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Cognitive apprenticeship in a building design office

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ABSTRACT

This thesis presents a research study that investigated student learning in a mentor supported design office situation, using a cognitive apprenticeship learning approach that utilised authentic design project tasks. In this study, 29 final year Technical And Further Education (TAFE) building design students undertook authentic building design projects with expert building designers, who acted as mentors, in commercial design office situations.

The mentors guided student learning by using a cognitive apprenticeship approach to learning, implemented with authentic design projects designed to replicate the everyday culture of practice activities typical of commercial design office operations. This study follows the progress of these students as they worked in collaboration with their mentors in the design and presentation of design solutions developed for the projects. Data about the students' learning experiences in this setting were collected and analysed to determine their learning outcomes, the kinds of knowledge acquired and the means through which knowledge was transferred in the study situation.

A holistic interpretivistic approach was used to collect data, in three phases. The first of these was a pilot-study with the other two phases providing the main data gathering parts of the study. Much of the focus of the third phase of this study was on verifying findings emergent from analysis of data collected in the first two phases, as well as seeking greater understanding of the study phenomena. Throughout each of the three phases, data were collected from multiple sources, which included interviews, direct observations, personal journals and drawings.

Analysis of the data showed that using cognitive apprenticeship learning methods organised around mentor supported authentic projects implemented in authentic commercial design office situations provided successful transfer of declarative, tacit and procedural knowledge from the mentor to the students. This thesis concludes with recommendations for the classroom application of cognitive apprenticeship learning methods, as used by the expert building designers who participated in this research.

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CHAPTER ONE

INTRODUCTION

This thesis documents a study that investigated learning outcomes and knowledge transfer for students working in collaboration with mentors on authentic projects, in commercial building design offices. In this Chapter, the organisation of this thesis is presented first, followed by a discussion of the background to the study. Then the purpose, significance and aim of the study are presented, with the research questions. The Chapter concludes by presenting the context in which the research was conducted, along with definitions used for interpretation of the research data.

Chapter Two presents a review of the related literature and research pertinent to the study. The literature review begins with an overview of cognitive apprenticeship methods and the role of expert practice in the learning environment. Specific research studies in which cognitive apprenticeship teaching strategies are explored then discussed with reference to the learning situation studied in this research.

Chapter Three begins with an overview of the research methodology and structure developed over three phases of data collection and analysis used here. The study sample is also described. This is followed by a discussion of how the trustworthiness of the study, including validity and reliability issues, were addressed using data triangulation and other methods. Chapter Three concludes with a discussion of the situational uniqueness in this research.

Chapter Four details the data collection methods used for each of the three phases of this research. The manner in which data from multiple sources, including interviews, direct observation, video recordings and drawings, were gathered is also discussed.

The methods used for coding and analysis of the study data are detailed in Chapter Five, along with the processes used to refine and extend the analysis procedures in response to emergent themes and findings. This Chapter also details the development of coding categories and index tree structures used to organise and analyse data collected during each of the three phases of this research.

Chapter Six presents findings that emerged from analysis of data by coding in categories developed as detailed in Chapter Five. Findings from analysis of data coded about four main emergent themes are presented using coding categories developed to represent multiple aspects of each theme. Each category used for the final coding of the research data is included in this Chapter, along with examples of data from which findings were developed during analysis. A summary of findings is presented at the end of the Chapter. Assertions about learning outcomes are also presented with reference to the research questions.

Chapter Seven begins by presenting answers to the research questions of this study. Then, the overall study findings are discussed in terms of the six key teaching strategies of a cognitive apprenticeship (Collins, Brown, Newman, 1989) learning approach as used in the theoretical framework that underpins this research. The Chapter concludes with a discussion of ways for implementing the study findings in classrooms and authentic settings organised using cognitive apprenticeship methods.

Chapter Eight concludes this thesis with a discussion of the limitations of the study, as well as making recommendations for further research based on the study findings.

Background To The Study

Until the introduction of formal courses by the Department of Technical And Further Education (TAFE) in 1964, training for building designers in Western Australia took place using traditional apprenticeship methods in architectural design office situations. Graduates from the first formal building design training courses were regarded as architectural drafters, a role that mostly saw them operating as assistants to architects. In response to changes in industry practice, which saw the demand for more highly trained, design-competent architectural drafters, TAFE courses were developed to provide students with more of a design focus, while maintaining drafting skills. Further development of TAFE training courses for building designers became necessary when in 1985 Computer Aided Design (CAD) methods were introduced to commercial design office practices in Perth Western Australia (Baird, 1996).

The introduction of CAD based design practices to TAFE building design courses changed the focus of teaching methods from using mostly traditional hand-skill-based design and drawing documentation methods, to using computer-based methods for building projects. This change brought with it new ways for problem solving and developing design solutions through the use of computer assisted drawing methods and three dimensional visualisation tools. It also shifted the focus from mostly learning physical skills for drawing production, to learning cognitive ways for resolving design problems. Building design students were now also required to incorporate aspects of other associated construction disciplines that also use computer technology, into their CAD based drawings. This necessitated new elements being introduced into training courses for building designers to address aspects of their work that changed because of the blurring of traditional boundaries between associated disciplines, brought about by their use of computer methods.

New learning approaches for teaching building design in Western Australia being trialed at the time of this study being commenced have CAD technology and practical experience as key components. This study examines learning outcomes for students undertaking authentic design projects under the direction of expert building designers acting as mentors, as part of those new learning approaches. The projects used for this study used real (authentic) client generated building design briefs for housing projects. They were conducted in commercial design office settings, with the mentors using teaching elements based on a cognitive apprenticeship (Brown, Collins, Duguid, 1989; Collins, et al., 1989) approach to learning, but not explicitly modelled on this theory.

The authentic design projects undertaken by the students under the direction of expert building designers acting as mentors provided opportunities for a highly detailed study of student/mentor interaction in the design office settings used for this research study. The authentic situations embedded in the design projects used were planned to replicate problems typically faced by building designers in their everyday culture of practice activities. The use of authentic learning experiences (Knufman, 1996; Pieters and de Bruijin 1992) developed through real life type situations in which strategies for solving problems are embedded in the context of the task, are considered by many to be the cornerstone of cognitive apprenticeship learning (Duncan, 1996; Choi, & Hannafin, 1996; Jarvela, 1995; Hennessy, 1993; Berryman, 1991; Brown, et al., 1989; Collins, et al., 1989).

This research was conducted in three phases. It began with a pilot study, referred to as Phase One, results from which were used to refine data collection and analysis methods used in Phase Two and Phase Three, which together formed the principal part of the study. Phase Two mostly used open ended interviews to collect data about what the study participants said took place during their collaborative design office activities. Phase Three mostly involved data collection by direct observation and video recording of student mentor collaborative work sessions.

All three phases of this study centred on the events and outcomes experienced by students when working on real work design projects with the support of expert building designers acting as mentors. Each student was assigned to a mentor by a lottery ballot with numbers picked from a hat by one of the coordinating TAFE lecturers. Three different authentic design projects were used to provide the students with learning

experiences in the context and culture of professional design office practices.
The design projects were implemented by the mentors using cognitive apprenticeship teaching strategies including modelling, coaching, scaffolding, articulation, reflection and exploration, as presented in the learning model proposed by Collins, Brown, Newman (1989).

This approach differed from the usual hypothetical exercises traditionally used in TAFE building design classroom based learning situations. The design projects used provided students with authentic, task focussed, problem solving situations in which they applied theoretical knowledge acquired through their TAFE studies, with the support of industry mentors using their everyday culture of practice methods. This format, using industry experts as mentors, is similar to that reported by Hennessy (1993) who contended that such an approach provided students with opportunities to acquire multiple problem-solving methods as used by the mentors in the resolution of real projects.

The main focus of this study was to investigate the learning outcomes for students in authentic cognitive apprenticeship styled learning situations. The study also sought to understand how the students acquired knowledge and skills used by experts to solve complex problems. Building designers, through years of practice, develop their knowledge, skills and abilities beyond the scope of their original formal training. This special knowledge is sometimes referred to as tacit knowledge (Collins, et al., 1989). The manner in which this knowledge is communicated to learners also formed the basis of one of the research questions.

Learning building design in Western Australia

The development and delivery of the first formal building design courses in Western Australia in 1964 was undertaken by building design/drafters who had formerly been involved in on-the-job apprenticeship type training of building designers (then called architectural drafters).

Training exercises in those courses were designed to resemble tasks faced by practicing building designers, however it was soon found that the rich experiences of actual real life projects could not readily be replicated in classroom activities. Consequently, new courses were introduced in 1968 incorporating a requirement for students to also undertake work experience on real projects in a building design office over a two-year period, following their initial two-year full-time classroom based training course.

When the structure of the full time building design courses was changed to include additional theory based subjects in 1982, the requirement for workplace experience was dropped from the courses. This happened at a time when the building design industry was undergoing changes to respond to the introduction of CAD methods for the production of drawings and other documentation for design commissions.

Findings from a study of the building design industry (Baird, 1996) indicated a need for building design graduates to have experience in authentic projects and CAD methods to make their training relevant to industry requirements. Competency in using computer technology emerged as an essential part of training courses for building design students. In response to industry demands for building design graduates to have authentic experience in design and CAD use, TAFE introduced mentor supported authentic design projects as part of their award courses. Prior to this study, no research or evaluation had been conducted to determine student learning outcomes from using mentor supported authentic building design projects. The authentic projects used here also incorporated CAD based building design and documentation methods and this provided opportunities to study knowledge transfer in technology based learning situations as explored by Jarvela, (1995). For this reason, amongst others, this study was regarded with interest by the TAFE staff and building designers who acted as mentors. Findings about how CAD based methods used by the study participants led to knowledge transfer are regarded as important to this research because most commercial building design office practices in Western Australia are organised using CAD for the design and documentation of building projects (Baird, 1996).

New building design courses to address computer technology

The role of the building designer in the period from 1960 to 1979 was principally concerned with the documentation of designs created by architects. From early 1980 building designers expanded their roles into areas once seen as the domain of Architects only. In response to these changes in the role of the building designer, new TAFE courses were developed to reflect the demand for a greater and more diverse range of subjects focussed more on design than drafting. These courses included the use of personal computer based (CAD) packages for drawing presentation as part of learning advanced design and construction theory. This led to course formats that made less use of traditional hand skill methods and increased use of computer technology for design/construction practices.

The use of CAD technology by building designers and other related disciplines led to overlapping of roles and responsibilities for building designers, engineers, surveyors and many other consultant practices within the construction industry domain. This in turn led to the need for training of building designers to include aspects of consultant disciplines that in the past would have not been part of their usual culture of practice activities. Problem solving methods and heuristic design strategies used by building designers to resolve problems in their everyday practices now incorporate additional elements that require advanced cognitive skills. Training courses developed for building designers in 1996 as part of a National curriculum addressed many of these issues and have computer technologies incorporated into almost every subject area.

Traditional building design and drafting methods that use hand skills to document design ideas are being replaced with CAD methods (Baird, 1996). CAD has changed the nature of design and drawing by replacing paper-based exploration and representation of ideas with manipulation of a database of information from which complex forms can be explored [illegible] emergent problems resolved. With little manipulation, the CAD drawing database can be replicated, modified and presented in a multitude of different forms to suit various discipline applications such as electrical services, structural details and bills of quantities. The content and delivery strategies of TAFE building design training courses have evolved to reflect this shift in building design practices.

A change in thinking

The fine hand movements and tactile feedback of drawing board-based methods is not present in computer based drafting. CAD requires the user to construct a model by interpreting mental concepts into computer operations and digitiser input. The emphasis in drawing production has shifted from mostly hand skills to more cognitive ways for resolving solutions by using computer technologies across multiple associated disciplines. Building designers now use a database of design information and elements to develop design solutions and drawings.

CAD use in this way allows designers to cross traditional discipline boundaries. It has given building designers control over structural documentation (previously the domain of the engineer), quantities and estimates (previously the domain of the quantity surveyor), artistic presentations with walk through three-dimensional capabilities and civil survey documents. Using CAD methods means that the drawing is now a database consisting of vector coordinates for line construction, and other data about dimensions, notes and textures. A model is no longer a miniature structure made from cardboard and plastic, but a computer representation of a three-dimensional shape that represents the virtual structure of a design.

The authentic design office situation and real projects experienced by the students provided many experiences that embraced different aspects of design practice that the students may not have otherwise encountered in their classroom-based learning. Here, the design office situation is considered to embrace the physical environment and the organisation of building designer working relationships with associated professions. Design office practices are concerned with the ways in which building design problems are resolved using different strategies and procedures that typify the culture of practice.

For the mentors, working across discipline boundaries is part of their everyday design office practice, but for the students this was another aspect of their involvement in an authentic design project that extended their learning experiences. The manner in which the mentors shared their knowledge with students through design activities that included other disciplines associated with their usual practices was a key part of this research. CAD based design practices provided the means for integrating multiple discipline activities into the authentic design tasks undertaken by building designers in their everyday practices (Baird, 1996). For this reason findings about the use of CAD methods for knowledge transfer in the study situation used in this research are regarded as being important.

The study environment

This study investigated the learning outcomes for building design students working under the direction of expert building designers acting as mentors in commercial design office situations. For many students this was their first experience working in a design office situation, being treated in ways similar to that used for the design office staff. They also experienced some of the working pressures and expectations typical of the design office environment. The design project collaboration was constructed to provide experiences typical of a design office team-based approach to problem solving so that the students could experience first hand the development of a design for an authentic project. In effect, the students worked in the industry for which they are training but in a monitored environment with the support of a mentor who was expert in the field of building design.

Significance of the study

This is the first study to be reported in which cognitive apprenticeship methods have been implemented using authentic building design projects in commercial design office settings. No other study has yet been conducted in Australia to evaluate the effectiveness of a cognitive apprenticeship based authentic work program for students of building design. Some studies have been conducted elsewhere in which a cognitive apprenticeship learning approach has been used in classroom situations (Jarvela, 1995; Hennessy, 1993) and workshop situations (Cash, Behrmann, Stadt, & Daniels, 1997), but not in authentic design office settings as used here.

Findings from this research study may have relevance to training courses offered by TAFE. Particular emphasis has been given here to determining how students acquire the kinds of tacit knowledge that the mentors develop over years of professional practice, as well as heuristic design strategies and procedures used by them to resolve design problems. Application of such information to formal courses may potentially assist in the development of richer, more effective learning approaches for future students.

