. When Jill asked her to explain, the girl said that when you push down on the handle it acts as a lever. Fleer (1992a, 1992b, 1996a) contends that the introduction of the DMA process should be through meaningful experiences that have some social purpose. The technological problems posed by teachers need to contain real life scenarios wherever possible in order to ensure that the learning is seen by the children to meaningful and relevant to their lives. In order for technology education to be effective, Jane (1993) also believes children need to be involved in the DMA approach in relation to real life situations.

Jill's DMA program incorporated aspects from other areas of the early childhood curriculum. Other curriculum areas incorporated into the DMA sessions included science, mathematics, art and craft. Perhaps the most noticeable curriculum area was in the language arts where listening, speaking, reading and writing frequently featured. Towards the end of each session it was quite common for Jill to have the children orally share their work with the class. Near the beginning of the session for week five, each child was asked to read aloud the sentence from their own page in the class Big Book about 'Wheels'. A good deal of integration of various curriculum areas occurred informally during the DMA sessions. For example, children in this study were required to work out with each other the materials needed for their models. They would then collect these materials for their models. Sometimes they needed to count some of the materials, such as the number of plastic wheels. On occasions children were asked to write about what they had made as can be seen in Figure 5.7. They wrote about their DMA experiences for the class newsletter and at the end of the term they were required to reflect and self-evaluate their DMA experiences.

During the course of this study, Jill allocated a total of eighty minutes each week to the DMA aspect of the technology curriculum. As mentioned earlier, Jill's DMA activities integrated other areas of the curriculum and therefore it is difficult to be precise in the exact allocation of time. The fact that she set aside a block of time each week that was devoted specifically to DMA activities ensured that the children did have a regular exposure to DMA. At no time did it appear that Jill's allocation of eighty minutes per session was excessive. My initial reaction, when I first found out that the sessions were of eighty minutes duration, was that it would be too long to maintain young children's attention. I was pleasantly surprised to find that they maintained their interest during the sessions. I was also surprised to discover that they seemed to have well developed time-management skills. When Jill set a task, she gave them a time-frame within which to complete the task and most acted accordingly. Although Bindon and Cole (1991) advocate that whenever children become highly motivated on a DMA task, it is worth capitalising on their enthusiasm by allowing them to work intensively on a project until its completion, this was not necessary with the children in this study. The children in Jill's class knew how much time had been allocated for a task and worked accordingly.

Jill's preparation and planning of the DMA sessions was comprehensive and I believe that this was an important factor contributing to the success of her DMA program. She made sure that attention was paid to motivation and ensuring that the DMA experiences provided the children with challenge and extension. As part of her organisation and planning, she also made sure that the topics chosen were relevant to the children's experiences and needs. In addition, she made sure that other areas of the curriculum were incorporated into her DMA sessions. In her organisation and planning she also made sure that adequate time was allowed for the DMA activities so that they could be realistically completed within a given time span.

ASSERTION 2

The teacher selected a variety of teaching strategies that resulted in effective DMA learning outcomes.

The fact that effective DMA learning outcomes occurred in the study was demonstrated by the children producing creative and realistic models, some of which had moving parts. The main teaching strategies which Jill used included her use of questioning, providing modelling behaviour, using computers and displaying children's work. Jill made use of questioning as an important aspect of her pedagogical repertoire. From an analysis of the collected data I found that four main features about her questioning technique began to emerge. The majority of her questions tended to be almost exclusively the 'closed' type. Jill frequently repeated verbatim the children's answers to her questions. The time that elapsed between Jill asking a question and expecting a response was very short. And lastly, the frequency of Jill's use of questioning during 'teacher talk' time with the whole class was very high.

During those times in the DMA sessions when Jill spoke to the whole class, she frequently asked questions, the majority of which tended to be 'closed' and they usually required convergent so called 'correct' answers. An example of Jill's use of 'closed' questioning can be seen in session four where I documented the dialogue involved in a child's presentation to the class of their completed 'wheel' model made with plastic construction pieces. Jill started with two open-ended questions but she then followed these by asking two 'closed' questions that required one word 'correct' responses. When she asked Kym to describe how the wheels turned around, presumably Jill wanted the child to mention the axle. When it was apparent that this was not going to be forthcoming, she asked Kym to demonstrate to the class how the wheels turned around. Further examples of Jill's use of closed questions can be seen in the other examples of the teacher - child dialogue provided in the narrative account of the DMA program which has been presented in the previous chapter.

A number of studies have examined teacher questioning and have all concluded that the use of 'closed' type questions is a common occurrence (Wood, 1986). The language children hear from classroom teachers usually has a high incidence of questioning that seeks to elicit a predetermined correct response (Makin, Campbell, and Diaz, 1995). These types of questions have also been referred to as 'display' questions by Wells (1983) and he suggested that they tend to stifle children's ideas and hence reduce opportunities for the use of linguistic skills. It was interesting to note that on the few occasions when Jill used an 'open-ended' question, such as in the example given in the narrative for session three (when she asked what would happen if the inclined plane had been increased), the responses obtained showed the boy's linguistic abilities extended.

Another interesting feature to emerge from Jill's use of questioning was that she invariably repeated the children's responses to her questions word for word. Examples of this can be seen in the first five teacher-child dialogues documented in the previous chapter. Appendix 5 also contains a number of instances of Jill repeating verbatim children's responses to her questions. According to Dwyer (1989), this common teacher habit of repeating children's answers, (which rarely occurs during everyday conversation), has the effect of frequently closing off discussions. It may have been more useful if Jill could have rephrased the children's answers using different words and so extend children's exposure to expressive and receptive vocabulary.

The time taken between Jill asking a question and expecting a response from the children was another aspect of her questioning strategy. From my viewing of the video tapes and listening to the audio tapes of the sessions, it became apparent to me that Jill tended to leave relatively short pauses after asking a question and expecting an answer. If the answer was not immediately forthcoming, she would quickly resume control of the interaction. Wood (1986) has reported on the findings of studies which have shown that when teachers have extended these pauses (from one to three seconds) the frequency and level of child response was shown to increase. It would seem that children usually need more time to think about their answers to teacher questions than teachers normally allow.

The final aspect of Jill's use of questioning during the DMA program that I was able to detect concerned the frequency at which she asked questions. Once again the examples of teacher-child interactions provided in the previous chapter reveal that nearly every teacher utterance contained a question, which was usually of the closed type. Wood (1986) had found that if teachers used fewer questions, then child explanations and elaborations became more frequent and longer. That is, the more teachers interrogated, the less children would say. He even claimed that the extent to which a child reveals her or his ideas and seeks information, was inversely proportional to the frequency of teacher questions. As Wells (1983) concludes, the teacher-child interaction needs to be truly reciprocal in order for children to use talk as a means of understanding and controlling the world in which they live.

In summary, I found that Jill's use of questioning helped the children think about their DMA, although I maintain that her questioning technique could be improved. Jill did not very often use questioning to challenge the children to think deeply about DMA issues. Her questioning technique may have been more effective if she had used more 'open' type questions; tried to rephrase children's responses to her questions; allowed more time for children to think before they gave their response; and perhaps asked less questions and encouraged children to ask more of their own questions.

During the sessions, Jill was able to provide additional assistance to individual children. During the session in week six, she spent considerable time helping Pam make her model. The idea to glue together pop sticks to make a car framework came from Jill and as a result the model was more sophisticated than others made by the children who did not have direct exposure to Jill. The teacher provided additional suggestions and ideas to not only the children receiving the teacher assistance, but also to the class as a whole when they viewed the finished products. As a result all children in the class were able to benefit, as this teacher modelling provided an opportunity to expand their repertoire of ideas and thinking. According to Seaward (1996), teacher modelling can be an extremely valuable strategy to assist children in the DMA process, with the expert being observed by the novice. This teacher modelling can be linked with Vygotsky's (1978) notion of socially constructed learning in which children are moved through their zones of proximal development. The term 'zone of proximal development' is used to refer to that area in which a child is unable to act alone and needs support from adults or other peers. DMA projects are able to provide rich opportunities for children to extend their zones of proximal development.

The use of computers as a complementary tool for DMA learning was another of Jill's teaching strategies. Wherever appropriate, Jill was able to incorporate follow-up (or introductory) computer activities for the DMA sessions. In the morning session of week seven the children were asked to draw a design of their piece of playground equipment. That afternoon they were asked to improve their design on the computer using the 'pencil' on the *Kid Pix* computer program. Designs were subsequently printed off for each child. Afterwards, Jill commented to me that the children had found it a lot easier to draw straight lines while using the computer. The use of graphics computer programs has been advocated by Benson (1990b) to assist children's designing. On at least two occasions during the study, Jill was observed using the classroom stand-alone computer to prepare materials for the DMA sessions. No doubt this would have acted as a good example for the children of the teacher role modelling computer usage. During the course of this study Jill has demonstrated how DMA activities can be enhanced by using computers.

It was obvious that Jill valued the children's work and attempted to encourage the children to be proud of their accomplishments. An important aspect of her teaching was the display of children's completed work. Each week I would observe new displays of children's work in her classroom. She made good use of coloured photographs of the children's completed models and usually added computer generated captions. These coloured photographs were incorporated into class Big Books, big charts as well as being regularly included in each child's Take Home Book. The use of a photographic record of completed models and devices has also been advocated by Beat (1991) and Gilbert (1987). Both Davison and Gaster (1985) and Matusiak (1990) argue that the display of pupil's completed DMA work can provide a source of valuable feedback.