Outcomes from this study may also have implications for other similar industry/institution based collaborative projects working with a cognitive apprenticeship styled learning environment. Many University and TAFE courses have practical components. Disciplines such as engineering, architecture, multimedia, surveying, medicine, dentistry and the arts require students to under take one-on-one practical experience components to achieve graduation. Findings from this study contribute knowledge about learning in authentic situations that may be applicable across many disciplines.

PURPOSE OF THE STUDY

The aim of this study was to investigate how students learn in a cognitive apprenticeship learning situation, implemented in a building design office. This study sought broadly to investigate "the content taught, the pedagogical methods employed, the sequencing of the learning activities and the sociology of the learning" (Collins, Brown, Newman, 1989, p. 454).

Research Questions

The study focussed on:

1. *What kind of declarative knowledge and procedural knowledge is acquired by students in the building design profession in a cognitive apprenticeship learning situation?;*

2. *What kinds of procedural and declarative knowledge are transferred in this learning situation?;*
3. *How is tacit knowledge acquired in a cognitive apprenticeship learning situation?;*
4. *If problem solving, heuristic strategies are used, how are they picked up by the student?; and*
5. *What features of this learning situation promoted student learning?*

Context

This research study focussed on the events and experiences of students working in collaboration with expert building designers acting as mentors using authentic design projects, in commercial design office situations. Data were collected from 29 students, 19 mentors and 3 TAFE lecturers.

Some activities needed for briefing the study participants and to initiate design work were conducted in classroom settings. These activities were however more focussed on the administration of the student/mentor collaborative situations and were used mostly to organise and inform students, rather than present learning activities. During these classroom sessions, TAFE lecturers provided the students with:

- initial briefings about the authentic design project they were to undertake with a mentor;
- information and advice with regard to contacting each student's allocated mentor;
- information about codes of behaviour and protocols when in a design office situation;and
- guidelines concerning the role of the mentor and what the students may experience when working in a design office under the direction of a mentor using practices that include cognitive apprenticeship teaching methods.

During the introductory classroom sessions, the students participated in discussions with me involving the entire class group, small focus group sessions and individual problem solving and project development learning activities. As part of these sessions, I briefed the students on:

- the aims of this research project;
- confidentiality safeguards and the use of pseudonyms for all participants;
- voluntary participation and freedom to withdraw from the study at any time; and
- interviews and observation methods I would use for data gathering.

As part of these briefing sessions, written permission was also obtained from each of the participating students for audio and video recording of interviews and working sessions with the mentors. Their permission was also obtained for me to use all data collected for writing this thesis and any other consequent publications.

Cognitive apprenticeship in this study situation.

The learning environment used here was regarded as being structured around the learning content, method, sequence and sociology, in accordance with the framework which Collins, et al., (1989) suggest provides the "characteristics of ideal learning environments" (Collins, et al., 1989, 456).

The reasons for this contention are:

- the students worked on authentic projects, in a building design offices with expert building designers acting as mentors, assisted by other people for whom this situation was their everyday working environment and culture (Brown, et al., 1989);
- the students had the opportunity to explore first hand working practices and problem solving activities used by the mentors to facilitate the resolution of a building design, in the context and culture (Hennessy, 1993) of an actual design practice;
- the students were guided and supported by the mentors who were expert in the building design profession and able to model the techniques and skills required to resolve problems emergent from the tasks embedded in the authentic design projects; and
- the students were exposed to mentor articulation of their problem solving approaches when presenting ways of dealing with building design problems.

In this study situation, the mentors provided the students with knowledge of their usual design practices and the tacit knowledge developed by them over years of experience and expert practice (Hennessy, 1993; Pieters and de Bruijin, 1992).

Throughout each of the authentic design projects all of the students had the support of a mentor. As will be demonstrated, the students were encouraged to develop and apply metacognitive problem solving approaches when extending their learning beyond the boundaries of the tasks used in the study and in their exploration and development of advanced design solutions. Although the mentors may not have been fully aware of cognitive apprenticeship constructs, for the reasons demonstrated above their methods when working with the students were regarded by me to fit well with the theory and contain many of its elements. Results presented later in the study confirm this.

Definitions Used In This Study

Cognitive apprenticeship is considered to be a process in which students acquire knowledge and learn the processes that experts use to handle complex tasks, situated in the context of their use. It involves learning through guided experience on "cognitive and metucognitive levels not just physical skills and processes", but seeks the externalisation of processes in bringing tacit knowledge into the open for students to learn with help (Collins, et al., 1989, p. 457).

The Collins et al. (1989) cognitive apprenticeship approach used here has six teaching strategies. Each of these is presented next, as defined by Collins, et al. (1989), along with the manner in which their use here has been interpreted.

Six Teaching Strategies Of Cognitive Apprenticeship

1. Modelling

Modelling is defined as follows:

> Involves an expert's carrying out of a task so that students can observe and build a conceptual model of the processes that are required to accomplish the task. In cognitive domains, this requires the externalisation of usually internal (cognitive) processes and activities; specifically, the heuristics and control processes by which experts make use of basic conceptual and procedural knowledge. (Collins, et al., 1989, p.481)

In this study modelling also included activities used to support learning through personal demonstration of processes or procedures used to create building designs and to resolve problems emerging from the exploration, development and assessment of possible solutions. Of particular interest was the manner in which building designers, when working one-on-one with a student, conveyed their knowledge and skills by modelling their approach to the identification and solving of design problems emergent from the authentic tasks of the design project. Modelling also included the demonstration of design strategies that affected personal style in building design.

2. Coaching

Collins, et al., (1989, p. 481) defined coaching as:

> Consists of observing students while they carry out a task and offering hints, scaffolding, feedback, modelling, reminders and new tasks aimed

> at bringing their performance closer to expert performance. Coaching may serve to direct students' attention to a previously unnoticed aspect of the task or simply to remind the student of some aspect of the task that is known but has been temporarily overlooked. Coaching focusses on the enactment and integration of skills in the service of a well understood goal through highly interactive and highly situated feedback and suggestions; that is, the content of the coaching interaction is immediately related to specific events or problems that arise as the student attempts to carry out the target task.

Carver, (1995, p. 206) contends that coaching occurs when "the teacher observes and facilitates while students perform a task". Coaching also involved activities or situations where a mentor assisted students by working collaboratively with them to resolve design problems. The use of coaching is considered here to include mentors guiding students in the use of heuristic design strategies and problem solving methods by articulating the reasons behind design decisions, procedures and individual style elements that are typical of their usual design office culture of practice methods.

3. Scaffolding

Scaffolding is defined as follows:

> Refers to the supports the teacher provides to help the student carry out a task. (Collins, et al., 1989, p. 482)

Another feature of using scaffolding to assist learning in a cognitive appreaticeship approach is the gradual withdrawal or "fading" of the help provided by scaffolding. Collins, et al., (1989, p. 482) define fading as:

> Fading consists of the gradual removal of supports until students are on their own.

In this study, scaffolding is regarded as including tips and tricks such as heuristic design strategies, problem solving methods and resource materials provided by the mentor to assist student learning or problem resolution activities in design. It also included techniques, explanations or partial solutions that enabled students to progress beyond points of difficulty.

4. Articulation

Articulation is defined as follows:

> Includes any method of getting students to articulate their knowledge, reasoning, or problem-solving processes in a domain. (Collins, et al., 1989, p. 482)

In this study, articulation has been regarded as more than just talking or having discussions with others; here it is thought of as verbalising:

- personal thoughts and opinions when thinking about design ideas;
- reasons for using particular heuristic design strategies;
- ways for using problem solving strategies based on personal experience of similar problem situations;
- explaining personal interpretations of design problem situations, the underlying reasons for using particular design strategies and possible solutions or decisions; and
- sketching to show personal ideas, design strategies and problems solving methods.

5. Reflection

Reflection is defined by Collins, et al., (1989, p. 482) as follows:

> ... enables students to compare their own problemsolving processes with those of an expert, another student and ultimately, an internal cognitive model of expertise. Reflection is enhanced by the use of various techniques for reproducing or "replaying" the performances of both expert and novice for comparison.

In this thesis, reflection means re-examination of ideas, concepts and design solutions at a metacognitive level when exploring the pathways taken in the development of building designs for the purpose of branching into other lines of exploration or to evaluate design solutions or elements for inclusion in final design presentations.

6. Exploration

Exploration is defined by Collins, et al., (1989, p. 483) as follows:

> Involves pushing students into a mode of problem solving on their own. Forcing them to do exploration is critical, if they are to learn how to frame questions or problems that are interesting and that they can solve. Exploration is the natural culmination of the fading of supports. It involves not only fading in problem solving but fading in problem setting as well.
> Exploration as a method of teaching sets general goals for students and then encourages them to focus on particular sub-goals of interest to them or even to revise the general goals as they come upon something more interesting to pursue.

In this thesis, the term "exploration" is also used to describe student and mentor activities in which design variations and multiple design solutions were developed using metacognitive design methods. It also applies to using sketching of design forms to determine relationships with other design elements or their suitability to include in final design solutions, as well as for discovering new aspects or elements of the design situation that affect the emerging design solutions.

Culture of practice.

In this thesis, the culture of practice refers to the physical and intellectual environment in which the expert building designers, acting as mentors, conduct their everyday practices in the context of the building design discipline.

Students studied here undertook authentic projects under the direction of expert building designers working in their usual design office culture. For this reason, the students were not simply undertaking tasks in a convenient setting, but were operating within an expert designer's culture of practice, with one-on-one mentor support to assist them in interpreting the tasks at hand in the context and culture of expert practice. Conducting this research study in authentic design office settings, with expert building designers acting as mentors, provided ways to investigate student learning in circumstances in which they were actively engaged in the "the practice of solving problems and carrying out tasks in a domain" (Collins, et al., 1989, p. 459). Brown et al., (1989, p. 40) argue that:

> People entering the culture (learning) need to observe how practitioners at various levels behave and talk to get a sense of how expertise is manifest in conversation and other activities.

By using authentic design office situations, the students studied here undertook their learning in a culture of practice based on the cognitive domain of expert building designers, implementing their usual ways of solving problems and carrying out tasks.

The "office set".

The "office set" is a bound volume of sketches, drawings, notes and other materials such as trade literature, photographs and the like that together represent the progressive development of a design project. It documents all of the design elements explored by having every sketch and drawing produced during the design process affixed in their order of production with notes and references linking concepts or possible solutions. The "office set" provides ways for reflecting on the progress of a design task and an audit trail of design variations explored during the creation and refining of emerging solutions. The tenn "office set" is a design industry recognised description of not just a body of drawings and the like, but also describes a manner of working used by most building designers to coordinate information and design concepts together in a single working tool. For this reason, the term "office set" has been adopted for use in this thesis when describing building design methods as applied in many different contexts regarded by me to be part of the design office culture of practice used for this research situation.

Work Session.

The most common design office activity referred to in this thesis is the "work session". The term "work session" is used here to describe interactive exchanges between students and mentors as they work collaboratively to resolve a real work design problem in the context of the everyday culture of practice for that design mentor.

Conclusion to this Chapter

This Chapter began with a brief description of the content of each of the Chapters. Following this the study background was presented along with a discussion of the study purpose and the research questions upon which it was constructed. After discussion of the study aims, the context in which data were collected was described, with some important terms used throughout this thesis also being defined.

In the next Chapter a review of the related literature and research pertinent to this study are presented.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This Chapter presents a review of the related literature and research pertinent to this study. It begins by discussing aspects of the context and culture of the learning situation regarded by Brown, Collins, Duguid (1989) as important to knowledge transfer. The role of concepts and knowledge as cognitive tools in the cognitive apprenticeship approach to learning suggested by Collins, et al., (1989) is also discussed with reference to the commercial design offices learning situations and authentic tasks undertaken by the study participants. Following this, several studies based on a cognitive apprenticeship approach to learning are presented along with findings pertinent to this research. The Chapter concludes with the theoretical framework underpinning this research.

Learning in context

Brown, Collins, Duguid (1989) contend that traditional teaching methods tend to promote the acquisition of *inert* knowledge not linked to the context of its application. They also suggest that such knowledge is not readily transferred or applied by students in other contexts and support instead a learning approach that embeds learning in activities that make deliberate use of the social and physical context in which the knowledge and skills apply. This they say supports the situated nature of knowledge (Brown, et. al, 1989). It is from this perspective that this study is structured and for these reasons that commercial design offices and expert building designers were used to construct the learning situation.

Knowledge as tools

In a situated learning environment many researchers (Cash, Behrmann, Stadt, Daniels, 1997; Brown, et al., 1989) contend that concepts and knowledge should be seen as cognitive tools for further learning. Brown et al. (1989) contended that students make best use of those tools when they are applied in a learning situation that replicates the ordinary practices of the culture through authentic activities realistically presented as in the culture of application. Student use of cognitive tools is regarded by Brown et al. (1989) to be within the context of a culture and leads to learning values and contextual features linked to the original purpose, rather than assimilating knowledge and skills in isolation as inert knowledge. Such a process, is described by Brown et al. (1989), as one of enculturation, where activity, context and culture are interdependent. The use of learning tools in this way is said to allow students to build an "increasingly rich understanding of the world in which they use the tools and of the tools themselves" (Brown, et al., 1989, p. 33).

Authentic activities in learning are those, that replicate the types of problems likely to be encountered in real life experiences. The use of authentic experiences in realistic learning situations supported by expert practitioners facilitates a cognitive apprenticeship styled learning approach.

Cognitive apprenticeship learning situations seek to involve students actively in the exploration and problem solving strategies of real life, authentic, situations in which they are required to develop solutions based on the needs of the problems faced (Jarvela, 1995; Brandt, Farmer & Buckmaster, 1993).

The learning culture

In this study, students worked with expert building designers as mentors in commercial building design offices that were for the mentors their usual culture of practice settings, which were adopted by the students. Having such a setting provided a working culture for cooperative interaction between mentor and student, using mutual problem solving activities based on authentic experiences. The collaborative nature of working in this way emulates the manner in which traditionally a master (expert) worked with an apprentice in a coaching, supportive fashion, providing tips of the trade or tacit knowledge through verbal articulation of thoughts in the development of solutions (Jarvela, 1995; Hennessy, 1993).

The expert Mentor - Modelling

In a cognitive apprenticeship learning situation students are supported in their learning by a model, or expert mentor, who coaches them in the application of problem solving strategies. The mentor also assists the students to overcome problems that present as barriers to their progress by providing timely scaffolding in the form of advice, hints, tips, learning materials and the like. In a study by Cash et al. (1997), involving automotive students working in a cognitive apprenticeship situation, findings reported indicated that working collaboratively with mentors and other students, led learners into a culture of practice in which they developed confidence and articulated their learning into individualised pursuits. In a different study, Brandt et al., (1993, p. 75) contended that mentor modelling of problem solving methods form powerful instructional tools that can be used in ways that allow: "knowledgeable proficient people to show learners how to do something by stating aloud what they are thinking while doing the activity". They also suggested that mentor guided learning in a cognitive apprenticeship situation is effective when authentic tasks are presented in a realistic context and the mentor models the "what how and why" of the methods used to resolve problems emergent from those authentic tasks (Brandt et al., 1993, p. 77).

Working in a mentor supported cognitive apprenticeship situation provides students with opportunities to acquire learning skills, using them as tools in other applications outside of the culture and context in which they were first experienced (Jarvela, 1995; Brandt et al., 1993; Hennessy, 1993). The task focussed, mentor supported real work projects used here are appropriate for use in a cognitive apprenticeship approach because they provided students with authentic learning experiences. They also provide ways for mentors to model methods, typical of their usual culture of practice activities, for resolving problems faced by students when developing solutions for design problems that emerged from the projects untaken by the study participants.

Social construction of knowledge

Brown, et al. (1989) contend that cognitive apprenticeship attempts to promote learning within the nexus of activity, tools and culture. Similarly, Vygotsky (1978) contended that learning takes place in situations through collaborative social interaction and the social construction of knowledge.

As a social activity, learning is seen to be very much a group centred activity. A cooperative society of learning drawers upon the knowledge, skills and collaborative value of people working together to achieve their goals (Brown, et al., 1989). The emphasis on social interaction (Schoenfeld, 1987) and a collaborative approach to learning is fundamental to the implementation of a cognitive apprenticeship learning approach.

Application of knowledge developed in isolation from its contextual meaning may result in students being unable to make the connections between knowledge and its use in other situations other than its learned example (Abbott, 1998; Berryman, 1991). This study placed the student in a learning situation where the context and culture of practice was part of the everyday working conditions of those surrounding them (Collins et al., 1989).

Metacognitive strategies

The development of cognitive and metacognitive strategies and processes is considered by Collins, et al. (1989, p. 455), to be more important than "low level sub-skills or factual knowledge". Brandt et al., (1993, p. 70) contended that the use of a cognitive apprenticeship approach "builds on existing knowledge and problem solving strategies, avoids reinventing the wheel, expands awareness, highlights otherwise overlooked aspects". They also contended that in a learning environment organised using cognitive apprenticeship methods, students learn to resolve problems emergent from authentic tasks and problematic situations by making use of tacit knowledge constructed from real world experiences. They also contend that students, having experienced conceptual models developed by mentors are able to apply such models as an advance organiser, or as an interpretive structure for making sense of hints during interactive coaching sessions and to act as an internalised guide for successive approximation and reflection. Using reflection, students compare their own performance against that of a mentor and apply standards modelled by mentors in the development of their own metacognitive practices (Berryman, 1991; Collins, et al., 1989).

Reflection and multiple points of view

Collins, et al. (1989) regard student use of reflective practices provides them with ways to compare their own performance with that of the expert mentors guiding them. When, as in the case of this study, several mentors are available to the student, then multiple points of view can be explored as reported by Jarvela, (1995) leading to other possible problem solving strategies, enhanced performance, outcomes or solutions (Hennessy, 1993).

As students develop their expertise they can take over the teachers role during sessions of collaborative problem solving. In so doing, they participate in a culture of expert practice both as a recipient, and as a practitioner, having meaningful benchmarks and incentives as modelled by their mentors (Hennessy, 1993; Collins et al., 1989).

In a cognitive apprenticeship learning approach, the teacher or mentor attempts to articulate as completely as possible the abstract principles underlying the application of knowledge and skills into diverse situations or contexts. In so doing students may successfully transfer knowledge, skills and principles across discipline or task boundaries. The building design profession demands of its exponents, highly developed communication skills centred on verbal and visual articulation of abstract concepts and the visualisation of three dimensional forms involving diverse situations and problematic forms. Mentor articulation and the transfer of their tacit knowledge, heuristic design strategies and problem-solving procedures is fundamental to student learning in this context.

In support of their argument for cognitive apprenticeship, Collins et al. (1989) examined three teaching models using the principles of cognitive apprenticeship. They are, Reciprocal Teaching, Procedural Facilitation and Authentic Learning Experiences.

Reciprocal teaching

The discussion of the Reciprocal Teaching-in-Learning model proposed by Collins, et al. (1989) is based on studies by Palinscar & Brown (1984) which centre on modelling and coaching students in four strategic skills and make use of role reversal where students and teachers take turns at being the teacher.

Initially the teacher provides scaffolding to assist and encourage the student to achieve the learning goals. As the students develop their knowledge and skills, the scaffolding is slowly withdrawn or faded, leaving the student to extend their knowledge and develop their own resources from the base they have been assisted to build. Critical to the success of such activities is the modelling by the teacher of "expert strategies in a problem context shared directly and immediately with the students" (Collins, et al., 1989, p. 463).

Procedural Facilitation

The second learning approach considered by Brown et al. (1989) in the development of their cognitive apprenticeship learning model, was Procedural Facilitation (Scardamalia, & Bereiter, 1985; Scardamalia, Bereiter, & Steinbach, 1984). This approach provides explicit procedural supports in the form of prompts to assist students in developing expert writing strategies. Once again what is sought here is a leading and supportive role by the teacher or mentor. Their role is to provide expert, explicit modelling (Hennessy, 1993) of the problem solving strategies needed for the given tasks and to assist the development of metacognitive skills through scaffiolding that provides the tools to elevate student performance (Dinmore, 1997). Building design, with its creative/artistic elements requires high level thinking and problem solving and with its technical elements demands precise use of information and procedures that can be defined through scaffiolding and modelling.

Authentic learning experiences

The third learning approach considered by Collins et al. (1989) was that of Schoenfeld (1987) who conducted a study of small group problem solving sessions in a cognitive apprenticeship learning environment with authentic learning experiences. Schoenfield (1987) sought to identify what the students were doing, why were they doing it, and how would success in what they are doing help them find a solution to the problem (Collins, et al., 1989).

The aim was for students to reflect upon their activities and thus self-monitor their progress towards solutions and diagnose their skills by articulating the reasons for decisions taken in the same fashion that experts express aloud their thoughts during modelling sessions in problem solving in the learning environment. Collins, et al., (1989) contended when working in this way students develop control over reflective and metacognitive processes in their problem solving.

Expert practice in the learning environment

Collins et al. (1989) developed a four part learning framework based on content, method, sequence and sociology. Of particular interest to Collins et al. (1989, p. 477) was strategic knowledge, being part of the tacit knowledge that underlies an expert's ability to "make use of concepts facts and procedures as necessary to solve problems and to carry out tasks". Collins et al. (1989) also contended that strategic knowledge involves problem solving strategies and heuristics. Choi, & Hannafin, (1996) contended that experts in various disciplines or fields of study use such knowledge as a vehicle for learning how to learn and to acquire new knowledge. This is recognised as a foundation stone in the learning framework used adopted for the researcy (Abbott, 1998; Collins, et al., 1989).

In seeking to differentiate between factual and procedural knowledge, Collins et al. (1989, p. 477) used the term strategic knowledge to refier to tacit knowledge that "underlies an expert's ability to make use of concepts, facts and procedures as necessary to solve problems and carry out tasks". Findings reported by Choi & Hannafin, (1996) and by Jarvela, (1995) suggest that by grounding the learning in authentic tasks, conceptual, factual and procedural knowledge was less likely to become inert, and thus applied inappropriately by students in situations removed from the contextual domain of learning

The study situation used for this research is in keeping with the cognitive apprenticeship learning environment suggested by Abbott, (1998, p. 18) who contends that "The process of learning has passed from simple self-organisation to a collaborative, social, problem solving activity much dependent on talk, practical involvement and experimentation". A collaborative learning environment is considered by Abbott (1998) to be one in which people work together in solving problems using a team approach in sharing knowledge and skills to achieve commonly supported goals. Mezirow (1996, p. 119) similarly supports the view that learning takes place in collaborative learning environments in which students' need to become "critically reflective and to participate in critical discourse. From this perspective, Mezirow (1996, p. 119) contends that "learning is a process of using a prior interpretation of the meaning of one's experience to guide future action". This approach to learning also involves the use of reflection, a process in which the learner reviews their own performance in problem solving and then compares this to the performance of the mentor, with a view to making modifications to enhance future actions (Dinmore, 1997).

A Cognitive Apprenticeship learning approach

In proposing their cognitive apprenticeship learning approach, Collins et al. (1989, pp. 481- 483) listed the following teaching strategies: modelling, coaching, scaffolding, articulation, reflection and exploration. Many other theorists have explored this structure and added their own interpretations and sub categories (Duncan & Rohorer, 1996; Choi, & Hannafin, 1996; Jarvela, 1995; Carver, 1995; Hennessy, 1993; Berryman, 1991; Brown, et al., 1989).

Implementing such a learning approach can effectively take place by developing a learning sequence for tasks and context environments, progressively increasing in complexity to promote higher learning (Lave, 1988, 1990). This may begin with a conceptual map or cognitive model of the overall task or situation which may provide students with a more diverse range of tools for problem solving than if they learn only task specific skills (Mumford, 1993; The cognition and technology group at Vanderbilt, 1990; Collins et al., 1989). In this study, group discussions outlining the project learning sequences were used as an advance organiser for students, their mentor and TAFE staff managing the project.

Culture of expert practice: Mentor/Student Collaboration

Having mentor/student collaborative activities situated in a culture of expert practice provides opportunities for students to develop a sense of ownership of the learning and become intrinsically motivated to continue, far more so than in a traditional classroom using didactic methods (Collins, et al., 1989). Collaboration between all parties to the learning is thought to "foster the situated articulation of processes and concepts" (Collins, et al., 1989, p. 490). Such collaborations are thought to help students to develop cognitive and metacognitive processes over which they have control and make conscious use of in problem solving in other contexts or domains.

Learning in context

The importance of learning in context and the value of authentic learning environments to the acquisition of tacit knowledge, that is knowledge and skills developed through life experiences and professional practice, was noted by Duncan (1996). In a study focused on mathematics, language and problem solving, Duncan (1996) found that students benefited from a cognitive apprenticeship classroom culture and improved their understanding and work on application type problems.

Instructors who used modelling found "increased student attention and enthusiasm during modelling based lessons" (Duncan, 1996, p. 76). It was also noted that students quickly recovered from errors in this style of learning and were able to transfer knowledge well.

Simulations and authentic activities in the learning situation

Computer technology has become an important learning tool. Jarvela, (1995) explored the use of a cognitive apprenticeship approach with students who investigated and modelled the control technology principles of an automatic washing machine using LegoLogo (Papert, 1980). Data were analysed in terms of scaffolding, modelling and reflection, using video recordings of four pairs of students working for nine hours. In her findings, Jarvela, (1995, p. 243) contended that "situation-specific modelling" has the potential to promote spontaneous, more advanced exploratory activities among students. The use of simulated learning experiences in this way provides interactive task focused activities that replicate authentic real world tasks, problems and scenarios students are likely to face in the workplace. This approach can permit students to test a variety of effective problem solving methods in a variety of situations designed to enhance learning (Brandt et al., 1993). Communication between students and expert mentors is now theoretically possible from any place on the globe with computer access and this opens the way for social interaction between individual or large numbers of people who may learn from each other in a vast multi-cultural setting.

This study used authentic design office situations, with authentic projects to create realistic experiences for the students. Dewey (1938) spoke of learning through experience, while Knowles (1980) saw meaningful learning as associated with everyday problems in the social world, as did Vygotsky (1978) and Schön (1983). Rogoff & Gardner (1984) contend that thinking is intricately inter-woven with the context of the problem to be solved and explored a learning paradigm based on the cognitive practices of humans, located in authentic activity. Resnick, (1987) suggested that authentic activity has to involve situations where the actual cognitive processes are required rather that simulated, as sometimes done in schools. The use of thinking aloud by experts when articulating their tips and tricks as they work through situated tasks with students is a concept well supported in the literature about situated cognition and cognitive apprenticeship learning.

Work by researchers in the cognitive apprenticeship field has often been focussed on the organisation and manipulation of the learning environment (Lave & Wegner, 1991; Rogoff 1984). Brown et al. (1989) regarded learning and development to be a dynamic process that results from the active participation of individuals in culturally organised activities. Jarvela, (1995) contends that the learning environment should provide opportunities for social interaction for exchanging of ideas and knowledge in ways that support reciprocal understanding between the students and the mentors. Collaborative interaction between the mentors and the students assists individual students to negotiate meaning in their learning experiences and to develop a frame of reference for working with the mentors with enhanced reciprocity in their interaction (Voight, 1987; Nystrand, 1986).

Situated Learning

Lave (1990) argues that learning is a function of the context of an activity and culture in which it occurs and can thus be seen as situated. This follows on from an earlier social learning theory proposed by Bandura (1977) who suggested a form of learning which integrates behaviourist ideas about reinforcement with cognitive processes of understanding the behaviour of others and identifying with it. This theory has the key elements of experience and expectations. From experience we learn the consequences of our responses and expectations derive from the anticipated consequences of our responses. From this, there derives a major role for reflection in learning, a characteristic seen in later learning approaches using situated learning and cognitive apprenticeship.

Situating learning is considered to take place when using authentic activities that develop understanding through social interaction and collaboration, in the culture of authentic domain activity with modelling, scaffolding and reflection. Its practice is based on observation, guided and supported practice and on feedback for the development of cognitive and metacognitive skills (Collins et al., 1989).

In a study by Jarvelu (1995), these principles were used in the evaluation of student/teacher interaction in a technologically rich learning environment. In that study it was shown that in scaffolding sessions some students interacted well with the teacher and in so doing, received reciprocal and self directed social interaction. Some students saw the teacher as interrupting their work just as they were getting to a solution, thus taking a more individual heuristic approach (Jarvela, 1995).

One possible downfall of this type of learning according to Jarvela (1995) occurs when learners become overly dependent on the mentor for scaffolding in the tasks at hand and does not then take responsibility for their own learning. It is fundamental to the success of the student becoming self supporting in the learning that scaffolding support is gradually faded out by the expert or mentor as the student develops skills and confidence.