Jill's selection of teaching strategies during the implementation of the DMA program resulted in effective DMA learning outcomes for the children. She made good use of questioning and provided intense individual assistance on occasions that resulted in extending the complexity of the child's model. Such a strategy also provided additional ideas for the other children in the class. During the DMA sessions, Jill used computers as an effective complementary tool for learning. A final feature of Jill's selected teaching strategies was her use of displays of children's completed DMA work.

ASSERTION 3.

The use of group work was an important component of the teacher's DMA program.

In each of the DMA sessions observed, children tended to interact with each other in different ways, depending on the tasks at hand. Jill deliberately structured the sessions so that the children were required to work cooperatively in groups. She gave careful consideration to the size and composition of groups and provided some opportunities for children to choose who they worked with while in some sessions she allocated the children to pairs or small groups. In the fifth session Jill had requested the children to make their 'wheel' model in pairs. Eight children decided to make their own model, rather than make one model between two. It would seem that children at this young age find it difficult at times to share tasks since they tend to be egocentric (Bishop & Simpson, 1992).

Although children's interactions within groups are very complex (Richie & Hampson, 1996), the need for the on-going development of group work skills became evident from the observations made in this study. Problems arose from the tendency of some children to sit back and watch others do the work. This was particularly noticeable in those sessions in which the children were instructed to work in pairs or small groups and produce between themselves only one model. In many instances, one child (usually the group leader) did all the work while the others simply watched as passive onlookers. During the two sessions in which the children worked in pairs to make a model with 'wheels', Denise made most of the van while Angela seemed quite happy to be a passive observer for most of the time.

My discussion with both girls, revealed that the original idea to make the van came from Angela, whose mother had just bought a new van.

Further group work difficulties occurred in those sessions where the group was required to reach a consensus. The group work task for the session in week three required the children to predict, and then test a car as it rolled down inclined planes. A group of boys allowed their teacher-designated leader to do all the work. They never really became involved in the set group tasks. During the debriefing this issue was mentioned to Jill and she said that in the past she had successfully used name tags to designate group tasks. These name tags included a group leader / observer / recorder / and reporter as has been advocated in *Primary Investigations* (Australian Academy of Science, 1993). In her action research project of children working together on technology tasks, McMylor (1996) also detected a lack of group work skills and acknowledged the need to devise strategies for careful nurturing of group work.

It would appear that even at this early stage of children's formal schooling, socialisation plays an important part. During the session where the children were completing their playgrounds, a group of children were busily engaged in swapping Power Ranger cards rather than completing their model playgrounds. Cusick's (1986) study of an American high school found that academic work occupies only a small proportion of a student's time. It seemed important for American high school students to sustain a complex network of social relations with other students. The Power Ranger card incident observed in this study suggests that seeds for social behaviour are sown during the first few years of formal schooling.

During the conduct of this study no incidents of obvious disruptive behaviour were observed. The children's level of interest and motivation was very high. This was confirmed from viewing the video tapes from some of the sessions. Children often moved around the classroom observing how other children were tackling the tasks. For the majority of the time, the children were busily engaged in their various tasks. While discussing a similar observation in her DMA classroom, Wright (1996) believed that the children's high level of interest in the DMA activities acted as a unifying force, motivating them to contribute in positive ways.

This study has revealed that collaborative group work was an important aspect of the DMA program and contributed to building a learning community within the classroom. The social interaction that occurred during the DMA activities made the learning to be a fundamentally social event (Pace & Larson, 1992). I felt that the children's group work skills were able to develop over the duration of the term. The children's group work for the final DMA task of making playgrounds was more effective than earlier in the term. I noticed that the children generally were able to work together more harmoniously for this last task. Obviously the group work activities earlier in the term assisted them to subsequently gain group work skills such as leadership, delegation, sharing of ideas and staying on task for longer periods. However, overall I did find that the children, while working in groups, experienced difficulties in the delegation of tasks and reaching consensus. I felt that they would have benefited from some extra help in these areas.

ASSERTION 4.

Assessment was a continuous process that involved both the teacher and children in critically reviewing work.

Continuous assessment appeared to form an integral part of the whole of Jill's DMA program and was directly related to the appraisal stage of DMA. She assessed individual children and the DMA program as a whole from both formal and informal perspectives. Her formal assessment strategies included making notes about each child's efforts and recording at the beginning of a task what each child intended to make. At the end of a session, she shared and discussed with the whole class individual children's designs and models. Jill encouraged the children to critically assess each other's work. Photographs were taken of completed models and sometimes included in the Take Home Books. In the final session for the term, she used a prepared evaluation sheet on which the children were asked to write down what they had enjoyed in technology during the past term. At the end of the evaluation sheet was a box in which Jill wrote some comments about each child's performance. This sheet was glued into each child's Take Home Book.

Throughout the study, Jill stressed to the children the need to self-assess their work. As Jill moved around the room while the children were engaged in making their models, I observed that she was supportive and encouraging to the children and their efforts. She would also ask them questions and challenge them to think of ways to further improve their models. She encouraged them to appraise their designs and their construction activities. An ethos that models can always be refined and improved pervaded her DMA teaching. The children responded enthusiastically and talked about their models both positively and negatively. This observation contrasted with what Humphreys (1996) found in her action research study, where her children were reluctant to make any judgements about their own work and share them with others. The children in Humphrey's study were older than the children in this study.

An area of concern relating to assessment emerged from this study. A potential problem arose from attempting to assess individual children when they worked as members of a team on a DMA task. (This difficulty also arose in Lever's (1990) study.) As mentioned earlier, I found that when the children were working as a member of a group, they either did most of the work or very little. A classic example was Mohsen, the boy from a non-English speaking background. When he was assigned to groups, I observed that he provided negligible input to the groups. When Mohsen was in the group constructing a vehicle with 'wheels' using commercial plastic construction kits, he provided little assistance to the group's finished product. In such a situation, it would have been very difficult for Jill to assess the amount of contribution that he had made to the group's output given that she had to simultaneously monitor the progress of twenty five other children.

In summary, Jill used on-going and continuous assessment as an integral part of the DMA process. She encouraged the children to appraise their designs and their model making activities. The appraisal stage was not necessarily seen as the final stage of the DMA process which was viewed as being cyclic. Throughout the period of my observations, Jill kept stressing to the children the fact that the final products were dynamic in that they can always be further improved. Finally, a potential difficulty was raised when Jill tried to assess individual children when they were working on a DMA task as members of a group.

ASSERTION 5.

The teacher and the children made safe use of a wide range of materials and appropriate tools.

The children in Jill's class were able to choose from an abundant supply of materials and they had ready access to a wide range of appropriate tools. As previously mentioned in the background information chapter of this study, the school was able to allocate a generous budget that enabled the supply of a comprehensive range of consumables. For the DMA task that required the children to construct a model with 'wheels', a range of commercially made plastic and cardboard wheels was available for them to use. This use of commercially made wheels enabled the children to concentrate on constructing the vehicles and attaching the wheels using axles, rather than spending time making their own wheels. Jill varied the types of materials the children used and in one of the sessions she made use of commercially produced plastic construction kits. At Highfield junior primary school these kits were rotated between classes thus providing the children in Jill's class access to a wide range of kits during DMA sessions and in their free play situations.

Because DMA had been a school focus the previous year, many good quality tools suitable for use with young children had been purchased from the South Australian DECS Technology Centre. These tools were mounted on a moveable board and were generally lighter and smaller than those used by adults. Highfield junior primary school had made sure that the tools were readily accessible by the children. Both Benson (1990a), and Hicks and Ranger (1990) have argued that effective storage and accessibility of tools and materials are important ingredients of effective DMA programs.

An important feature of the use of materials and tools was the fact that Jill continually kept the children aware of safety issues. Whenever the children were about to use tools, considerable attention was given to the correct and safe use of tools, since some were potentially quite dangerous. Jill had prepared a special chart outlining the rules for the safe use of the glue guns and this was on prominent display on a pin up board in the classroom. She referred the children to this chart several times during the course of the study. Roeder and Simms (1993) maintain that when teachers stress safety precautions rather than dangers, they are making science (and technology) sessions more female-friendly. In the DMA session for week nine, when some of the groups had completed their playgrounds before the others, Jill asked these children to add some of their own 'safety features' to their playgrounds. Such a request would have helped the children think about the concept of safety.

Also associated with this concept of safety, I observed that the children in this study did not appear to have any noticeable untidy work habits. Many of the older children that I have taught, often would leave materials and tools scattered all over their work areas which meant that they would spend time just trying to locate items. In Cooke's (1996) study of older primary children, she too found that many of them had developed untidy work habits.

When a number of the children in this study initially began to use many of the tools, it seemed that they were content to try them out in order to explore their properties. One boy was observed to drill holes in an empty yogurt container when he first obtained a hand drill. This had nothing to do with the subsequent model he made. While observing Denise and Angela, I noticed that they used the adhesive tape rather freely as if they were exploring its properties. The phrase 'messing about' has been used to describe this type of activity in which children are free to explore without superimposed questions or instructions (Holt, 1991). Sawing the thin pieces of wood was a new experience for the majority of children and many found it fairly difficult to do the first time. With practice, most became quite proficient at sawing the wood. The provision of opportunities for children to develop the pre requisite knowledge and skills before launching them into problem solving activities has been advocated by Banks and Jinks (1982) and Napper (1991).

To summarise, Jill's children had access to a wide range of materials and appropriate tools. A range of materials was used in the DMA sessions including commercial construction kits and every day consumable recycled household materials. The issue of safety awareness was stressed by Jill and it was found that the children had tidy work habits. Many of the children wanted to initially explore the properties of various materials and tools prior to being given DMA tasks.