Using authentic situations to develop Cognitive Understanding

The application of a cognitive apprenticeship approach to this study situation has some similarities to a study by Casey (1996) who used multimedia technology in the construction of authentic learning tasks. In his study, Casey (1996) sought to incorporate a framework for analysing and sequencing content and to develop appropriate strategies for learning in a distributed and diverse environment. Using a cognitive apprenticeship approach to training weather forecasters, Casey (1996) sought to provide a mechanism for incorporating communities of practice in multimedia solutions that would provide a method for building and reinforcing cognitive understanding. In formulating his multimedia approach, Casey (1996, p. 76) reported "Cognitive flexibility develops transfer of skills by incorporating a multi-perspective approach to expertise that enables the learner to traverse or criss-cross the knowledge in numerous ways. This viewpoint is of special importance here because the traditional role of the building designer has changed with the introduction of computer technology to encompass a range of professional disciplines that formerly were the domain of separate but related professional practitioners.

Casey (1996) placed special emphasis on auditory coaching from experts, making it more thorough by addressing complex issues surrounding the case presented in the learning. Through articulation, students were encouraged to demonstrate their mastery of new tools and knowledge and to participate in open discussion forums with colleagues. By grounding the learning in an authentic environment or real world situation, students may better understand why and what they are learning and learn through doing more than through listening. In so doing students explore what strategies work for given situations and what strategies do not work in a real world context. The aim is to learn to problem solve in multiple contexts (Casey, 1996).

Working with a mentor provides learners with the opportunity to observe their problem solving strategies and application of expert knowledge and experience. Hearing an expert articulate thoughts as they problem-solve or demonstrate work practices and procedures is regarded by many researchers to assist in setting standards of practice. It also allows students to test their expertise against others in a forum where mentor support is gradually withdrawn as student skills improve. Modelling and coaching work well with multimedia but are most effective when used in co-operative learning environments or communities of practice in which there is interaction between all parties to the learning. These teaching strategies also require well developed verbal communication exchanges throughout the learning processes (Casey, 1996; Collins, et al., 1989).

Other studies using Cognitive Apprenticeship methods

Cash et al., (1997) studied the effectiveness of cognitive apprenticeship instructional methods in college automotive technology classrooms. They used traditional classroom teaching methods with one group of students and a cognitive apprenticeship approach with a different group learning automotive technology. The cognitive apprenticeship group had an emphasis on modelling, coaching, fading and verbalisation of thoughts by expert mentors.

In reflective debriefing sessions, students were encouraged to use problem solving to assist in the development of their diagnostic skills, with the instructor fading support as their skills emerged. This particular hand-skills/cognitive skill study makes an interesting comparison with the multimedia format Casey (1996) study because the same fundamental learning model is applied through very different learning contexts.

Findings from the Cash et al. (1997) study indicate that the cognitive apprenticeship model proved to be more effective than traditional methods of instruction in the development and acquisition of information, knowledge of troubleshooting procedures. It also proved to be an effective method for students to learn to apply diagnostic skills in the context of teaching air-conditioning in automobiles. Although the long-term effects of this were considered to be inconclusive, the writers saw the emphasis on instructional constructivist practices of significant value in a cognitive apprenticeship model. In particular, the sequencing aspect of cognitive apprenticeship in conjunction with the use of a starting approach that uses a broad understanding of systems as a base for exploring and learning was seen as preferable to the traditional approach centred on factual knowledge of components theory.

Tacit knowledge and Reflection in Cognitive Apprenticeship learning

Explicit knowledge and problem solving methods developed through practical experience form the basis of expert practitioners' tacit knowledge of their domain of professional practice (Collins, et al., 1989). The use of modelling, articulation and reflective practices by mentors in this study, to reify for students their tacit knowledge, is discussed later with reference to findings from studies by other researchers as presented in this section. Mentor and student use of reflective practices (Abbott, 1998; Mezirow, 1996) to make visible tacit knowledge was also studied. This use of this approach was based on the ideas of Schön (1983), who explored the concept of the reflective practitioner. An important aspect of a cognitive apprenticeship approach to learning, is the key feature of reflection by students and teachers in the learning process. Schön (1983) supports the notion of reflection in action, which is viewed as the exercise of interactive, interpretative skills, in the analysis and solution of complex and ambiguous problems (Calderhead, 1989). The reflective processes of an individual may be considered as an internal evaluative dialogue and self focussed (Butler, 1992), or external and used as a research form in evaluating how learning may take place (Schratz, 1992). In a cognitive apprenticeship approach to learning, all of the participants in the learning situation should employ reflective practices to understand and evaluate their learning events, then apply what they may learn from it to their future actions. This may be considered as a form of knowledge that Schön (1983, p. 54) described as "knowing in action" which is "the characteristic mode of ordinary knowledge". Schön (1983) also contended that this is tacit knowledge, in the sense that we are usually unable to describe the knowing that our action reveals. He also suggested that reflective practices in learning are only stimulated by certain puzzling situations. In a cognitive apprenticeship learning situation, it may become the role of the expert mentor or teacher to stimulate the learner to reflect upon events and processes that affect their learning and promote its application in developing their tacit knowledge.

In a study of the use of reflection-in-action by adult educators, Ferry & Ross-Gordon (1998, p. 98) found that "reflecting educators whether novice or experienced, use reflecting-in-action, or reflecting-on-action as a means to develop expertise". They also noted that reflecting practitioners use a constructivist decision making perspective, an approach supporting Schön's (1983) theory.

The manner in which students acquired explicit or factual information about how experts tackle problem that emerge from design situations and why they used particular methods for different situations, was closely studied as part of this research.

Self-directedness

Where Abbott (1998) takes the view that learners need to become self starters who can problem solve in cooperative, collaborative, diverse situations, Mezirow (1996) looks to learning strategies that explore intentions, purposes, feelings, values and moral decisions. It is ability to think for oneself and to negotiate one's own purposes, values and meanings that he sees as communicative competence and a possible definition of self-directedness in learning. The learning tasks created for this research were based on work centred purposeful authentic projects that required decision making involving peoples lifestyles and therefore involved purposes feelings and values, as suggested by Mezirow (1996). In this regard, the students were considered to be self-directed.

Summary

Throughout the literature there appears to be a widely held view that it is important to bridge the learning activities of the classroom, with the expectations that the application of that learning may bring in the work environment for which the students are training. Linking the practical aspects of problem solving in real life situations presented as learning experiences, directed and supported by a teacher or mentor is the cornerstone of the cognitive apprenticeship (Brown, et al., 1989) approach to learning. The cognitive apprenticeship approach seeks to embed the learning in activities that make deliberate use of the social and physical context in which the knowledge and skills apply. It is suggested that concepts and knowledge be seen as tools for further learning (Brown et al., 1989) and that they are best applied in a learning situation that replicates the ordinary practices of the culture through authentic activities realistically presented in the culture of application.

Cognitive Apprenticeship in this study situation

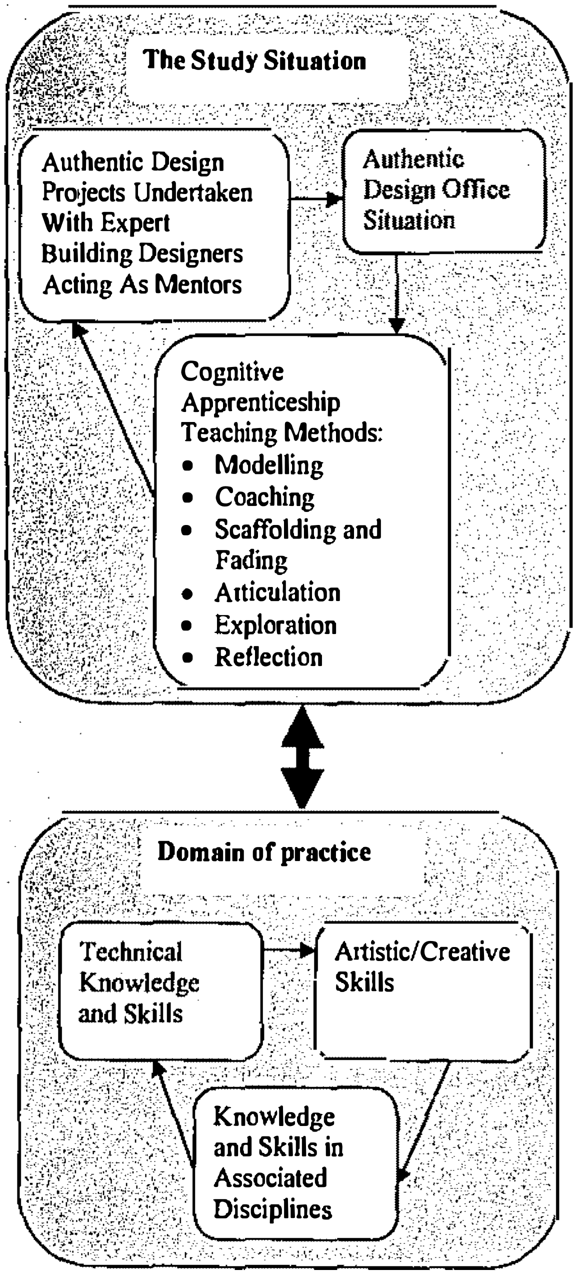
The students in this study undertook authentic design projects in commercial design office situations alongside other staff operating in a range of disciplines necessary for the successful practice of building design. The study situation and mentor supported authentic projects undertaken are in keeping with the principles of cognitive apprenticeship as explored throughout this chapter. The study situation from the beginning incorporated all of the vital elements of a cognitive apprenticeship styled approach to learning and included:

- use of real life authentic learning tasks situated in the culture and the context of their usual application;
- mentor use of modelling, coaching, scaffolding, articulation, exploration and reflection to assist students to acquire knowledge and skills necessary to successfully resolve building design problems in the context and domain of professional culture of practice activities;
- support of mentors, expert in building design, who articulate their problem solving strategies as they are implemented in the development of a building design solution for an authentic project;
- modelling of heuristic strategies, design strategies and presentation (drawing) techniques by mentors, to affect transfer of procedural, declarative and tacit knowledge developed by the mentors over years of experience;
- articulation of problem solving approaches and metacognitive learning strategies used by experts when developing solutions to complex problems in the building design domain of practice, including multiple other disciplines required for resolving authentic design tasks; and
- collaboration with other experts, in the design office setting, who provide multiple perspectives, design ideas and heuristic design strategies that assist student learning.

The Theoretical Framework

Figure 1 (p. 30) shows diagrammatically the theoretical framework used by me to investigate student learning in a design office situation organised around authentic projects under the direction of mentors using cognitive apprenticeship teaching methods.

Figure 1. Theoretical Framework For This Study



In order to investigate how knowledge and skills are acquired by building design students when working under the direction of a mentor in a cognitive apprenticeship learning situation, it is important to first understand the nature of the building design discipline. There are three aspects of building design practice that each present different demands for student learning. These are shown in Figure 1 as three boxes that together represent the domain of practice.

The first aspect of the domain of practice in building design requires students to develop technical knowledge and skills necessary for resolving and documenting design solutions at a procedural level, a role position regarded in the design industry as technician or drafting assistant (Baird, 1996). The second aspect of building design practice requires students to acquire knowledge and skills in using creative, innovative practices to develop new design concepts. The development of creative design skills is regarded by some researchers to occur only when designers can visualise and refine ideas in metacognitive ways and to then be able to communicate these by using verbal articulation of personal thoughts supported by graphical images to convey complex three dimensional forms.

The third aspect of the building design domain of practice involves the development of knowledge and skills necessary for incorporating associated discipline elements into design solutions. Building designers must integrate information and structural content from other disciplines such as engineering, electrical, hydraulics and many others into every design. Student learning in the broad practice of the building design domain must include elements from these associated other disciplines in order to replicate authentic practices.

The theoretical framework developed for this study links each of these three elements of the building design domain of practice to an authentic situation (see Figure 1, p. 30). The three elements shown in "The Study Situation" box of Figure 1 are designed to represent the usual practices of expert building designers in an authentic learning situation based on a cognitive apprenticeship (Collins, et al., 1989) approach to learning, using authentic tasks with discipline experts acting as mentors.

In order to study how knowledge transfer takes place and how students acquire skills needed to resolve complex problems in the manner used by experts, the study situation and the tasks undertaken must replicate the mentors' usual culture of practice activities and be implemented in the context of their everyday practice.

This study was conducted in commercial design office settings, with expert building designers as mentors and students undertaking authentic building design projects. These conditions are based on what the literature reviewed for this study suggest is appropriate authentic conditions in which to apply methods that situate learning in the context of real experience. The cognitive apprenticeship approach to learning that underpins this study has six teaching strategies that can be readily applied in the study situation used here. They are, *Modelling, Coaching, Scaffolding* (and *Fading*), *Articulation, Exploration* and *Reflection*. Throughout this study, the manner in which each of these was used to assist student learning was closely studied, along with many other aspects of mentor practice and situational factors that emerged. Findings about all aspects of student learning that emerged from analysis of the study data are presented later in Chapter Six of this thesis.

The theoretical framework shown in Figure 1 (p. 30) was developed to address each of the factors regarded by me to constitute the building design domain of practice and the elements of a cognitive apprenticeship approach to learning.

Conclusion to this Chapter

This chapter had three parts. The first part presented a review of the related literature and research pertinent to the study. The literature review began with an overview of many different aspects of a cognitive apprenticeship approach to learning including such things as learning in context, social construction of knowledge, reflective learning practices and authentic experiences. Some aspects of the role of tacit knowledge used by experts in the learning environment were also explored.

In the second part of this Chapter, some specific research studies in which cognitive apprenticeship teaching strategies are explored, were discussed with reference to the learning situation studied in this research. In the final part of this Chapter, the theoretical framework upon which this study is based was presented diagrammatically in Figure 1, along with a brief discussion of how each of the elements in that framework were used in conducting this research.

CHAPTER THREE

METHODOLOGY

Introduction

This Chapter begins with an overview of the research methodology. The methods used to ensure rigour in all three phases of data collection are then described. This is followed by a discussion of issues to do with entry to the field of research and the study sample. In the latter half of this Chapter, issues of trustworthiness are addressed with reference to the data collection and analysis methods used. More detailed information about the data collection methods and data analysis methods used here is provided in Chapter Four and Chapter Five of this thesis.

This Chapter concludes by addressing aspects of situational uniqueness in this study.

Methodology

This is essentially an interpretivistic study based on qualitative data that sought to provide "detailed, thick description; direct quotations capturing people's personal perspectives and experiences" (Patton, 1990, p. 40). The study used a naturalistic inquiry approach structured to have design flexibility in that it was:

> Open to adapting the inquiry as understanding deepens and/or situations change; avoids getting locked into rigid designs that eliminate responsiveness; pursues new paths of discovery as they emerge. (Patton, 1990, p. 41)

An interpretivistic approach has been chosen because it permits great flexibility in following new pathways revealed in the data as it presents through fieldwork inquiry (Patton, 1990). Patton (1990) also contends that using this approach allows the researcher to work close to the subjects and to explore in depth and detail the study situation, while remaining open and flexible when interpreting the study phenomena.

This study was conducted in three phases, with emergent findings from the first two phases being used to develop and refine subsequent phases. This approach also allowed reflection on early findings when new data and findings led to different aspects of student learning emerging through analysis. Reflection on earlier findings and retracing of themes during analysis helped to add rigour to the study methods and provided ways for exploring in greater detail aspects of student learning thus revealed. Methods used to gather data in this research are listed below as part of the description of the three phases of this study. Each of these is discussed in detail in the next Chapter of this thesis.

Development of the study structure was undertaken in ways to ensure the reliability and validity of the research through an analytically rigorous, replicable, systematic approach with cross checking of data to entertain rival alternative explanations for encountered phenomenon (Eisenhardt, 1989). These aspects are explored in a later section of this Chapter dealing with the trustworthiness of this study.

I have sought to ensure that data were systematically recorded and studied, by having multiple data collection and analysis methods. Information collected included interview data, observational data about student/mentor interactive experiences, impressions and statements emergent from informal discussions with the study participants, student diary journals, sketches and drawings. Using these methods made it possible to study in detail the real world situations encountered by students undertaking authentic tasks in commercial design office practices. Data gathering sought to be conducted in a "non-manipulative, non-controlling way with openness to whatever emerged and having no predetermined constraints on outcomes" (Patton, 1990, p. 40).

Planning and preparation for this study

Prior to each phase of data collection, individual interviews were conducted with the study participants to ensure that:

- each was a willing participant;
- each would accept my presence as an observer during work sessions;
- each was fully informed of the ethical provisions I had made, particularly to ensure the anonymity of the their participation; and
- I obtained written approval from each of the participants to use data collected during this study for writing of this thesis and any subsequent publications.

During discussions with each of the study participants, I made brief notes about any aspects of the study that they identified as of special importance, or of concern, to them. Information obtained in this manner was recorded in my personal journal as part of the study audit trail and was used to formulate and refine the study structure.

Also, during such discussions, I sought the students' cooperation in keeping a personal journal of their design office experiences, thoughts and observations throughout their design project. Their written approval for my use of these journals as part of the overall data collected for this study was obtained at that time.

The study structure

This research study had the following three phases of data collection:

Phase One – Pilot study;

Phase Two – Data gathering using mostly interviews; and

Phase Three – Data gathering using mostly direct observation of work sessions.

Data were collected over a 14-month period. During this time, three different groups of students were studied as they worked with expert building designers (mentors) on three different authentic building design projects that formed the core of the three phases of this research study. Two of the mentors, who had participated in the pilot study project, also participated in the project undertaken for (main data collection) in Phase Two. All five mentors, who participated in the project used for Phase Three of the main data collection, had participated earlier in Phase Two of the main data gathering. This facilitated comparison of data concerning similar events, from two main phases of data collection, each using different methods of data collection.

In all three phases of this research I was the principal instrument of data collection (Patton, 1990) and as such became engaged with the study situation and participants as a participant observer and inquiry agent. As each new data were collected, I transcribed and coded them using an index tree structure developed with the aid of NUD•IST (Non-numerical Unstructured Data Indexing Searching & Theorising) (1998) software. The index tree structure was progressively refined as new data were collected and analysed, with emergent findings being used to create additional coding categories in response to developing themes (Richards & Richards, 1995). This aspect of data collection and analysis is discussed in detail in Chapter Four and Chapter Five of this thesis.

Phase One – The Pilot Study

Phase One of this study was a pilot study designed to trial the suitability of the study situation, authentic projects and data collection methods. It was planned to determine the broad picture of student learning experiences when working with a mentor on an authentic project and to confirm that cognitive apprenticeship principles did indeed apply.

Planning of Phase One began with informal discussions with three TAFE building design lecturers and two of the five mentors who worked with the 22 students who participated in this phase. All those involved in these discussions had previous experience of working with students on authentic projects and in design office situations. Having this background experience enabled the discussion group to comment from an informed position on:

- the kinds of projects that were suited to student/mentor collaborative learning;
- the time frame needed for applying typical design office procedures to a simple project while allowing time for the students to acquire the necessary knowledge and processes typically used in the mentors' everyday culture of practice activities; and
- appropriate ways for collecting information from the participants and timing of that collection to get the most informative data, with the least disruption to the mentors' office practices and the students' work/study schedules.

Findings from Phase One were used to refine the proposed main data gathering parts of this study "with respect to both the content of the data and the procedures to be followed" (Yin, 1994, p. 74).

Phase One of this study examined the learning experiences of a group of 22 students working under the direction of five mentors, on the design and presentation of an authentic project in a real workplace situation.

Data were collected using the following methods:

- interviews;
- observation of classroom briefing/discussion sessions;
- student diary journals;
- design presentation drawings; and
- personal journal notes of student design critique and assessment sessions.

At the completion of Phase One, data collected using these methods, along with my own journal which sought to take a holistic view of the project phenomenon (Patton, 1990), were then analysed. Findings, emergent from analysis of Phase One data were used to develop the main study structure and to formulate inquiry methods and interview guide questions used for data collection during Phase Two and Phase Three of this research.

Phase Two – Data collection using mostly interviews

The main data gathering method used in Phase Two of this study was face-to-face interviews. Interviews were conducted with 10 students and 11 mentors who worked in 10 different professional design offices. Other data were also collected during Phase Two using the following methods:

- discussions with TAFE lecturers;
- observation of classroom briefing sessions;
- observation of classroom design planning sessions;
- sketches and drawings;
- informal discussions with students; and
- telephone conversations.

Each of these data collection methods is discussed in detail in Chapter 4 of this thesis.

Phase Three – Data collection using mostly observations

Phase Three of this study was conducted in order to further investigate and confirm Phase One and Phase Two findings, as well as to explore other aspects of student learning by direct observation of student/mentor collaborative work sessions.

The main data collection method used in Phase Three of this study was observation of student/mentor collaborative work sessions in the design offices of each of the mentors. Each of these work sessions was also video recorded for later analysis. Although most of the Phase Three data were collected using video recordings, other data regarded by me to provide important insights into the overall learning situation, were also collected during this phase of the study using the following methods.

- interviews;
- informal discussions;
- telephone discussions;
- sketches and drawings; and
- student diary journals.

Each of these data collection methods is discussed in detail in Chapter Four of this thesis.

Table 1
Data Collection Phases and Participant Numbers

Participant	Phase One	Phase Two	Phase Three
Students	22 (7 of whom also participated in Phase Two)	10	4
Mentors	5 (all go on to participate in Phase Two)	11 (5 of whom also participated in Phase Three)	5
Lecturers	3	3	3
Data collected	interviews; observation of classroom briefing/discussion sessions; student diary journals; design presentation drawings; and personal journal notes of student design critique and assessment sessions	discussions with TAFE lecturers; observation of classroom briefing sessions; observation of classroom design planning sessions; sketches and drawings; informal discussions with students; and telephone conversations.	video recording of observed design office work sessions; interviews; informal discussions; telephone discussions; sketches and drawings; and student diary journals.
Situation for students	Study at a country camp location with work undertaken in multiple design offices and workshops	Ten different commercial design office situations with each student one-on-one with a mentor or multiple mentors	Four different commercial design office situations with each student one-on-one with a mentor or multiple mentors

Entry into the field of this study

Patton (1990), when discussing research methods involving fieldwork, suggested two necessary parts for entry into the field for research. The first, negotiation with the intended participants of the research assists the researcher in determining appropriate behaviours and activities of the researcher in the field setting. This may ensure that the presence of the researcher minimises a negative influence on the course of events for participants. From my work as a TAFE lecturer and professional designer, I was well known to the participants. My presence in the various design office settings took take place following negotiations with each of the study participants and with their written approval having first been secured prior to conducting any data collection procedures.

The second aspect of fieldwork noted by Patton (1990, p. 251) is that of the "actual physical entry to the field setting to collect data". I undertaking this research I had many roles involving data collection including informal and semi-structured interviews with participants, telephone conversations and observation of student/mentor collaborative work sessions. My experience as a building designer, TAFE building design lecturer, CAD trainer and university lecturer ensured my appropriateness as the instrument of data gathering in the building design domain of practice used for this research.

The Researcher in this study

I have thirty years experience working as a building designer including 23 as a lecturer in building design in training colleges and with industry based training providers. I have considerable depth of experience in the building design industry and an awareness of the content and delivery methods employed in building design courses available in Australia. In two earlier research studies (Baird, 1997, 1996) I examined other aspects of the building design industry linked to training for building design students. Findings from these have been well received by the building design profession, including those building designers who participated here as mentors, and this assisted me in making entry to the field of this research study.

Throughout this study, I remained conscious of any bias that my experience in the building design profession might bring to data collection and analysis and addressed any skewing effect that this may have had by using replicable structured methods for collecting, recording and analysing data. During analysis of the study data, I discussed preliminary emergent findings in member check interviews with other building designers, building design trainers and students in order to confirm my interpretation of the study phenomena.

Investigator predilections

In recognition of the possibility that my closeness to the study participants might have skewed my perception of events in recording data, I have taken great care in the design of questions used in interview guides used when conducting interviews and observations to avoid bias my findings. A key characteristic of qualitative research is the involvement of the researcher in the study (Patton, 1990), working close to the events and often participating in the study experiences alongside the other players. I took a reflexive approach by documenting an audit trail to ensure where possible the confirmability of data, free from investigator bias (Guba, 1981).

The study sample

Data in this research study were collected in total from 29 students, 19 expert building designers (acting as mentors) and three TAFE staff, all of who volunteered to participate in the design projects and all three phases of this research study. The students were volunteers from four class groups completing their final-year Diploma in Building Design TAFE courses. All of the mentors were practicing commercial building designers who volunteered their services. A team of three TAFE lecturers collaborated with five (of the 19) building designers (mentors) in the development and execution of the authentic design projects used in this research study. All three TAFE lecturers also contributed data and participated in member check interviews involving preliminary findings, as the study progressed and following the final data analysis.

At the commencement of the research study, each of the study participants was assigned a numbered pseudonym so as to ensure anonymity and confidentiality of data collected. In this thesis, students are identified by Student #, mentors as Mentor# and TAFE lecturing staff are shown as Lecturer#, where "#" represents the participant's assigned pseudonym number. Numbers were assigned to each participant at the time of interview. A single numerical sequence has been used for the overall group of participants, but with status being defined by the title of "Student", "Mentor", or "Lecturer". Where quotations from interview data have included various persons' names, these have been replaced with other pseudonyms.

Of the 22 students who participated in the Phase One (the pilot study) of this research study, nine went on to participate in Phase Two of the study, each working one-on-one with a mentor. All five mentors, who participated in Phase Three of this study had participated earlier in Phase Two also. By collecting data from some students and mentors who participated in both Phase Two and Phase Three of the study, it was possible to obtain information using different collection methods, about learning events in those two Phases, as viewed by the same participants with their individual perspectives. This added to the trustworthiness of data collected.

In Phase Three of this study, I observed 12 work sessions in which collaborative interactions of five mentors in four different design offices who worked with four students, were closely studied. Each of these work sessions was video-recorded for later analysis.

Mentor selection for Phase Three was based on preliminary findings from Phase Two, that suggested their work practices and mentoring methods were representative of the overall group of mentors and was most likely to be able to confirm or deny emerging findings.

Data for this research study were collected over a 14-month period, encompassing three TAFE semesters.

The Mentors in this study

All nineteen of the mentors who participated in this study were practicing expert building designers. They each participated in this research on a voluntary basis. Many of the mentors had at some time been students in the building design courses being undertaken by the students in this study. Many had also worked as part time teaching staff in those same building design courses and had personal experience of the teaching approaches currently used in TAFE. Having had first hand experience of the TAFE building design courses provided the mentors with opportunities to develop awareness of the sorts of learning situations and the type of training that the students were accustomed to at TAFE.

Prior to the commencement of the student/mentor collaborative work sessions used for data collection, the mentors were briefed by the TAFE lecturers who coordinated the building design projects used in this study to ensure a uniform approach to dealing with the students and the design brief. I also interviewed each of the mentors at the start of the study to confirm broadly that they did indeed use a cognitive apprenticeship approach when working with the students in the design office situation.

The building design profession has two main discipline aspects in its domain of practice. The first, an artistic discipline, demands of the designer creative, innovative interpretation of client needs. The second disciplinary aspect involves the implementation of technical knowledge and procedures for developing construction solutions. Different building designers working from the same brief will almost certainly develop individualised designs, using design processes developed to suit their philosophy or preferences. For these reasons, it was anticipated that the expert building designers, who worked as mentors, would operate differently with each of the students. It was also thought likely that the designs produced by each student/mentor collaboration would present individualised building design solutions. The final form of the design solutions thus developed was therefore not considered as part of the data used for this study, as they were relatively unimportant to the research questions, although aspects of how the design solutions were developed were of prime importance.

The Students In this study

All of the student participants were in their final year of a two-year full time Diploma in Building Design course at TAFE. Student participation was on a volunteer basis with informed consent. The students were made aware that they could withdraw at any time without penalty. The study total of 29 students who participated in this research were drawn (in lottery style using name tags picked from a hat) from a pool of 60 students who volunteered from four different class groups. The authentic projects undertaken by participants represented for the students a major part of their final training because the design solutions they developed were used by their TAFE lecturers to evaluate their performance in several subject areas. In addition to design and drafting skills, aspects of professional practice, knowledge of codes of practice, business ethics and design office protocols were included as elements of the building design project undertaken. These elements, when viewed collectively, represent the core activities required of building design students in the broad scope of their field of study and formed the basis of the student/mentor collaborative work sessions used in this research study.

Trustworthiness of the Study

Validity

Patton (1990, p. 11) comments that " the validity and reliability of qualitative data depend to a great extent on the methodological skill, sensitivity and integrity of the researcher". As the instrument of data collection in this study I made use of rigorous, replicable data collection and analysis methods to ensure the validity of the study findings. This manner of working also draws upon an approach recommended by Goetz & LeCompte, (1984) who contend that the researcher must demonstrate the credibility of their findings in order to confirm the reliability and validity of their research.