3 RESEARCH QUESTION 2: EMERGING ISSUES

The second research question posed sought to identify some of the underlying structural and organisational issues that appeared to emerge during the conduct of this study. The main DMA issues to arise from this study are presented as three assertions.

ASSERTION 6.

There was a weak link between the children's designs and their making and appraising activities.

In this study, Jill incorporated designing tasks as an integral and important part of the DMA process. However, from my observations it was apparent that Jill only provided the children minimal guidance and attention whenever they were asked to draw designs. This resulted in a weak link to exist between the designing stage and the making and appraising stages. There seemed to be three possible reasons why children did not make further use of their designs during the subsequent making and appraising stages. I believe that they did not have a clear idea of what designs actually looked liked. Secondly, they did not seem to understand the purposes for drawing a design. And thirdly, closely associated with the above two reasons, they did not appear to know how to go about drawing a design. Also to emerge from my analysis of the data concerning this design stage, were other issues related to the area of design. These included the aspects of design perspectives, the children's attitudes towards the design tasks and the association between the designs drawn and the finished products. Each of these will now be discussed in turn.

The first possible reason for the weak link concerned the fact that the children had no clear idea about what designs looked like. The two DMA activities in which the children were asked to initially draw designs were in session five when they were asked to make a design with wheels and in sessions seven when they designed a piece of play-equipment for their group's playground. After the children had drawn their initial designs, I did not see any evidence of them referring back to their designs during any of these and subsequent sessions. Once the children had completed drawing their designs, they usually went over to select from the collection of materials that Jill had assembled. The materials that they selected seemed to be largely determined by what was available rather than what was needed to build their design. The design sheet Jill had prepared for session five contained space for the children to list materials but unfortunately this section of the sheet was not used. While talking to the children before they started drawing their designs, Jill did ask them (as can be seen in the dialogue presented in the previous chapter) to think about the materials that they were going to use.

The children seemed to confuse drawing pictures and drawing designs. In session four, when asked to draw a design of their finished model (see Figures 5.2 and 5.3) nine children included people in their designs. During session five, where the children were asked to initially draw a design of a model that had wheels, once again nine children included people in their designs (see Figures 5.4 and 5.5). The boy who drew a racing car in Figure 5.5 (top) also included a road. When I asked him about his picture he was able to relate to me a short story. When pressed further about how he was going to make his car, he told me that he was not sure. It seemed to me that he did not really understand the difference between drawing a picture and drawing a design.

Atkinson (1991) believes that children use drawing as a flexible and powerful tool to perform a variety of representational tasks such as actions, event, time-sequences, people, objects and narratives. (The boy mentioned above was obviously using his drawing as representing a narrative.) Atkinson also refers to a range of children's drawing discourses. I would argue that designs are a specific type of drawing discourse in which objects become representations that capture, explore and transmit ideas visually. In this study it would therefore seem that the children, when asked to draw a design, used a range of drawing discourses which resulted in a variety of representational forms. This may have been due to the fact that Jill had not taught them specifically about designing.

A second possible reason as to why the children in this study did not visibly link the designing stage with the other two stages of making and appraising, may have been because they were unclear as to the purpose of drawing designs. In Jill's class, there seemed to be an unstated rule that the designs should result in a perfect product from a first draft. They did not see their designs as a 'first ideas' stage of a continuous DMA process whereby they could regularly return to their designs to rework. (A similar analogy could be drawn from the process approach to writing where children's first written drafts have often been considered to be final products.) Jill required the children to draw a first and final design for all the design tasks except the one for the playground making sessions. For the piece of playground equipment design task, the children were able to redraft their designs using a computer. Generally the children were not encouraged to work through 'drafts' of their design drawings along similar lines to that used in process writing. The designing stage in this study was related to the making and appraising stages in a linear way. Jones and Carr (1993), in their New Zealand study of Technology Education, found that the technological processes used by the majority of students proceeded in a linear fashion. On the other hand, both Jane's (1995) case study of Technology Education in a Victorian primary year five class, and Ritchie and Hampson's (1996) study of children in a Queensland primary year six class, found design to be interrelated to the making and appraising stages in a cyclic fashion. The three interrelated components of plan, build and test were able to inform the children about the other features. Ritchie and Hampson (1996) have argued that teachers might consider teaching children that design is an interrelated DMA process that can involve several planning - making - testing loops.

The impressions I gained from my observations of the children during the designing stage was that they wanted to get over the designing task as quickly as possible so that they could get on with the next stage of making which seemed to them to be more important and interesting. In their study of year two / three children in Victoria, Jane and Smith (1992) found a similar situation with children who also wanted to quickly complete the design part so that they could move onto the making stage. From my observations of the children in this study, it was obvious that they did not understand that drawing designs can act as an aid to enhance their problem-solving and thinking about ideas and exploration of options visually on paper. Egan (1995), who has explored the narrative aspects of children's drawings, maintains that the focus of design drawing should be to explain rather than depict. She has argued that concentrating on the pictorial aspect of drawing reinforces the concept of drawing designs as an end in itself unrelated to the subsequent task of making. It could be also be argued that with the young children in this study, a lot of their designing occurred cognitively, without them necessarily recording their ideas on paper.

A third possible explanation relating to the weak link found between designing and making may have been due to the fact that the children did not know how to draw designs. Had Jill spent more time teaching them designing skills, then maybe their models could have been improved further. Cousins (1994) in her paper on DMA has also raised this issue of the need for teachers to focus on teaching design drawing skills and stressing to children the purpose of designs.

On the Design Sheet handed to the children for session five (Appendix 6), Jill had the original intention of having the children think about what they were going to use to make their models, and to list them on the sheet. (Jill had overlooked asking the children to complete this section on their sheet.) The intention appeared to be a good idea, because it would have forced the children to think about possible materials that they could use to make their design. Had Jill taught the children design skills, she could have introduced to the children the notion of size and scale to use. Samuel (1991) has argued that wherever possible, young children should have access to a limited choice of materials and that they draw their designs with this in mind. He also believes that they should design 'life size'. Jill could have also talked to the children about the complex issue of copying and building on from the ideas of others.

Another issue to emerge from my analysis of the children's designs was that of perspective. It was interesting that when the children were asked to draw a design of their completed model made using plastic construction kits, half the group chose to use a plan view perspective (see Figures 5.2 and 5.3). When the children were asked to draw a design in session five, they all drew it from a side perspective (see Figures 5.4 and 5.5.). This observation reinforces the view that the children lacked knowledge and understanding about the designing stage of the DMA process. Work by Fleer (1992a, 1993) has shown that young children can successfully be taught to draw 'birds eye'/plan view perspectives of models.

In this study, the designs were all characterised by flat images that revealed the height and width of objects (see Figures 5.2, 5.3, 5.4 and 5.5). Atkinson (1991) has claimed that children's early representational forms are typically like this. On the other hand, as children grow older, their drawings become characterised by a shift towards more perspectival forms. I found that it was reasonably difficult to make subject judgements about the designs drawn by the children. The children's designs observed in this study seemed at first glance to be fairly straight forward and lacked a high degree of creative innovativeness. However, this observation may be due to my own attitude towards representation that is probably based, for example, on intellectual realism. What I maintain is that the variety of children's design drawing discourses suggest that their use of drawing was far more complex than I had first imagined. I believe that in attempting to interpret children's designs one needs to be sensitive to the various uses and meanings which children give their drawings. This also means that the context needs to be taken into account.

Although the connection between the children's designs and their models were weak, the children had a very positive and enthusiastic attitude towards drawing designs. The children enthusiastically applied themselves to the designing task and seemed to enjoy drawing their designs. Previous studies by Claire (1991), Cooke (1996), Jane and Smith (1992) and Smits (1990) found that children disliked engaging in any form of graphic presentation. (It was interesting to note that the children in these studies were older than those used in this study.) Jill varied the designing task and this may have been a contributing factor to the children's enjoyment. In the session for week four, the children were asked to draw their designs after they had made their 'wheel' model using commercial construction kits. Claire (1991) conducted a case study of DMA teaching and found that, for reception children, learning the skills involved in drawing often occurred in the context of recording what had already been made. In session seven, Jill had the children make use of the computer to redraft their earlier drawn designs of their pieces of play equipment.

As mentioned throughout this discussion on designing, the children in this study did not exhibit a strong connection between their drawn designs and the other two stages of the DMA process. As a result I was unable to visually detect a strong correspondence between the models made and the designs drawn by the children for the two tasks of an object with 'wheels' and their piece of play equipment. Samuel (1991) believed that children often translate their highly imaginative images into elaborate drawings that bare little relationship to anything that they could possibly make. I found it too difficult to try to categorise the designs and models. When I spoke informally to the children about their completed models and original designs, most were vague and were unable to talk about the connection between the two. At the time I felt that this was because they were unsure about their designs and why they had to draw them. What this aspect of the study did highlight for me was that this whole area of the analysis of young children's design capabilities was very complex. I believe that it is an area worthy of a more in-depth treatment than was possible during this present study.

The children in this study when asked to draw designs, used a range of functional forms of drawing discourses. According to Atkinson (1991), as children grow older, so their repertoire of drawing becomes narrower - usually towards representational. Because of the need to ensure that the eclectic nature of the functional forms of children's drawing remains broad, I believe that it is therefore necessary to ensure the act of designing does not become restricted to representation exclusively. Young children need to see the use of drawing design sketches as a function that allows their exploration and transmission of ideas visually. The designing stage is the all important thinking stage and is an important part of children's drawing discourse which should be fostered by the teacher.

This study has demonstrated that the design stage is an important part of the DMA process, even though I did find a weak link to exist between the design stage and the other two. I have argued that this weak link may have been caused in part by the children's lack of a clear idea of what designs look like, their purpose and lack of skills to draw them. Associated skills such as listing materials, size and scale, copying and perspective have been discussed. It became apparent to me that this designing stage provided the children with an opportunity to engage in a form of cognitive thinking about the problem-solving task using a visual medium. Drawing designs provides a medium that allows children to clarify and communicate their ideas. The fact that children's resultant artefacts differ from the original designs was possibly normal and illustrates the draft status that designs can assume. I felt that the thinking process used by the children engaged in the design task was probably more important than the end product produced. A lot of the children's designing and planning must have occurred without their ideas necessarily being expressed on paper.

ASSERTION 7.

Participation in DMA activities included all members of the classroom community.

In the previous chapter I mentioned the gender interactions occurring between the teacher and children. In the initial session, most of these interactions occurred between Jill and the boys. Following this session I debriefed with Jill, and she decided to make a conscious effort to redress this situation during the remaining sessions for the term. From my monitoring of some of these remaining sessions, this was largely achieved.

The 'target students' identified in this study were a mixture of boys and girls. This was contrary to Tobin's (1993) findings in which he found that the majority of target students tended to be boys. Another interesting finding to emerge from this study was that the actual target students themselves were not consistent throughout the different DMA sessions. Different target students dominated the interactions in each of the sessions monitored. This could be explained by the fact that since children at this age have not been at school for very long, they therefore are still discovering their particular niche within the complexity of classroom interactions.

In this study, the range of topics and materials used did not appear to favour a particular sex cohort. The DMA topics selected by Jill as themes for the children's design briefs, did not appear to be gender biased. In the session where the children had to use the plastic construction kits, they were asked to make a model containing at least one wheel. In the class Big Book based on the theme of 'wheels', the wide variety of pictures drawn by the children reflected that they were not given gender restrictive instructions. Similarly, in the sessions held during weeks five and six, the children were asked to make a model of something with 'wheels'. During the sessions that involved making a piece of play equipment, the children were also allowed to pursue their own interests.

In Jill's class there was an 'identified' special education boy named Corrie. During this study I observed that Corrie participated at his level of ability and was able to achieve successful learning outcomes. During the playground making session, Corrie was totally engrossed in making a ladder for his slippery dip for at least twenty minutes. He meticulously glued together the rungs of his ladder, no doubt resulting in improved fine motor coordination. His level of interest and motivation was very high and this was reflected in the pride that he had in his finished products. The provision of a series of shorter tasks for special education and younger children has been suggested (Benson, 1990a). However, I found that such an approach was not warranted in this study since the children were highly motivated and absorbed in their DMA tasks most of the time.

From the above analysis of inclusivity and DMA, it could be argued that DMA activities are ideally suited to addressing gender issues and assisting special education children. The teaching of DMA in Jill's early years class revealed that it can be a gender-neutral curriculum in which girls and boys are equally able to fully participate in DMA learning activities. Both girls and boys were able to enjoy their participation and there appeared to be no obvious differences in the models produced. Arising from an examination of the target students in the class, there did not appear to be the same gender specific differences that have been found to occur in classes with older children.

ASSERTION 8.

The setting of tasks was problematic during the implementation of the DMA program.

Jill's actual wording for some of the DMA tasks caused a number of children to interpret the task in such a way that they did not appear to be fully extended. The instructions to 'make a piece of play equipment' resulted in some children making static models of a sand pit or bike track. (As a consequence, these models were completed well before the rest of the class.) Had the original instructions stipulated that the piece of equipment must have at least one moving part, then these children no doubt would have been challenged to a greater extent.

Another difficulty relating to task setting that emerged for some children, was the issue of being able to handle a number of tasks simultaneously. A number of the tasks set by Jill did not always appear to be clearly understood by many of the children. In the third session about inclined planes, many children were confused when they were asked to carry out a number of tasks simultaneously. This situation was discussed with Jill during the debriefing session and I suggested that sometimes it may be more advantageous to break down the tasks into separate steps and have all the children complete a small number of tasks first before proceeding. I felt that, with very young children, sometimes it might have been more effective if Jill had set them only one task to complete and then brought them back together before having them move on to the next task. Samuel (1991) has stressed the need to place constraints on the DMA tasks in order to avoid possible confusion and achieve high standards of output.

The videos of some of the sessions in this study show that the actual total time some children appeared to spend working on their set tasks was rather limited. A great deal of their time seemed to be spent on talking to others, looking around and fiddling with items not directly associated with the task at hand. Yet in sharp contrast, a number of instances of perseverance were often observed where individual children were totally absorbed at a task for considerable periods of time. For example, one boy used an F saw to cut wood and was occupied continuously for at least twenty minutes.

Another issue associated with tasks that emerged during this study, was the problem of what to do with those few children who finish their work early. I have previously mentioned that on one occasion during the study, a particular boy decided (on behalf of his group) to have them make all their playground equipment pieces out of plasticine. As a consequence, most boys in this group had completed their models well before the rest of the class. Jill and I had to then challenge these boys to improve their models by, for example, making them more rigid and to incorporate some moving parts. This same boy and his partner were also the first to complete their model with wheels in session six. Although I assisted them to improve their model, they still had a long wait before the end of the session.

The setting of DMA tasks was found in this study to be an area that presented a number of problems. Some of Jill's wording of tasks failed to fully extend some children. On occasions Jill gave the children a number of tasks simultaneously and this seemed to cause some difficulty. Individual instances of prolonged on task behaviours were often observed. Finally, there was the issue of some children who finished their DMA work well before the rest of the class. This may in part have been caused by the children not clearly understanding the set task.

4 SUMMARY

Five factors contributed to the effective implementation of Jill's DMA program. These included Jill's organisation and planning skills which included aspects such as motivation, extension and enrichment, relevance of topics and time allocation. Jill selected a variety of appropriate teaching strategies including questioning, teacher modelling, integrated use of computers and use of displays. The use of group work, continuous assessment, and the use of a wide range of materials and appropriate tools were all important components of the DMA program.

In addition, three underlying structural and organisational issues emerged from an examination of the data. There was found to be a weak link between the children's designing stage and their making and appraising stages. DMA activities were also found to be ideally suited to addressing gender issues and assisting special education children. And lastly, the setting of tasks seemed to be problematic.

All of these factors and issues have implications for teachers who wish to implement DMA programs in their classrooms. These implications will be explored in the next chapter, together with a discussion of the limitations of the study and suggestions for further research.

CHAPTER 7

CONCLUSIONS

1 OVERVIEW OF STUDY

Arising from this study it has become clear that young children who have just commenced their formal schooling can successfully begin to develop their technacy skills through being involved in a DMA program. Conducting research with very young children can be difficult at times because of their sometimes unpredictable responses and behaviour patterns. I found working with these young children to be a challenge that was very rewarding. It is easy to underestimate young children's abilities to solve problems and construct models. This study has shown that children just beginning their formal schooling are able to effectively engage in DMA activities that result in creative and innovative end-products of varying degrees of sophistication.

In this final chapter, I will address the third research question which is:

- What are some of the implications for classroom teachers which arise out of these identified factors and issues?

Following a discussion of the implications for teachers, some of the possible limitations of the study will be mentioned as well as suggestions for further research.

2 IMPLICATIONS FOR TEACHERS

As mentioned previously, case studies enable the readers to vicariously interact with the material presented. Readers are able to bring to the case study their own background experiences and situations. In this case study I have been able to identify five main factors that have contributed to the successful implementation of the DMA program in Jill's early years class. Three issues that emerged during the course of the study have also been discussed. Each of these identified factors and issues have implications for teachers who may wish to implement a DMA program in their classrooms. Although the implications arising from this study have direct relevance for junior primary teachers, many may also apply to teachers of older children.

2.1 Organisation and planning

During the conduct of this study Jill allocated eighty minutes each week to work specifically on DMA activities. Because the children were highly motivated, their interest and enthusiasm were usually maintained for the whole of the session. Also, because of the integrated nature of Jill's DMA sessions, it could be argued that the children spent some of their time learning other areas of the curriculum such as mathematics and communication skills. From informal observations made elsewhere at Highfield junior primary school, I did not see a lot of evidence that technology was being regularly taught in the other classrooms. Simply making a syllabus mandatory does not necessarily guarantee that it will be taught, since teachers tend to avoid those sections of the syllabus where they lack confidence. Ferry (1993) found that most primary teachers in New South Wales spent less than twelve minutes per day on science / technology teaching and this was less than half of the time recommended for such a key learning area. No doubt many primary teachers find the pressures created by an increasingly crowded elementary curricula to be a possible reason for avoiding the teaching of design and technology (Wallace & Louden, 1992). According to Farley (1986), schools vary enormously in the time that they devote to DMA. In the UK, DMA has its own designated time of one hour per week (Seaward, 1996). The question of time available in the curriculum for DMA activities featured high on the list of restrictions identified by staff in Oliver's (1996) action research project. This study has demonstrated the benefit of timetabling a regular specific block of time to DMA activities. By having a regular block of time set aside for DMA, teachers are thus able to make sure that it is taught regularly to children.

During the making stage of some of the DMA sessions, a number of children moved around the classroom observing how other children were tackling the tasks. It could be argued that this type of behaviour should be encouraged. In fact Neville (1995) has suggested formalising a structured observation phase during all model-making sessions. At some stages during a session, the teacher can request that all children stop work and move around the classroom. The children can use this opportunity to observe and discuss with each other their models. This sharing of ideas she referred to as 'Spy Time', which some teachers also refer to as 'Peeping Time'. In her action research study, Zarins (1996) found that the 'visitors' and 'watchers' were more often boys, although no such trend was found in this study.