All of the participants who contributed data became in some way co-researchers by presenting personal views of their experiences throughout the course of the project. By adopting this approach, the reliability and validity of this study were addressed throughout the design of the study structure, data collection and data analysis. The methods used for the collection, coding and analysis of data in this study were consistently applied in a manner that was replicable in the context of their application to similar situations and the culture of design practice present in the situation of this research study. These methods are described in the next chapter.

Findings that emerged from analysis of data collected at different times throughout the prolonged engagement data collection period were presented by me to the study participants in order to confirm interpretations. This provided opportunities to confirm the internal validity of data by comparing what I recorded, with what the participants considered as their experiences. In this way, the validity of data about the conditions affecting learning events present in the study situation were examined at the level of the participants' first hand experiences (LeCompte & Goetz, 1982). Over the duration of the study, this approach assisted in minimising the observer effect (McMillan & Schumacher, 1989) in which the researcher may have some impact on the study participants' knowledge in the study situation. To avoid possible negative influences that might be seen as a threat to internal validity as brought about the presence of the researcher in the design office situations of this study, multiple data collection methods including interviews and observation sessions were used.

Using multiple data collection methods provided opportunities to compare data from different sources about the study phenomena. Having a lengthy data collection period provided me with opportunities to be reflective in my continual data coding and analysis. It also assisted me to refine and implement ways of confirming or corroborating constructs used when developing other coding categories for the study data. Overall, this led to the development of a replicable structure for recording and interpreting the study data and provided the means to add rigour to the study methods.

Having multiple data sources enabled me to construct my knowledge of the study phenomenon by keeping detailed records of every event observed and interview conducted which collectively formed a "chain of evidence" (Yin, 1994, p. 33) of my investigations. Following analysis of data recorded in this way, I presented preliminary findings to students and mentors in member check post observation session interviews to obtain their views on my interpretation of the study events. By comparing my understanding of the study events with that of the participants, I was able to constantly refine and implement replicable procedures for data collection in a bid to ensure the overall validity of the study. During Phase Three, when seeking to examine the internal validity of findings emergent from analysis of the study data, I engaged in informal interviews with the study participants during which I presented my preliminary emergent findings, along with:

- samples of sketches and drawings produced in student/mentor collaborative work sessions;
- video vignettes of student/mentor collaborative work sessions; and
- samples of frequently occurring quotes from the study participants.

Information obtained from informal interviews of this kind helped to reveal aspects of the study situation where activities or interactions involving causal relationships that needed to be explored cautiously, or distinguished from spurious relationships. This assisted me in examining the internal validity of the study by providing information that explained the study participants' learning experiences and progressively built upon my understanding of the overall study phenomenon.

Face validity of the study data was established through discussions with the coordinating TAFE lecturers and other study participants, during which preliminary emergent findings were presented for their consideration and evaluation (House, 1977). Critical evaluation of emergent findings by the study participants provided insights into their personal and situational interpretation of the study phenomena when examining the authenticity (Lincoln & Guba, 1985) of the study. Feedback provided by the study participants assisted me in constructing my knowledge of the students' learning experiences and the factors that supported their acquisition of knowledge and procedures typically used in the design office culture of practice. Using data triangulation based on multiple data sources including interviews, direct observation in the design office and student outcomes as shown in actual sketches and drawings assisted me in validating emergent findings.

Reliability

LeCompte & Goetz (1982, p. 211) contend that "reliability refers to the extent to which studies can be replicated". This study utilised aspects of an ethnographic approach to research in that it involved "participant observation and intensive fieldwork" for data collection, while interpreting and applying its findings from the "cultural perspective" of the building design profession (Patton, 1990, p. 68). Interpretation of data collected using multiple methods, detailed in the next chapter took place as a naturalistic inquiry in that it used "real world situations as they unfold naturally" (Patton, 1990, p. 40). For this reason, many aspects of the research settings used in conducting this research cannot be precisely replicated because of the dynamic nature of each mentor's working methods and the changing circumstances of the design office environment as determined by everyday events. The circumstances of this research involved real-world situations that emerged from authentic design activities undertaken by students with the guidance of expert building designers acting as mentors. The student/mentor collabomtive exchanges that took place throughout the study provided numerous opportunities for collecting data about the events activities experienced by the study participants. The validity of data collected concerning these events was supported through the use of a variety of data collection methods, over the 14 month data collection period (LeCompte & Goetz, 1982). All of the data collection methods that I have used for this research are discussed in the next chapter of this thesis.

Patton (1990, p. 40) contends that a naturalistic inquiry is characterised by methods that are "non-manipulative, unobtrusive and non-controlling; with an openness to whatever emerges and a lack of pre-determined constraints on outcomes". In order to as much as possible make findings from this study replicable and to ensure the reliability of data collected, rigorous and replicable methods for data collection, data recording and data analysis were consistently applied throughout this study. This approach was guided by methods suggested by McMillan & Schumacher (1989) who contend that reliability in qualitative research is linked to the researcher's interactive style, the data recording and data analysis processes, as well as the interpretation of the participant meaning in the data.

As the researcher and the principal instrument of data collection (Patton, 1990), I maintained control over every aspect of data collection, coding and analysis by recording, transcribing, coding and analysing the study data. To avoid possible skewing of the data or biased interpretation, I used member check interviews during Phase Two and Phase Three to confirm my understanding of the study events by presenting to students and mentors emergent findings for comment. Feedback obtained in this way throughout the study and when using methods that facilitated close involvement with every aspect of data collection, coding and analysis, assisted me in obtaining consistency in the description of the participants experiences and the events studied in this research. This approach also guided my interpretation of meaning of the study phenomena as expressed by the participants. Such an approach McMillan & Schumacher, (1989) contend supports the individualistic and personalistic nature of qualitative research methods.

Methods used to enhance Reliability of the study data

McMillan & Schumacher (1989) contend that reliability in qualitative research is linked to the consistency shown by the researcher when interacting with the study participants and in the data recording and analysis processes used. Throughout this research I have maintained a highly interactive role with all of the participants by conducting face-to-face interviews during Phase Two of this study and by being a participant observer in student/mentor collaborative work sessions conducted during Phase Three of this study. Working in the field, close to the study events with the participants, provided me with opportunities to study and observe first hand the relationships and working practices, experienced by them, in the culture of the mentors' usual design office practices. Consistency of data collection, coding and analysis was enhanced by using the same open ended interview guide questions for all of the interviews and by video recording the student mentor work sessions for later analysis with the aid of coding categories emergent from preliminary data analysis. A description of my interactive style of working with the study participants, the data collection methods used, the development and application of the study data coding and indexing structure and the analysis methods used, is presented in the next two Chapters of this thesis.

Three types of problems, that could threaten the reliability of data collected using naturalistic inquiry methods, were identified by Guba (1978) as boundary problems, focussing problems and authenticity problems. Boundary problems are said to occur (Guba, 1978) when there exists an absence of clear selection criteria for the study sample. In this study, boundary problems were avoided by having the entire sample drawn from four undergraduate level class groups of building design students, each of similar academic level and all clearly defined, hence bounded, volunteers. Having an all-volunteer sample also avoided focussing problems that occur when the researcher is not confident that all of the participants are willingly taking part in the study events. All of the participating mentors here were volunteers who had actively sought to work with the students and had made available the resources of their commercial design practices for the purpose of this study. Throughout the study, all of the participants were reminded at each new phase of data collection that they could withdraw their participation at any time. The reminders were provided verbally and using forms with which the participants gave their written permission for the recording and publication of information they provided. Since none of the participants chose to withdraw from the study at any time, it is reasonable to assume that they were all willing contributors and therefore it was unlikely that focussing problems affected data collection. Some of the students participated in both Phase One and Phase Two because of their continuation in the building design course over two semesters in the one year. The four students who participated in Phase Three did so during their final semester in the building design course.

The third potential problem noted by Guba (1978) that may be encountered in a naturalistic inquiry is that of the reliability or the authenticity of the sources of information. It is difficult to determine if all sources of information in a naturalistic study are authentic and therefore worthy of trust. In this study, all of the mentors were practicing commercial building designers, qualified and registered with the Building Designers Association of Western Australia. Work practices and ethical standards, used by the building design mentors in this research, were governed by the industry standards and constitution of their professional body. All of the mentors are known to me through my professional design practice and through contact I have had with them as part-time lecturers in TAFE. For these reasons, I consider that data collected from them is likely to be authentic.

The students all chose to participate in the mentor supported authentic design projects and in the research study. Throughout the study they showed a great willingness to contribute information and copies of their design works, giving their permission for publication of all such materials. The enthusiasm and openness demonstrated by the students suggested that they were confident with their contributions being open to scrutiny by others. From this, I consider it likely that data collected from the students was a reasonable record of their experiences in the events of this study.

To ensure that as much as possible the data collected represented the study phenomena, I have detailed in the following chapters the processes that I used for the examination and synthesis of the overall data collected.

Goetz & LeCompte (1984, p. 210) argue that reliability in ethnographic research is "dependent on the resolution of both external and internal design problems". This applies here also because this study has some ethnographic aspects due to the prolonged and intense data collection. They contend that external reliability addresses the issue of whether independent researchers would "discover the same phenomena or generate the same constructs in the same or similar settings" and that internal reliability refers the "degree that other researchers, given a set of previously generated constructs, would match them in the same way as did the original researcher" (Goetz & LeCompte 1984, p. 210).

External Reliability in this study

Goetz & LeCompte (1984, p. 213) argue that "no interpretivistic study attains perfect external reliability" in the traditional positivistic sense, however the external reliability of a study may be enhanced by the researcher addressing five aspects of the design of the study as follows:

- researcher status position;
- informant choices;
- social situations and conditions;
- analytic constructs and premises; and
- methods of data collection and analysis.

How each of these was addressed in this research is now discussed.

Researcher status position

The status, and role played by the researcher within the study group, must be clearly identified as part of the description of the study phenomena (Goetz & LeCompte, 1984). My role and status in conducting this research has been described earlier in this Chapter. As the researcher in this study, I also have a long history of working as a building designer and as a teacher of building design, with close links to all of the participants. My personal insights into the practice of building design and learning building design is grounded in personal experience of working both as a designer and teacher of design. Having this background assisted me in exploring the learning situation of this study from an informed perspective from both the students' point of view and that of the mentors' role when guiding the students through authentic design tasks. By conducting all of the interviews, observation sessions, transcription and interpretation of data personally, I was able to remain fully informed of every aspect of this study at all times and receptive to findings emergent from analysis of those data. In this way, I was able to maintain a global view of the study and to refine my research methods in response to emergent findings.

Informant selection

Goetz & LeCompte (1984, p. 215) argue that "no single informant can provide universal information". They contend that in a naturalistic study, each participant has unique and idiosyncratic information that cannot be readily replicated by others in a similar study To address this issue, Goetz & LeCompte (1984) recommend careful description of the study participants and the process used for their selection. Earlier in this Chapter the study participants and the circumstances of their voluntary involvement with this research, have been described. The study group was made up of students from a very specific discipline area and the mentors from a professional body governed by national standards of professional practice.

Social situations and conditions

In order to reduce the threat to the external validity of data in a study such as this, Goetz & LeCompte (1984) argue that the researcher should provide descriptions that include function, stucture and specification of features pertinent to the context of data collection. Such factors are subject to change over time, or from one study to another. The design office settings and the social settings developed through interaction between the researcher and the study participants, are described as part of the data collection procedures and data analysis in the next two chapters of this thesis.

Analytic constructs and premises

Replication of the study informant group, the relationships and social contexts of their interactions is said to be difficult if not impossible if the constructs, definitions, or uoits of analysis that informed the original research are "idiosyncratic or poorly delineated" Goetz & LeCompte (1984, p. 215). This study has been structured using constructs founded on a cognitive apprenticeship (Collins, et al., 1989) approach to learning. Categories used for coding data throughout this study, have been derived from key elements of a cognitive apprenticeship (Collins, et al., 1989) approach and refined as findings emergent from analysis of each new data collected. In this way the categories used for the indexing structure developed for the final coding and analysis of the overall study data, were thought to reliably represent the constructs upon which the study is based and consistent with findings emergent from analysis methods applied to all data collected.

Detail of methods of data collection and analysis

The replicability of any research study is influenced by the level of detail given by a researcher to the documentation used for data collection and analysis. Goetz & Goetz & LeCompte, (1984, p. 217) contend that a study description must identify and detail:

> ... the strategies used for data collectioo, the varieties of observational and interviewing strategies, the range of non-interactive methods and the strategies used in amplifying, modifying and refining data during early stages of analysis while the researcher is still operating in the field".

The data collection strategies used in this study are described in detail in Chapter Four. Analysis of the study data is described in Chapter Five. Throughout this study, the strategies used for data collection and data analysis were applied consistently and informed by field notes that describe the circumstances of the interviews and observations used to record events and information about the situations under study. Threats to the external reliability of data due to incomplete description of the data collection and analysis strategies have been addressed in Chapter 4 and Chapter 5 of this study, where detailed description of the collection, coding and analysis of data is documented.

Internal Reliability

When considering the internal reliability of a qualitative study, the researcher must determine to what degree other researchers, given a set of previously generated constructs, might arrive at similar conclusions. In studies where multiple research sites or multiple researchers are involved in data collection, it is necessary to have uniformity in the "description or composition of events, rather than the frequency of events (Goetz & LeCompte, 1984, p. 218). Being the only researcher allowed me to collect, code and analyse all data by using the same methods throughout. This included the use of low inference descriptors in verbatim accounts of conversations, interviews and observations, with personal impressions and situational factors being recorded in field notes being used to guide analysis and synthesis of multiple factors in the study events. Information recorded using data collection methods detailed in the next chapter of this thesis, was transcribed by me into text files for coding and analysis. Throughout this process, I presented my verbatim transcription of interviews and video taped records of observed student/mentor work sessions to the study participants for their scrutiny. In addition, I presented to the study participants my interpretation of the events and meaning of the study data to obtain their views and to confirm preliminary emergent findings.

Information obtained in this manner assisted in structural corroboration of data collected throughout the study and enhanced its credibility through plausible findings as confirmed by researcher observations (Guba, 1981). Recorded observations of design office events throughout the course of the study were reviewed with member checks at the time of data collection and later, through data triangulation. This also enhanced the study credibility and reduced the likelihood of non-interpretability effects due to factor patterning (Guba, 1981). Documentation recorded from interviews and journals contributed to the establishment and maintenance of an audit trail for this research. An audit trail may permit later researchers to revisit events similar to those encountered as part of this research, and to implement activities that as near as possible replicate those used here, with the potential to generate similar findings.