2.2 Teaching strategies

The educational benefits to the learner of teacher-generated questions have been widely recognised and validated in the literature (Biddulph, 1990; Redfield & Rousseau, 1982). In this study, teacher questions were seen to play an important part in the DMA skill development process and Jill made good use of them. Sometimes Jill had a tendency to rely fairly heavily on 'closed' type questions. Teachers need to ensure that they use open-ended questions as part of their DMA teaching. Open ended questions are better able to probe, and allow children to extend their thinking into more lateral and creative levels.

Jill was able to provide a valuable role-model for the children by actively engaging in the DMA process alongside and together with individual children. Such an approach allowed for the extension of a child's zone of proximal development (Vygotsky, 1978). This adult contribution usually resulted in more sophisticated models being made and these in turn may have provided a source of inspiration and ideas for other children in the class. Teacher modelling during all three stages of DMA teaching can be a useful pedagogical strategy.

The valuable role that computers can play in developing children's technacy skills has also been demonstrated in this study. Throughout the series of DMA sessions, computers played an important complementary support role. Even at the beginning stages of children engaging in design tasks, computers were shown to be of great benefit. No doubt this issue will gain increasing importance in the years ahead and teachers need to be willing to explore further ways of incorporating computers in order to enhance their DMA teaching.

Finally, there are two useful books which DMA teachers may wish to consider. They are the *NSW Science and Technology (K-6) Syllabus* (Board of Studies, 1991) which lists over twenty DMA teaching strategies, and *Introducing technology Education R-7* (Department for Education and Children's Services, 1994).

2.3 Group work skills

DMA activities provide an ideal opportunity for cooperative learning in which children work in groups and this study revealed that it is sometimes necessary to provide them with skills for working productively in groups. This study has also revealed that children working in groups may need special assistance with reaching consensus and understanding the role played by various group members such as group leader, observer, recorder and reporter. Jarvis (1993) has provided a number of suggestions on how teachers can go about developing effective cooperative groups in their classrooms. She includes strategies for developing cooperative and problem-solving skills, listening and negotiating skills and leadership skills. The children in this study found the collaborative learning in the DMA sessions to be an enjoyable experience and no overt behavioural problems were observed. As Wright (1996) has noted, children's interest in DMA activities acts as a unifying force, contributing to the absence of any disruptive behaviour.

2.4 Assessment

Assessment forms an integral part of DMA and is a cyclic and continuous process. In this study, teacher assessment of children's DMA work has been shown to present several difficulties. Assessing individual contributions during group work was seen as potentially causing problems. Because set DMA tasks encourage originality and inventiveness, there was no one `correct' solution. Children were actively encouraged to explore and experiment. A wide range of accepted responses were not only likely but were encouraged (Eggleston, 1992; Kafai, 1991). Throughout the DMA program in this study, Jill encouraged the children to self-assess their designs, making activities and completed models. Jill established in the classroom an ethos that models can always be further refined and improved. In addition, the children were encouraged to critically assess each other's work as part of the DMA process. Teachers implementing DMA in their classrooms need to incorporate such an assessment ethos into their programs.

2.5 Materials and tools

The importance of children having ready access to adequate resources was clearly demonstrated throughout this study. The children were able to use a wide range of appropriate tools and they had access to a wide variety of consumable materials - both commercial and recycled. This study has shown that the implementation of an effective DMA program does not necessarily require expensive specialist equipment and materials. The majority of DMA activities in this study involved the create-from-scratch approach as opposed to the exclusive use of commercial (mainly plastic) construction kits. One of the advantages of using a variety of consumable materials is that the children were able to take home their models after they have been made. They do not have to be dismantled for the next lesson or another class. Many general texts about teaching DMA in primary schools include comprehensive sections about materials and tools (Idle, 1991; Jakab & Keystone, 1993; Johnsey, 1991; Makiya & Rogers, 1992; McLoughlin & Wright, 1994; Richards, 1990b; Williams & Jinks, 1985).

Because Jill's class had access to an abundant supply of materials and tools, it was possible to have the whole class engaged on DMA activities at the same time. In some classrooms there are limited resources, and therefore sometimes it is not possible to have all children involved in construction activities at the same time (Bindon & Cole, 1991). In such a situation, flexibility of time allocation has been advocated (Clayfield & Hyatt, 1993) as another option or the whole class can be involved simultaneously at different stages of the DMA process (Wisely, 1988). The use of technology work stations has also been suggested as another possible classroom organisational strategy to overcome this problem (Newton & Newton, 1992a).

Throughout this study Jill continually kept before the children an awareness of safety, particularly about the safe use of tools and the work environment. A chart about rules for the safe use of the glue guns was on prominent display in the classroom. The children in the study were taught to move safely about the classroom and routines were in place for tidying up work areas. The every-day consumable recycled household materials used by the children in this study enabled them to learn the skills of design and construction with familiar and safe objects

(Eaton, 1991; McManus, 1991). Although the issue of safety may be self-evident, never the less I believe that teachers need to be ever vigilant during DMA activities.

Children's prior exposure to materials and tools also emerged as an important prerequisite for successful DMA outcomes. This study illustrated the need for young children to be given time to explore the properties of various materials and to practise using tools prior to being given DMA tasks. To allow this to occur, many schools are now providing tinkering tables to allow children to develop their knowledge and skills in mechanical and electronic areas, and to develop competence in the use of tools and machines (Beat, 1991; Bennett, 1989; Hildebrand, 1989; Wisely, 1988). The term 'tinkering table' was first used by Jan Harding from Chelsea College, London (White, 1989). Children working at a tinkering table can quickly learn to use various tools such as screwdrivers (McManus, 1991) and pliers (Leder & Sampson, 1989). Jill's classroom did not have a 'tinkering table' and the children would have probably benefited from access to one in order to provide them with some additional exploratory experiences.

2.6 Designing

This study has revealed that the teaching of design skills is as important as the making and appraising stages of the DMA process. Young children can successfully engage in design tasks, providing sufficient emphasis on the design stage is given by the teacher. In this study the weak link between the design and making processes was consistent with the findings of other studies (Brennan, 1989; Cooke, 1996; Smits, 1990). Therefore teachers need to make a conscious effort to link the two stages of designing and making. Both Claire (1991), and Pace and Larson (1992), have suggested that children can draft a predesign drawing and then draw a postdesign drawing after they have constructed their model. This postdesign would then reflect the modifications that they had made to their model.

Jill was not observed modelling drawing during the design stage. Anning (1994) has noted that teachers rarely demonstrate drawing skills to young children. She maintained that the primary school culture often vetoes teacher modelling of drawing because it may force children into an adult mode of representation at the expense of individual creativity. Another researcher, Fleer (1990b; 1992a; 1995) argued that adult interactional patterns by teachers are crucial for the quality of children's learning. During the design stage of DMA, teacher modelling with children could be a valuable strategy before eventually handing over to them responsibility for the process. For example, teachers could explore with children various perspectives that can be used for drawing designs.

Another useful strategy during the design stage could be to show children examples of how rough sketches are produced by a variety of designers such as artists, architects and engineers prior to starting work on their final piece. Fleer (1996b) has presented a case study of a year three teacher who had her children investigate what architects do and the associated building processes. Such exposure can act as a resource bank for children's developing designerly thinking skills (Anning, 1992). Providing children with opportunities to discuss their designs with others has also been advocated by Liddament (1991) as a useful strategy to enrich children's designs. These nodal points (points at which the learner's understanding undergoes a metamorphosis) are embedded in talking to others. Cross-age tutoring has been suggested as another possible strategy (Tiddy, 1989).

The topic of children copying ideas from each other, already mentioned in section 2.1 of this chapter, needs to be raised again as part of design pedagogy. Much of our education in schools today disapproves of children copying work from others. Because in designing there is no one right solution, copying ideas and building on from them, can be a very useful technique. Hayes and Symington (1989) conducted a study of junior primary children's drawings during science lessons. They found that children gained drawing techniques as a result of seeing them used by their peers. Jackson (1996) has written about the topic of copying during design and technology and believes that there is an interface between group work and individual work in which respect for each other comes into play. She also believes that it is important for the teacher to discuss the various aspects of copying with children. Richie and Hampson (1996) also found considerable peer interaction in which ideas were shared within and between groups. They concluded that the sharing of ideas appears to be an important component of learning through technology based projects in primary classrooms.

2.7 Inclusive education

This study revealed that DMA can be an ideal area of the curriculum for introducing and developing non-sexist pedagogical initiatives. It provides a new window of opportunity through which to build real equality of opportunity (Eggleston, 1992). While implementing DMA programs, teachers are readily able to incorporate a focus on gender issues using 'action research' strategies along the lines that have been advocated by Kemmis and McTaggart (1984) and Stenhouse (1976). Teachers may wish to establish base-line data, implement intervention strategies and monitor the outcomes.

This study has also revealed that DMA activities are ideally suited to special education children who may be on a negotiated curriculum. Because of the nature of DMA activities, less able identified special education children are able to have positive, success oriented experiences and achievements that enable them to improve their self-esteem and self-concept. This study has shown that these children can achieve success at their level of ability. In addition, DMA activities are equally suited to those special education children who have high intellectual potential, since the nature of the open-ended problem solving tasks encouraged extension and enrichment.

2.8 Task setting

Jill's wording of some of the tasks presented to the children was shown to be problematic. Teachers need to pay closer attention to the DMA task setting stage. According to Bishop and Simpson (1992), in DMA it is important to leave the initial question as open-ended as possible so that children have to think carefully about the task being assigned. Newton and Newton (1990) maintain that closed problems tend to be limiting whereas open-ended problems are those which lend themselves to a variety of solutions. Teachers need to ensure that the original DMA task given to children is sufficiently open-ended; challenging; clearly stated; properly understood; and that progress is continually monitored to ensure compliance with the original task. Of course this is easy to say, but with only one teacher with a group of twenty six young children, this makes for a reasonably difficult challenge.

A suggestion has been made that DMA tasks should be framed within constraints (Samuel, 1991). This study demonstrates that it may not be necessary to set tasks within externally imposed strict parameters, as long as the set tasks are carefully worded to allow the exploration of a wide range of contexts, materials and tools. However, Hicks and Ranger (1990) believe that in order to promote technology, it is necessary to advance from static models and move towards working models designed and made by children from five years of age and upwards. In this study Jill could have included the words 'moving parts' in some of the DMA tasks set to ensure the avoidance of static models. If 'moving parts' had been included in the playground model's task, then the making of static models by some children would have been avoided.

This study has also revealed the difficulty encountered by young children when they were given too many tasks simultaneously. Various strategies were suggested to address this problem. Some tasks may need to be broken down into a number of smaller manageable steps. It may also have been advantageous if Jill had presented only one or two tasks at a time and to check to make sure that these tasks had been completed first before giving them the next.

And finally, a strategy has been suggested by Samuel (1991) whereby children are asked to first think about the materials and tools required to make their designs, and then make a list. This could serve to further stimulate their thinking about what they were going to make and how they might achieve it. Such a strategy may have assisted the group of boys, move beyond the exclusive use of plasticine by forcing them to think more deeply about what they were going to make and to select suitable construction materials.

3 LIMITATIONS OF STUDY

While observing the class over an extended period, it was impossible to note everything that occurred. Although a great number of children's behaviours and actions were observed, and an effort was made to understand them, it was necessary to progressively focus from the whole class to small groups, then to pairs and eventually to individual children. The first few sessions helped me to get to know the setting, the children, their names, and most importantly allowed the children (and the class teacher) to feel comfortable with me being present in their classroom.

As with any study, it is always possible to reflect back on how one would do it better next time. In hindsight I now realise that there are a number of aspects which I would do differently. My involvement in this research has been an extended learning experience for me. The study has been exploratory in nature and has resulted in opening up more questions that are left unanswered. It was only after the data collection stage had been completed, that I realised that the design process really needed a lot more raw data and analysis. I now believe that more formal interviews with Jill and the children could have been conducted, especially in relation to their designs. It might also have been useful to use an instrument such as that provided by Rennie and Jarvis (1994), to measure the children's perceptions of technology in order to see how it helped shape the DMA program.

As with the conduct of any educational research, a number of limitations emerged during the course of the study and especially during the analysis and reflection stages. An obvious limitation was the relatively short duration during which the data was gathered. Although the data collection extended over the last two terms of the school year (July through to December), and was collected on a regular weekly basis, it was found that extra time was needed at the commencement of the study to become familiar with the setting, the teacher, children and classroom routines. On reflection I felt that the recording of observations occurred too quickly. Before starting the data collection, I had only met the teacher on two previous occasions and spent only one afternoon in the classroom becoming acquainted with the class and its routines prior to commencing the study.
The familiarity with the type of setting used for the study was also a limitation. Because I had spent the majority of my own schooling and teaching career in similar types of schools, it could be argued that observations and perceptions may have been somewhat blinkered by enculturation. Wolcott (1975) has suggested prior cross-cultured fieldwork as an important pre-requisite to doing field work in schools to help overcome such an impediment. Delamont (1981) has also put forward four strategies that can be used by researchers when dealing with familiar situations. One of these strategies suggests that researchers develop self conscious

tactics to make the familiar problematic such as by actively questioning taken-for-granted aspects of schooling.

Because most of the children involved in this study were in their first year of formal schooling, their lack of school experience provided some limitations. When King (1978) was conducting his study, he found interviewing five year old children to be a difficult task. Although over the years I have interviewed a wide cross section of ages, I would have to concur with King. In order to help build up a picture of the children's technological background, I interviewed each child and found that some of their responses changed within a relatively short space of time.

It could be argued that another perceived limitation of the study is due to the actual amount and lack of variety of evidence gained. Given that a case study necessarily focuses on a bounded system (Stake, 1988a), and because of time constraints, the amount and variety of data gathered inevitably is restricted. After analysing the collected data, it was felt that maybe the scope of data sources may have been too limited. Useful additional data could have been obtained from some of the children's parents, other teachers on the staff of the junior primary school as well as from the adjacent primary school. This additional data could have improved the descriptive aspect of the case study. The use of interviews and questionnaires could have been readily used with the parents and other teachers. During the conduct of the study I was conscious of imposing too much on the busy staff, particularly towards the end of the school year. I was aware that staff morale was low due to industrial unrest and felt that it was not really the most appropriate time to intrude.

Limitations of the study may also be due to the methodological paradigm used. The case study genre of research can result in a relatively wide focus. I felt that the implementation of Jill's DMA program needed to be described in sufficient detail to enable the reader to experience something of its complexity. Any attempt to make the total picture more precise, necessarily tended to reduce the width of focus that was possible (Hammersley, 1992). That is, in seeking greater precision, some of the breadth of description was likely to be sacrificed.

A number of limitations of the case study genre have been identified by Merriam (1988). They include the fact that a case study that is too long and detailed has the danger of over simplifying or exaggerating the situation. Cases of necessity describe a bounded system which Lincoln and Guba (1981) aptly describe as `but a part - a slice of life'. Because much of teachers' knowledge is context-specific and conditional, multiple representations are needed to help teachers develop the professional knowledge needed for practical understandings of classrooms (Doyle, 1990). The sensitivity and integrity of the researcher, who is the primary instrument of data collection and analysis are also a potential source of limitation as are biases. I have attempted to address this latter limitation by providing some details of my background.

A final limitation may have resulted from the use of machine records as data sources. All sessions during term three were audio taped and some were video taped. These were subsequently replayed and used to compare my field notes. As analyst, it was only possible to interact with these audio and video tapes vicariously (Erickson, 1986). An associated limitation of using machine recordings as data sources, concerns the lack of access to contextual information while trying to analyse the replay. Both limitations were overcome to a certain extent by cross-checking the micro-ethnographical machine recordings (audio and video) with my field notes; Jill's lesson plans; worksheets; and notes from our debriefing sessions. In addition, Jill was able to read drafts of this report and was able to provide valuable feedback. This cross-checking process occurred throughout the conduct of this study, and attempted to detect any inconsistencies in the collected data.

4 SUGGESTIONS FOR FURTHER RESEARCH

This study has revealed a number of emerging issues about the DMA program that could warrant additional investigation. The following are some issues that could serve as the basis for sharpening further research questions:

- The National Technology Statement (1994b) and Profile (1994a) have been adopted by some schools. Is the Technology Statement realistic with regard to DMA and how do teachers use the Profiles to report children's DMA progress to parents?

- The area of gender and technology is a field ripe for further investigation by researchers. As mentioned previously in this study, this issue has probably received the most attention from researchers so far and there are more issues to explore. For example, DMA, creativity and gender could be investigated as could the effects of the gender composition of school staffs on DMA programs.

- This study has illustrated the value DMA activities have for special education children. Once again, further research could explore at a greater depth, the effects DMA programs have with children who have special education needs.

- Another emerging issue that was found in this study was that there did not appear to be a strong link between children drawing designs and the making aspects of the DMA process. As previously mentioned, this was also found to be the case in English studies by Cooke (1996), Brennan (1989) and Smits (1990). Jane (1995) has correctly pointed out that the process of design is an under-researched field.

- In this study I did manage to observe the practice of children copying each other's work during DMA activities from time to time. Is this a fairly common phenomenon? Jackson (1996) and Roth (1995) have both examined this aspect of DMA. Maybe this could be an area that warrants further investigation?

- The use of computers as an aid to enhance children's learning in DMA programs could also be a fruitful field for further investigation. As computer use in schools becomes more widespread, research into this aspect of DMA pedagogy could be useful to guide teachers' actions.

- This study revealed the perennial problem that faces nearly all classroom teachers in most curriculum areas concerning what to do with those few children who finish the set work early. Is this a widespread issue? How do different teachers handle this situation? A study could be conducted to further explore this aspect of classroom organisation.

- The subject of specialist teachers in primary schools seems to be an area worthy of further investigation. There are a few primary schools who have employed specialist technology teachers and their effectiveness could be evaluated. The effectiveness of special DMA rooms that have been set up in some primary schools could also be examined. Similarly, the usefulness of those primary schools in South Australia that have been especially designated as Technology Focus Schools could also be evaluated.

- As a follow-up to this study, a longitudinal study could be made of this class of children to monitor the extent of their exposure to DMA teaching in subsequent years. Unfortunately, because many junior primary schools have a tendency to mix and move children into new classes at the end of each school year, such a study may not be viable. It would probably be more realistic to conduct a longitudinal study in a smaller school where the children stay with the same cohort of children throughout their primary schooling.