Data Triangulation And Credibility

The credibility of this research was underpinned by the use of data triangulation. I have extensive experience as a lecturer in building design and as a practicing building designer and as such bring specialist knowledge and perspectives to undergird the study (Patton, 1990; Lincoln & Guba, 1985).

Multiple sources of data have been used here to ensure the reliability and validity of the research by establishing converging lines of inquiry, corroborating the same fact or phenomenon. Yin (1994, P. 92) contends that this may allow researchers to address a "broader range of historical, attitudinal and behavioural issues".

Data triangulation involves comparing and cross checking the consistency of information derived at diffierent times by diffierent means within qualitative methods. Patton (1990, p. 244) contends that:

> Multiple sources of information are sought and used because no single source of information can be trusted to provide a comprehensive perspective. By using a combination of observations, interviewing and document analysis, the fieldworker is able to use different sources of data to validate and cross check findings.

In this study, data triangulation was achieved by comparing:

- data about particular learning events obtained from the participants when interviewed;
- data pertaining to the same events as recorded in student journals;
- data derived from analysis of sketches and drawings created during work sessions; and
- data obtained from observation of student/mentor collaborative work sessions and analysis of video recording of those events.

This approach facilitated comparison of multiple data obtained using various collection methods, all concerning the same or similar events as determined to be frequently occurring or common activities in the study domain. Multiple interviews with some of the study participants permitted:

- comparison of the consistency of comments made by study participants in the early stages of the study, with their comments at the end of the study concerning the same issues and events; and
- comparing the perspective's of people over points of view from both within and from outside of the study program (Patton, 1990).

Data triangulation was enhanced by comparing information obtained through interviews, with entries made by students in their journals when recording their thoughts about design office experiences and by examining sketches and drawings produced by the participants in the work sessions. How data of these kinds was corroborated by other data derived from student and mentor drawings is described in Chapter Six, with emergent findings being discussed and reported in Chapter Seven of this thesis.

In this research, multiple data sources were used to study how students acquired design strategies and problem solving methods used by expert building designers when resolving design solutions. Data collected also focussed on procedures that emerged as learning elements for the students. Analysis of the study data documented in Chapter Five of this thesis includes procedures used to examine these data for consistency in overall patterns of occurrence in the different information or divergent data sources. Having data from multiple sources about the same events and learning experiences assisted me in developing a holistic view (Patton, 1990) of the study situation and an awareness of specific aspects of student/mentor collaborative practices that facilitated learning.

To minimise errors and biases in collecting and recording the study data, procedures for data collection were consistently applied using a pre-determined structure, which was further refined in response to emergent findings. The structure developed for this purpose was based on broad categories derived from a cognitive apprenticeship (Collins, et al., 1989) approach to learning and findings emergent from Phase One (the pilot study) and Phase Two of this research. Chapter Five of this thesis details the coding and analysis of the study data and explains how categories used to construct the indexing structure for coding the study data, were refined, added to and collapsed as the study progressed and new data were collected. This indexing and coding structure developed over the duration of this study was designed to ensure as complete as possible a true and correct record of events. The coding and indexing software NUD•IST (1998) was used for this purpose.

The use of a study structure shaped by the key elements of a cognitive apprenticeship (Collins, et al., 1989) approach to learning and a staged data collection strategy involving multiple methods assisted in making as many steps as possible in this research operational. This provided opportunities for many aspects of the study methods to be repeatable by another researcher at a later time. Data obtained in this way were appropriate to the goals of this study in that they provided depth and detail and were "sufficiently descriptive that the reader can understand what and how it occurred" (Patton, 1990, p. 26).

Situational Uniqueness

Another aspect considered in the naturalistic treatment of trustworthiness of the study data as suggested by Guba (1981) is that of situational uniqueness, which may produce non-comparability of data. There are many aspects of this study that are unique.

Training in building design and drafting is provided in Western Australia at just one suburban TAFE college. Many of the mentors involved in this study were initially trained at that centre. To avoid possible skewing of data due to this situational uniqueness, I ensured the collection of thick descriptive data by using multiple data collection methods and extensive field notes in support of my observations. I did this with a view to developing findings that were context relevant to the study. Where possible, I corroborated interview and student journal based data by comparison of these with other data obtained by observation of the events under study and from the students' drawings produced as part of the collaborative work sessions that were the main subject of the study interviews.

IMPLEMENTATION OF THIS STUDY

Table 2, below, shows the overall time line used for data collection during the three phases of the study, along with the data collection methods used in each phase.

Table 2
Data Collection Time-line

Study Phase and Data Collection Method	Year of data collection 1998	1999	2000
Phase One			
Discussions	***	*	
Interviews	**	*	
Observations	**		
Journals	**	*	
Sketches/Drawings		***	
Telephone	**	*	
Phase Two			
Discussions	**	**	
Interviews		******	
Observations	*	****	
Journals		**	
Sketches/Drawings		******	
Telephone		******	
Phase Three			
Discussions		***** **	****
Interviews		****	**
Observations		*******	
Journals		***	**
Sketches/Drawings		*******	**
Telephone		*****	**

Note: Each asterisk (*) indicates one month

Conclusion To This Chapter

This Chapter described the overall research study structure, the study sample and role of the researcher. Although described in detail in the next Chapter of this thesis, mention was also made in this Chapter of the data collection methods used in order to assist in the discussion of the reliability and validity of the techniques used to collect and analyse the study data. The framework for the research described is based on a naturalistic approach.

CHAPTER FOUR

METHODS USED FOR DATA COLLECTION

Introduction

This study sought to find answers to five research questions as shown earlier on page 8 of this thesis. In this Chapter, the methods used to collect data over the three phases of this research are detailed. Phase One was a pilot study and Phase Two and Phase Three together formed the main data gathering parts of this study.

Data were collected by investigating in detail many aspects of the interaction between students and mentors working together in collaborative design teams on authentic design projects in 10 different building design offices. In each design office, activities undertaken by the student/mentor collaborative design teams were organised to reflect the mentors' usual working practices, as implemented in the context and culture of a professional commercial situation.

This Chapter begins by describing the methods used in each of the three phases of data collection. It then goes on to detail each of those data collection methods with reference to the kinds of data obtained and the manner of recording them for analysis. The purpose of presenting the study data collection methods in this manner is to provide a clear picture of the replicable structure applied during each phase of data collection and analysis.

The Chapter concludes with comments about how the data collection and recording methods helped to ensure trustworthiness and rigour in the analysis of the study data.

Data Collection Phases In This Study

Data collection Phase One - Pilot Study

Phase One of this research involved 22 students working under the direction of seven mentors and three TAFE staff on an authentic design project. This first phase of the research was conducted as a pilot study in order to begin to address the overarching research questions, to provide the researcher with entry to the field of study and to trial proposed data collection methods, interview guide questions and ways for coding and analysing data.

Phase One was not intended to be an in-depth study, but sought just to explore the kinds of learning situations and outcomes likely to be experienced by students undertaking authentic design tasks under the direction of expert building designers in a cognitive apprenticeship learning situation. This section documents an overview of the methods used to collect, record and analyse Phase One data for use in developing the study structure and main data gathering methods used in Phase Two and Phase Three of the study.

Data were collected during Phase One using the following methods:

- interviews;
- observation of classroom briefing/discussion sessions;
- student diary journals;
- sketches and drawings; and
- researcher journal notes from observation of work sessions and critique or assessment sessions.

Data collection during Phase One began with informal discussions between the three TAFE staff who had organised the design project, two of the seven participating mentors and myself. During these discussions I made journal notes concerning the participants views, on how the organisation and implementation of Phase One might best be structured to address the overarching research questions. Data recorded during these sessions were later transcribed for analysis.

Prior to the commencement of the design project used for Phase One, the students were briefed by me about using their daily journals to record events and experiences they regarded as having assisted their learning about design when working with a mentor on an authentic design project. The following aspects of their experiences were suggested as possible broad categories with which the students could organise their diary journal entries:

- mentor supported design activities they had undertaken each day;
- how the experience of working with a mentor changed their approach to design;
- what they felt were their learning outcomes that emerged from the experience of working with a mentor; and
- what application did they see for the knowledge and skills acquired through working with the mentor.

Data collected in Phase One were initially coded using these broad categories and others that emerged during data transcription and analysis. Further development of the coding structure that resulted from analysis of Phase One data is described in detail in Chapter 5 of this thesis.

Data collection Phase Two – Main research study

The second phase of data collection made use of several data collection methods, as set out below in Table 3 (see page 58). In this phase of the research study, 11 expert building designers operating in 10 separate design offices acted as mentors to 10 students for the design and presentation of an authentic building design project. In nine of the design offices, the students worked one-on-one with their mentor and in one office, one student worked with a two-mentor team. Other staff also assisted students in most of the design offices. In addition to face-to-face interviews conducted with the students and the mentors who participated in Phase Two, data were also collected using the following methods:

- observation of classroom briefing sessions;
- observation of classroom design planning sessions;
- informal interviews and discussions with TAFE lecturers; and
- informal discussions with students.

Each student/mentor collaborative team worked to create a building design based on an authentic project brief. When the collaborative work sessions began, three observation sessions were conducted with one of the student/mentor teams. Data were collected during these observation sessions using journal notes and audio-tape recordings, which were later transcribed verbatim for analysis.

At the completion of the authentic building design project, face to-face interviews were conducted with each of the 11 mentors and nine of the 10 students. One student of the original group of 10 was unavailable for interview due to a country posting. The face-to-face interviews provided the main body of data collected in this phase of the study. The interviews were conducted in two stages during Semester one of 1999. A two week break between the groups of interviews was used by me to determine trends emergent from analysis of the first round interview data that could be used to refine the study structure and the interview guide questions for the second round of interviews.

All of the data collecting methods used for this research are described in detail later in this Chapter as they apply to Phase Two and Phase Three, of this study. Table 3 (P. 58) sets out the various data collection methods used, the number of instances in which they were employed, the situations of their use and the manner in which data were recorded.

Table 3.
Data Collection Phase Two

Data Collection Method	Number	Context In Which Conducted	How Recorded
Informal interviews and discussions	6	Prior to design project	Notes
	8	During the design project	Notes/sketches
	18	Following the design project	Notes/sketches
Interviews	23	At the end of Phase Two	Audio-tape and notes
Telephone discussions	24	Arranging interviews and follow up with TAFE staff/students	Notes
Observations	2	Briefing sessions	Audio-tape and notes
	2	Classroom work sessions	Audio-tape and notes
	3	Design office work sessions	Audio-tape and notes
Sketches and drawings	52	When interviewed at the completion of the design project	Photocopies and Photographs – scanned into computer files
Models	2		
Journals	4	Students	Notes/sketches
	1	Researcher	Notes

Data collection Phase Three – Main research study

The third phase of data collection took place over several months during which four students worked with five mentors in four different design office situations to design and document an authentic building project. Data collection in this phase was mainly based on my observation and videotape recording of twelve student/mentor collaborative work sessions. The work sessions varied in length from 15 minutes to three hours duration, with most being about one hour.

For this phase of data collection, I chose 5 mentors from the group of 11 who had participated in Phase Two. Selection of these five mentors was based on three factors. The mentors were chosen for Phase Two on the basis of "reputational case selection" (McMillan & Schumacher, 1989, p. 184) which uses a strategy involving a knowledgable person to make recommendations to the researcher. In this case, the informants making the recommendations were the TAFE lecturers who were familiar with the working practices of the overall group of mentors, having seen them working with students over a long period of time as sessional lecturers or on other authentic projects. Importantly, analysis of data gathered during Phase Two indicated that the 5 mentors selected used four different design/mentoring styles, which collectively were thought by me to be representative of the overall group of mentors. The two-mentor team in one of the design offices was chosen because those mentors used design and mentoring methods regarded by me as being typical of the overall group of mentors, but with a team-based approach. The decision to use the two-person mentor team was in response to emergent findings that indicated team-based methods in a design office setting enhanced learning.

Preliminary findings, emergent from analysis of Phase One and Phase Two data were discussed with the mentors after the observation sessions. These discussions provided member checks on the study data. Feedback from the mentors during these discussions confirmed many aspects of my interpretation of data already gathered. This allowed the study focus to be further refined for data gathering using observation sessions that were the main data gathering method for Phase Three of the research study.

Other data gathering methods used during Phase Three are detailed in Table 4 (see page 60). Each of the data collecting methods used is then discussed in detail following Table 4.

Table 4.
Data Collection In Phase Three

Data Collection Method	Number of contacts or items	Context In Which Conducted	How data Recorded
Informal interviews and discussions	19	Prior to design project	Notes
	18	During the design project	Notes/sketches
	12	Following the design project	Notes/sketches
Interviews	4	With mentors	Audio-tape, notes and sketches
	4	With students	
	2	With TAFE lecturers	
Telephone discussions	18	Arranging interviews and follow up with TAFE staff/students	Journal notes
Observations	12	Design office work sessions	Videotape, notes, sketches
Sketches and drawings	36	Collected throughout Phase Three as the design project progressed	Photocopies and Photographs-- scanned into computer files
Models	2		
Journals	4	Students	Notes/sketches
	1	Researcher	Notes

Data collection using informal interviews and discussions

Data collection using informal discussions between myself, students, TAFE staff and the mentors, took place at various times throughout the entire study. Often, these informal interviews and discussions involved students and mentors immediately following their collaborative work sessions and provided highly detailed accounts of how the participants felt about their interactions. Immediate feedback about the events and experiences obtained in this way I recorded as journal notes which were later transcribed verbatim for inclusion with other data. Comments made by study participants, during informal discussions about aspects of their design office experiences, assisted in developing my understanding of the diverse range of learning events and methods used by the mentors when working with the students. Student comments also provided insights into what took place in the design office situation and how that affected their learning. Data of these kinds assisted me in exploring different aspects of the study situation by targeting activities or working methods said by the participants to be important to learning and contributed to the development of interview guide questions used later during formal interviews to extend my investigation.

Informal discussions that took place between myself and each of the students and mentors sometimes revealed personal views about the working relationships that developed between the participants in the design office situation.

In most of my informal discussions with the study participants, they expressed personal views, described learning experiences, their progress with the work and in some instances mentioned their concerns about particular aspects of the situation. Concerns mostly were focussed on whether or not the students would finish the set work within time. There were no instances of student/mentor conflict and thus information obtained during informal discussions did not precipitate changes in other data collection methods to accommodate expressed difficulties. Mention is only made here of this aspect of the study because of the possible impact that confidential revelations of a negative kind, had there been any, might have had on the study structure given my role as the main instrument of data collection.