5 SUMMARY OF FINDINGS

This case study of the implementation of a DMA program in a junior primary class has revealed a number of factors and issues. In many ways it has only scratched the surface in exploring the myriad of factors that are involved in the successful implementation of a DMA program in an early years classroom. This study has reaffirmed that the teacher is a critical factor. Other recent DMA studies (Jane, 1995; Ritchie & Hampson, 1996; Roth, 1995) have also involved talented and committed teachers. Jill, the teacher in this study, had an understanding of the rationale underlying the DMA process and its place within the total early years school curricula. She was convinced of the educational value and importance of developing in children technacy skills through the DMA process in order to adequately prepare them for life in the twenty first century.

The study revealed five factors that contributed to the effective implementation of Jill's DMA program. Jill's organisation and planning for teaching her DMA sessions was thorough and included aspects such as motivation, extension and enrichment, relevance of topics and time allocation. She selected appropriate teaching strategies such as the use of questioning, teacher modelling, and display. Computers were integrated and used as complementary learning tools. During this study the children were able to work collaboratively in groups and teams, and in doing so gained valuable communication and social skills. Many persevered on DMA tasks for lengthy periods, resulting in improved manual dexterity and fine motor control. The majority of children tended to be motivated to work on DMA projects that they found enjoyable. As a result discipline was not found to be a problem. The children were encouraged to take responsibility for their own learning. Assessment of DMA learning was a continuous process involving both the teacher and the children in critically reviewing work. The effectiveness of the DMA program was also enhanced by the wide range of materials and appropriate tools that were available to the children throughout the study.

Three emerging issues associated with the implementation of Jill's DMA program were also revealed in this study. There was found to be a weak link between the children's designing stage and their making and appraising stages. DMA activities were found to be a powerful learning medium able to actively involve all girls and boys. Many socio-cultural pressures reinforce gender-role stereotyping and DMA was seen to have the potential to assist schools to work towards a more gender-neutral curriculum in which both girls and boys have equal access. Special education children were found to be assisted by involvement in DMA activities. And lastly the setting of DMA tasks was seen to be an issue that could cause difficulties. Poorly worded tasks were seen to not extend children sufficiently and often resulted in some children finishing their work earlier than the rest of the class.

DMA programs such as the one described in this case study, enable children to engage in problem solving and creative thinking activities. The children's practical technacy capability, as learnt through engaging in DMA activities, involved learning as a process in which mistakes are made and learning arises from them. While engaging in DMA activities, the children in this study had the opportunity to explore, experiment, take risks and learn from their mistakes. As Fleer (1996a) has aptly pointed out, DMA activities provide children with another way of thinking that helps them work with materials, systems and information. In this study the children found this different way of thinking to be challenging, rewarding and enjoyable. The effective implementation of the DMA strand of technology education in our schools will require a new acceptance of practical creative endeavours as legitimate learning outcomes for children. DMA programs should be seen as a legitimate part of children's multi-dimensional technology education. Technacy needs to find its place alongside numeracy and literacy as a legitimate basic skill that is able to provide children with the experiences, knowledge and skills that will be vital for their futures.

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APPENDIX 1.

Extract of field notes from visit to computer room on 26 07 95 (1:15-1.55pm)

Children had lined up at the steps when I had arrived and were ready to walk over to the computer room. Libby's mum accompanied us - (Libby is a girl in the class). The Deputy Principal was away today - she usually joins with the class for the weekly session. The computer room was situated in the new building of the Primary School - past the Library and Staff room. The computer room was large with benches around three of the walls. Banks of five Apple Mac computers were along each wall - making a total of fifteen. There were three HP inkjet printers as part of the network. At each terminal there were two low stools. The school also had a colour scanner and camera that was used to put pictures onto the computer. In April of this year the school had spent $64,000 on computers. They had a Commodore network prior to the current network.

[Are there stand alones in every JP classroom? How many in the total school?] All children have their own floppy discs.

[I was a little overwhelmed initially when I first arrived in this computer room - must be the same for many children.] Jill allocated five children (who did not have a name chart on their classroom desk) to go to a terminal and type their name, add 'stamps' and then print. She quickly revised steps for the procedures, using the *Kid Pix* program. (I temporarily got lost while trying to follow her instructions.) [I would be interested to come back later in the term to see further lessons and children's progress.]

The rest of the class was told to disperse, and they went off to their terminals. Two girls were left, and had to be sent to join children on terminals. (Jill sent one off while I sent the other).

As soon as the children arrived at their terminal, they all knew exactly what to do (maybe because they had a stand-alone in their classroom they had been able to have extra practice!) [For me it all seemed a bit confusing at first.]

Halfway through the session, Jill asked the pairs to swap over. Only about half the class worked on computers at the same time.

It appeared to me that the children were mainly using the *Kid Pix* to create a picture using stamps - some enlarged their stamps using the SHIFT/+OPTION keys. These they tended to print off themselves.

A year five student came into the room to get his disc which he had left in a drive. I asked him if he had a computer at home. He had and used it to play ATARI games. (I should have asked him what he does during his computer lessons.)
All classes in the school have sessions in the computer room - the primary school has a coordinator who accompanies their classes.
I observed that about half of the children moved to the *Playschool* program after awhile. About three quarters of the way through the session, Jill drew the children's attention to a boy's screen. He had managed to initially divide his screen into four quadrants, each containing a different colour.
At the end of the session, children had to close off their files - right on time to vacate the room, though I noticed that the next class had not yet arrived.
Jill then led her class off to the music teacher while she had some non instruction time. The music room was located in the primary school section. (I then left.)

General reaction/impressions:

I was extremely impressed with what I had seen. I could not help but feel that young children and computers had great potential and possibilities. Jill's class was gaining an awareness and familiarity through 'hands on' exposure with them. They were gaining confidence, comfort and ease with using them.
How can we measure children's progress with computer use?
Examples of what can do now - and later? Monitor at regular intervals. Concrete picture possible. Would like to conduct research on this area at a later date.
Does Jill have a program for this area of the curriculum? What would be some of the aims? For Example:-

- Loading disc - saving - printing
- Picture - type simple sentence. More advanced - several sentences. Make Class Books. Children's own books - collate. (School keen to keep parents informed of progress - TAKE HOME BOOK could form part of this process.)
- Familiarity with keys / alphabet/ Alphabet Book - words and sentences.

- Objectives a) confidence
  b) skills - what?
  c) integrate with other curriculum areas

While walking over to the computer room, in the foyer outside the library were on display models of 'chicken coops' made by a class of year 4/5 children. Also on display were some models of houses similar to ones in the local area around the school. What about children designing and making their own designs using their own ideas? E.g. energy efficient that use their own creativity and imagination. Would be good to talk to the teacher concerned.

APPENDIX 2.

Extracts from an interview with the Principal of Highfield Junior Primary School on 08/11/95 at 1:30pm.

I What I'm mainly getting around to is what is the current status of technology in the school?

P We actually had a Technology Coordinator in 1994. That was last year. Anyway, Jill did that for a little while. We had a science come technology coordinator the year before. That provided science lessons in the NIT time. (Non instruction release time for teachers) In 1995, because of other issues this year, we decided we could drop the NIT component. But also Jill and her predecessor Kathy had worked very hard in training and development of staff to try and make sure that the stuff they were doing in specialist lessons was also going to be filtered through and certainly as far as resources were concerned we spent maybe 3,000 or 4,000 dollars last year.

I 4,000 dollars last year?

P It certainly was a lot of money building up resources for the science and technology. And also for each class they had to have consumable materials. And this year our budget has been more around the 2,000 dollars to maintain what we have done in technology. It hasn't been a major emphasis.

I That is something that I noticed here. It is so important. The amount of technology resources that is in Jill's class there. It certainly helps to makes the technology work.

P Sure

I All the gear is there.

P And I think to be perfectly honest, Junior Primary teachers have probably been pretty good with technology for a long time, because we have always done things like junk construction. Maybe the way we do it is different now. We might get to use more wheels or glue guns and whatever. But I think that we have always had that component there but maybe we are looking at it with a different emphasis. So Jill and Kathy's role was to make sure people felt comfortable with having to do technology in their classroom. So last year we had our school closure day and we all had to go into the science room and we actually made what the kids did. And Jill has continued to be our unofficial technology person this year. She has just offered to show all the teachers how to make light-up Christmas cards with circuits and things. She is all into that now.

I Do you actually have a school policy on technology?

P We don't over our side. But the primary school, because they actually are a technology focus school.

I Yes I know they are a technology focus school.

P Because they actually have got a technology coordinator. So they would have a more formal policy.

I What sort of curriculum statements do you have? Have you got a document?

P Yes, actually each teacher has a folder. I'm just trying to think where mine is. Our technology one. What we have tried to do is update it according to the statements and profiles. Now we were a maths priority school and we were a maths focus school......

And later on during the interview:

I Just the last question I've got here. Has the School Council got a sub-committee that focuses on curriculum?

P Yes we do have an education sub-committee. We actually have an Information Technology sub-committee which I'm the chair. That really came about because of us buying computers and we had some very knowledgeable people on the education sub-committee - and we also had some very knowledgeable people in our community who had a lot to do with computers. So that information technology sub-committee arose out of the education sub-committee itself but now has a separate identity on the School Council.

I Now that's important. That's the way we are heading.

P We actually talked about making the technology sub-committee encompassing a wider brief. People have got the impression though that if you are doing Information Technology that's computers and that is technology. And that isn't technology.

I It is only one aspect.

P Only one tiny component of it. Because our brief was to look into what kind of computer system we could have here. Develop a 5 year plan on where we want to go and to see how computers fitted in amongst the curriculum. This should be just Information Technology.

I That is great.

P And my job has been to report back on how the use of facilities are and then our committee is then going to have a policy on our plan for the future and how we are going to resell them, up-grade, and all that kind of thing.

I And that's important because you have got all that hardware that has only got a 5 year life.

P Yes, well right. We are actually planning to turn over after 2 years. So this time, (not next year because it will only be a year), so in 1997 we'll be looking to change all of that over.

I Are you going to do the whole lot at once?

P We might do half and half. At the informal meeting we had the other night we discussed that maybe those ones out of our computer room might be put back into the classrooms so that everybody has one. We won't have the money to spend 60,000 on computers. And also, the computers should be an integrated package across the curriculum, because computers are not the sole part of the curriculum. So that committee is quite important to keep it all in focus. And our education sub-committee is a very alert group of people who have curriculum evenings. Things like we had a Science evening. We had a Technology evening. We actually had an Info Technology night which they organised. So that little group is trying to make the people - the parents, aware of the types of things that are happening in our school.

I Does the Design, Make and Appraise fit into the Technology?

P No. But that is a future part of it. They specifically wanted the Info Technology. They wanted to see where their money had gone. But Lionel over in the primary school - which probably would be worth if you could go over and have a chat with him - Lionel, because he is now a coordinator in technology. Now he will be looking next year to having a Technology night. Now he had this Astral Night this year which was basically about stars. His predecessor Richard had set up this great display of the designs the kids had made and had this wonderful display. The whole hall was full of all this lovely stuff that the kids had done and some of it was absolutely incredible the way they had thought about things. That was very well received so we have been looking to do. And I think that is what he is going to do more of it. Lionel is also involved with another project......

APPENDIX 3.

MCI Raw scores of children's *actual* perceptions of their classroom environment

NAME	ACTUAL RAW SCORES				
	Satisfaction	**Friction**	**Competition**	**Difficulty**	**Cohesion**
K M	15	15	9	15	15
Denise	15	9	5	5	11
A	13	5	5	7	15
K	13	11	15	7	15
Mohsen *	13	5	13	9	11
Peter *	15	7	13	7	15
A *	13	9	15	5	13
D Ha *	13	7	11	7	15
J *	11	7	9	9	11
D *	11	11	11	9	13
D H *	5	13	15	7	13
Kym *	11	9	13	5	11
J	11	15	11	11	11
Pam	15	9	7	7	15
A	11	13	7	11	13
B *	15	15	7	5	11
K H	11	11	9	11	13
Helen	11	7	13	11	13
N M *	15	7	5	11	13
Angela	11	15	13	11	15
N S *	11	7	11	5	11
J *	13	9	11	11	11
Corrie*	15	5	7	7	13
Libby	15	13	13	7	11
S	11	13	11	11	11
N T *	9	15	12	13	9
Mean	12.4	10.1	10.4	8.6	12.6

[* Boys**]**

APPENDIX 4.

Extract of field notes from session two on 02 08 95 (10:55am-12:15pm)

One of the first things that Jill said to me today was that Peter was not feeling well. After the bell the children came in rather casually and sat down on the carpet. Jill handed me a copy of today's lesson outline together with a copy of the science / technology profiles which she had used with the staff as part of their training and development last year.

I went to the front of the class and the children said good morning to me. Jill then revised the concept of lever from last week. She made use of a long plank of wood and a brick as a fulcrum to lift a girl who stood on an upside down table. (Before she did this she first used the plank of wood as a see-saw.

Jill then asked the children to move into a circle, and she asked two girls to stand in the centre with a skipping rope. They were asked to demonstrate to the rest of the class the act of 'pulling' using the rope. Jill asked What was happening? A boy answered 'stretching'. (This was not the answer she wanted.)

Jill then had two boys join the girls and asked all of them to pull. After these four sat down, Jill selected another group of four children (two boys / two girls) and the process was repeated. Next Jill put up a large piece of paper on which she had drawn a number of pictures down one side. She then selected a group of children to sit in the centre of the circle and the rest were told to act as 'observers' - (I am not sure that the children knew what she meant.) The children in the centre were asked to take off their jumpers - I noticed that Mohsen had considerable difficulty trying to get his off as I suspect that his mother would have normally done this for him. The 'observers' had to work out whether the children were 'pushing' or 'pulling' as they tried to get their jumpers off. The general consensus from the children was that they were 'pulling' and 'pushing'.

Next Jill selected another group of six children and they had to take off one shoe and then put it back on. Once again the observers had to work out whether they were pulling or pushing.

Another group was selected and this time they had to take off one sock and the process was repeated.

Jill then called for a group of five boys. She sent three back and asked the remaining two to pretend to put on their track pants. The final group of three boys had to pretend that they were brushing their hair. (One boy said that he had knots in his hair. Jill asked him what he should do about it. He replied, 'wet it!') The 'observers' had to once again work out whether they were pushing or pulling.

Next Jill asked one of the girls to go over to her desk and collect a bag which contained a soccer game (obtained from the toy box at her home). Jill used the game to demonstrate push and pull. She told the children that they could play with it during activity time. Next she produced a toy tractor and once again discussed with the children push and pull. Finally, she showed the children a Thomas Tank Engine and once again more discussion followed.

Then Jill asked a girl to collect a book from her tray and then showed the class how to fold one of the pages in half. She then asked the children what she had made. Children replied - two rectangles / equal boxes. (Jill was happy with these replies.) She then instructed the children to look around the classroom for examples of objects which could be pushed or pulled. They were then asked to draw a picture of an object on either side of their divided page under the correct heading label of either 'pulls' or 'pushes'. These labels were printed on green paper and the children were asked to cut them out and stick them on top of the page (on either side of the crease). Jill went through these instructions again to make sure that all children knew what was expected.

Jill handed out the heading labels and the children headed off to their seats. Jill and I went around helping the children to write the labels for objects drawn. I worked on the corridor-side of the room only. [I noticed that some children started straight away while others seemed to take ages to get started - e.g. sharpening pencils / talking / fiddling etc, - anything but the set task - why? Were they not sure of what to do?]

At this point two girls from the primary school came into the classroom and asked Jill for the small mirrors. Jill sent them off to the cupboard in the Science Room. She asked them how long they will need them. The girls said that they would have them back by lunch time.

I noticed that Denise had filled up her page with careful and neat work in her book. The group of girls sitting near the door seemed to be generally good organisers and remained on task to a greater extent than others in the class. (Need to make a note where everyone sits.)

I found that some children needed prompting - help with ideas, while others seemed to know exactly what was expected.

Jill asked the children to make a pile of their finished work books over by her chair (out the front) and when she saw that most of the children had finished, the children were asked to go and sit on the mat.
Jill asked these children how she could move the table in front of the blackboard. She received responses such as 'push / pull / lift' - then she asked how else - what could make it easier to move?
At this stage Jill noticed that the children were generally becoming rather restless and so she asked the children to stand up and she had them perform some exercises e.g. stretching / ten jumps / hands on head / shoulders etc....

APPENDIX 5.

Extract of field notes from session four on 23 08 95 (10:55am-12:15pm)

(Jill's dialogue while teaching the concept of axle)

T I've made something. How many wheels on the special thing I've made? Very quickly A?

A Four.

T Four. Is it going to move along? Okay. Put up your hand if you don't think it is going to move along. Why don't you think that it is going to move?

K The wheels are paper.

T The wheels are paper, so don't you think they are going to be strong enough. Is that the reason? A?

A Because you have sticky taped them.

T Because I have sticky taped them on. Okay. Any other ideas?

K (Teacher unable to discern response.)

T Because it is made of what? Any other ideas? A, why don't you think it is going to move? You had your hand up.

A Because they are not strong enough.

T Because they are not strong enough. Okay. Is it going to move? If I push it. But if I don't push it, it doesn't go. H - did you have a look? (So not let's worry about the caterpillars, we'll put them back in the box in a minute.) N, come and have a look at this. If I push it like that, it moves. But it does not keep on moving. If I push - (Is this yours D? No this is not yours D it is P's) P, if I push yours?

D It keeps going, it doesn't stop.

T But my car, it needs a big push and it just stops. Why do you think it stops and doesn't keep going? D is thinking.

D Because it is made of paper.

T Because it is made of paper and I've glued it on. How could I have made it better D?

T How do you think K? If I put sticks in it, it will actually go around. If I put a stick in it (turn around K and we shall catch them (caterpillars) in a minute) and it will go around. Do you know what you call this part in it? If I put a split pin in it (turn around K and sit up N - we shall catch them in a minute). If I put a split pin in it and it'll go around. Do you know what we shall call this part of the wheel? The part that goes through the middle of the wheel and helps it turn around. It is a big word. Do you know D?

D It is a long thing.

T It is a long thing. Sometimes it is a lot shorter (referring to the stick). Sometimes it is a lot longer to go right through.

C A pin.

T No, it is not a pin. H do you know? Do you A? Do you know N? Has anyone heard of the word 'axle'? (Don't worry about the caterpillars.) Who has heard of the word axle? D have you heard of the work axle? Where have you heard of that word axle?

C My dad has got some.

T Your dad has got some where darling?

C In his shed.

T Your dad has got some in his shed. D, are you going to tell us what word we have just used? J can you tell me what word we have just used? P, can you tell me what word we have just used? N?

N Axle.

T Everybody in a big loud voice.

AXLE

T An axle goes through a wheel and we have an end stopper on it. The wheel turns around. So which part is the axle here? A? Which part is the axle?

H The wooden part is the axle.

T Do you think that D? The round part is the axle. Not that part.

C The round part.

T That part. The split pin is actually the axle. N, you can go and pick up that caterpillar now!

APPENDIX 6.

Copy of yellow worksheet used in session five for children to draw their designs