Some of the time during Phase Two and Phase Three of this study, casual discussions and informal interviews took place in design office settings with both the student and the mentor present. On other occasions I conducted individual interviews in the design office, or in informal locations. At all times the participants were aware that data were being recorded and that confidentiality of all information collected was assured. Data collected during informal interviews and discussions I recorded in note form using a journal which I later transcribed verbatim for analysis.

Other informal discussions took place when I returned drawings and sketches borrowed for copying purposes from the study participants at the conclusion of Phase Two and Phase Three. During such discussions, I encouraged the participants to explain various aspects of their drawings in terms of the learning situations they had experienced in producing them in the design office student/mentor collaborative work sessions. Data thus gathered were recorded in detailed notes linking what the participants said about their work, with what could be seen in the sketches themselves. Such discussions also provided opportunities for me to discuss with the students the design processes used and the content of the drawings, with reference to the mentors' use of cognitive apprenticeship teaching strategies. Also discussed during these sessions were some of the relevant emergent findings as well as my interpretation of how events in the design of the student/mentor collaborative work sessions affected student learning. Such discussions provided member checks on the preliminary findings which were used by me to shape further data collection questions used in subsequent interviews and discussions. Notes recorded by me during these interviews were used also as member checks to confirm ideas and themes emerging from data gathered using other methods. This is explored in detail in Chapter Five of this thesis.

Data collection using formal Interviews

Formal interviews were conducted with the study participants during all three phases of data collection. In Phase Two, they were used as the main means for data collection. The interview guide approach adopted gave focus to the investigation of the mentors use of cognitive apprenticeship teaching strategies, while keeping questions open ended so as to allow investigation of new avenues that emerged from the participants answers.

Face-to-face interviews conducted were structured using an interview guide approach (Patton, 1990) that began with each of the respondents first being informed of the issues being explored, followed by questions about topics relevant to the research. The use of this approach is said by Patton (1990, p. 280) to allow the interviewer to "adapt both the wording and the sequence of questions to specific respondents in the context of the actual interview". By working in this way, questions designed to address various topics and subject areas relevant to the research questions were used to explore and probe in ways that "elucidate the subject area" (Patton, 1990, p. 283).

Interview guide questions for data collection were developed using information based on:

- discussions conducted with three TAFE lecturers, five building designers (mentors) and a group of 15 students during Phase One; and
- analysis of student journals-based Phase One (pilot study) data.

Two rounds of interviews were conducted during Phase Two of this study. Findings, emergent from analysis of data collected in the first round of Phase Two interviews, were used to refine the interview guide questions used in the second round of Phase Two interviews. The use of an interview guide approach in this manner facilitated "interviewing across a number of different people more systematic and comprehensive by delimiting in advance the issues to be explored" (Patton, 1990, p. 283).

Appendix A shows interview guide questions used for the first round of Phase Two interviews with the study mentors. Appendix 'B' shows interview guide questions used for the first round of interviews with students. Findings that emerged from analysis of data collected in the first round of interviews were used to refine and extend the interview guide questions for use in a second round of interviews. This led to the development of the supplementary interview guide shown in Appendix 'C', which was used along with the other two interview guides for the second round of Phase Two interviews with students and mentors.

In all interviews, open-ended questions were used initially, then more probing questions were introduced to explore specific aspects of the study situation that emerged from the participants' responses. Examples of some of those questions are shown here to explain how data gathering methods were refined as the study progressed. Most of the questions used during each round of interviews evolved during the interviews as I responded to the interviewee answers and followed new lines of inquiry with questions to explore emergent themes.

The following questions are typical of those developed during the second round of Phase Two interviews.

On entry skills or competencies at the start of mentor supported projects:

When asked:

What do you look for first of all when students come to work with you in the design office?

In response to this, some of the mentors said they sought particular skills such as CAD drafting or construction detailing, while others said that they just wanted the students to be able to think. To follow up each of these diverse answers with questions that teased out the details of how the mentors determined student skills then shaped their activities to address these, I asked questions as follows:

What kinds of activities did you use to establish the level at which the students were working in design and documentation (drawing, detailing and specification writing)?

Questions like this provided opportunities for the mentors to discuss their ways for evaluating student skills, or for establishing how they engaged the students in activities that demonstrated their approach to design using cognitive tools (Brown et al.,

1989) rather than just applying replicable processes to create solutions. Questions of this type also allowed me to explore in detail interaction between the mentors and the students, while remaining open to change according to how the mentors answered.

On the mentors' approach to teaching:

In the first round of interviews the students were asked:

Can you tell me about how your mentor helped you to develop your project design?

Some of the students responded to this question by describing how their mentor had detailed processes he used to analyse a design brief and then implement defined procedures to resolve each design element to progressively develop a final solution. Other students indicated that their mentor had simply produced design ideas by using sketching and talking. In order to determine what actually took place during design development sessions that led students to acquire design knowledge and skills, other questions were developed as follows:

Can you describe for me how you and your mentor worked together to develop a design solution?
In what ways did your mentor assist you in getting started with the design?
Would you describe for me what you and your mentor did in the work sessions to resolve problems that emerged during the development of the design?
In what way did your mentor assist you to come up with new ideas when you had become bogged down and to incorporate them into your design?

These questions and other similar ones helped me to explore the collaborative exchanges that took place in which the mentors introduced their design methods, applied heuristic design strategies and used *scaffolding* to assist student learning.

Each of the face-to-face interviews was arranged by telephone beforehand with the participants. Some interviews were arranged following observation sessions in the design office situations where the student/mentor collaborations took place as the study progressed. Written permission, for tape recording of interviews and work sessions, was obtained from each of the study participants, prior to each such event. All interviews were tape-recorded then transcribed verbatim for open coding in NUD•IST (1998). Interview guide questions were refined to reflect trends emerging from preliminary analysis of data.

When interviewed, most of the study participants made comments about their thoughts and feelings when describing their experiences in the student/mentor collaborative work sessions. These data I regarded as important because they provided personal insights into how they saw aspects of their learning take place in the study situation. Information obtained in this way I recorded in journal notes which I later transcribed verbatim for analysis with other data. Findings that emerged from analysis of these data were used to refine interview guide questions and to explore further other data regarded by me to provide multiple perspectives of the study phenomenon. Analysis of these data is discussed in Chapter Five of this thesis.

Formal Interviews In Phase Two

Two rounds of formal interviews were conducted during Phase Two of this study. Having two rounds of interviews enabled me to test for data saturation (Charmaz, 1990) and so that findings, emergent from preliminary coding and analysis of data from the first round of interviews, could be used to identify aspects of the study situation that warranted specific attention or further study. Findings from analysis of round one interview data also provided information that assisted me to refine interview guide questions for the second round of interviews.

For example, in the first round of interviews the following question was used to initiate mentor discussion of their use of sketching as a communication tool when working with students:

> In what ways did you use sketching when teaching students to communicate design ideas?

Findings from analysis of data collected in the first round interviews led me to contend that the mentors made extensive use of sketching, but the students were not as adept in using it as the mentors would have liked. For this reason, I refined the question to determine how the mentors used sketching when working with students and to determine their views on how the students used it. The question was extended to cover several aspects of mentor and student use of sketching as follows:

> In what ways do you use hand sketching when working with students? In what ways do they use it effectively to communicate their ideas and construction detailing?
>
> Can you tell me about how students respond when you use drawings to communicate your thoughts and ideas?

In the first round of interviews conducted in Phase Two of this study, four students, five mentors and three TAFE staff, were interviewed. All of the interviews were taped then transcribed verbatim for analysis. During each of the interviews I made journal notes about aspects of the study situation said by the participants to have been important learning experiences, as well as other aspects of their interaction. These notes included descriptions of the students' work practices, the way they dressed and the manner in which they spoke. The reason for recording personal information of this kind was in response to comments made by some of the students about changes they had made as a result of their design office experiences and when seeking to be accepted by others in the design office. Notes made when collecting these data were transcribed verbatim and included as memo-notes in the NUD•IST (1998) index tree developed for coding Phase Two data. One example of data collected during the first round of interviews used for developing new interview guide questions for exploring student dress and language use as part of their entry to the design office culture of practice is as follows:

> When I first went to his office I felt a bit embarrassed because I had gone there straight from TAFE and was in my old jeans and a t-shirt. The first thing I noticed was that all of the design office staff were really well dressed and some were even in suits. When Ian introduced me to some of the staff it was quite formal. Everyone was polite and a bit formal, not like at "tech" where anything goes. The next time I went there I put my best gear on and watched my p's-and-q's. (Student 20)

In response to data of this kind, questions like the following were developed for use in the second round of interviews:

> Can you tell me about the kinds of things that you did to fit in with the mentor and others in the design office?
> Can you tell me about any changes that you made to your way of speaking or presenting yourself as a result of working in the design office setting?
> In what ways did making such changes help you to work there?

At the completion of the first round of Phase Two interviews, data collected were transcribed verbatim for analysis to determine emerging themes. Analysis methods used with these data and emergent findings are reported in the next three chapters of this thesis.

During analysis of data collected in this first round of interviews, additional coding categories were created as new themes emerged from the data. Since new aspects of the study continued to emerge as data were transcribed and coded, I concluded that data saturation (Charmaz, 1990) had not yet been achieved and that further data collection was needed to explore other aspects of the study situation. Questions like those shown in the previous example were used in the interview guides for the remaining Phase Two formal interviews and were refined to reflect trends seen emerging from analysis of Phase One data. This brought about several small but important changes in the study structure by moving the focus more towards design exploration and creativity aspects of the student/mentor collaboration, rather than being centred on student acquisition of knowledge and skills as first structured. For example, the following questions were used to collect data about how the mentors assisted students to learn heuristic design strategies:

> Can you describe for me any special approaches you have developed that make use of techniques or prototype solutions to address particular design problems or building types, that can be used by others or adapted to other design problems?
>
> How might you teach others to use these, perhaps over a range of alternative applications?

The second round of formal interviews that took place during Phase Two of this study were conducted with five students and five mentors. During these interviews, in addition to the interview guide questions used for the first round of interviews, additional questions like those in the previous example and others designed to explore ways used by the mentors to encourage the students to develop creative and innovative design practices, were used. All of the interviews were recorded, then later transcribed verbatim for analysis. Coding of Phase Two data was regarded by me to reach "saturation" when all new data introduced through verbatim transcription of the second round of interviews were readily coded using existing categories and no new aspects of the study situation were emerging (Charmaz, 1990, p. 520).

Interview use in data collection Phase Three

Data collection during Phase Three of this study was mostly achieved using observation of student/mentor work sessions, but some interviews were conducted following completion of the student design project used in Phase Three. Interviews were conducted with the 5 mentors and the 4 students who had participated in the Phase Three data collecting observation sessions. During these interviews many aspects of the student/mentor collaborative work team interactions were discussed in terms of the events and procedures undertaken by the participants. Some of the participants also commented on how their design office learning experiences had changed their outlook on design and how this had led to their development of a personal design style. Mention is made of this here because I recorded comments such as these in my journal, along with sketches to show student use of particular design elements. These were useful later when interpreting other data.

All interviews were tape recorded and later transcribed verbatim for analysis. During some interviews I used sketches to record aspects of the learning situation described by the participants when discussing their use of heuristic design strategies and other elements of design used during the student/mentor collaborative work sessions. Data collected in this manner assisted me when transcribing my journal notes and when interpreting student information including sketches that most of the students made available to me for duplication and inclusion as part of the overall study data.

Data collection using telephone discussions

Throughout this research study, telephone discussions with almost all of the study participants were used as part of the data collection process. Information obtained by me during telephone conversations with the participants was recorded in the form of journal notes which were later transcribed verbatim for analysis. Data recorded in this manner were also used a part of the research audit trail to maintain rigour in the study. Initially I used telephone conversations to gain entry to the field of investigation by making contact with the participants and to arrange meeting times for interviews and observation sessions. As the study progressed, I made notes during telephone conversations with the study participants which I later used to confirm trends emerging from analysis of data collected during interviews, and observation sessions. This served as member checks.

In some instances, telephone interviews were conducted when the study participants were not readily available for face-to-face talks. Where it was not possible for me attend work sessions (due to simultaneous sessions in multiple offices), I conducted telephone conversations with the student and the mentor involved following each session. This was usually followed up with face-to-face informal interviews to confirm information and expand on points noted earlier. Data collected during these interviews were recorded in note form and then transcribed verbatim for later analysis.

Although the overall body of data obtained from telephone discussions was small when compared to that obtained using other data collection methods, it was useful when organising other data collection and when confirming other data.

Data collection using observation of work sessions

Observation and video recording of student/mentor collaborative work sessions took place in Phase Three of this study in order to confirm emergent findings and to explore other aspects of the study situation and events that were thought to have influenced student learning. The direct observation sessions conducted in Phase Three involved four students working under the guidance of five different mentors provided most of the data collected in Phase Three of this study. Two of the students worked with mentors who each held work sessions of up to 3 hours duration. These mentors also made themselves available on as as-needed basis for consultation in the design office by the students. One student worked with a mentor who began with a 90 minute work session, then a week later held a 45 minute session, followed by a 15 minute session a week after that. This mentor also made himself available during office hours. He also provided the student with his own office space alongside other designers in the design office. The fourth student in the Phase Three study sample worked with the two-person design team. In this situation, the mentors conducted six one-hour work sessions with the student.

In Phase Three, I collected data as a participant observer in 12 student/mentor collaborative work sessions. It was not possible to attend every work session because some ran simultaneously with others. Where this occurred, I conducted informal interviews with the students and the mentors involved afterwards so that I had an understanding of what had taken place before I attended the next observation session with them. Every work session that I attended was video-recorded for later analysis.

Video recordings of the work sessions were analysed minute-by-minute using a checklist based on key elements of a cognitive apprenticeship approach and from findings that had emerged from analysis of Phase Two data. Table 9 (Chapter 5, p. 95) shows data codes used for the analysis of the video data. It shows the frequency of events observed to take place during each minute of the taped work sessions. Analysis of these data is dealt with in detail in the next Chapter of this thesis.

In addition to video recording of the student/mentor work sessions I also recorded journal notes about other factors thought to have influenced the learning situation being developed in the design office, for inclusion in the overall data gathered in Phase Three of this study. These notes also included student comments about their overall work load and difficulties they faced in managing working in the design office at the same time as completing other studies. Data recorded in journal notes were transcribed verbatim for analysis along with other data collected in Phase Two and Phase Three of this study.

Data collection using sketches and drawings

Sketches and drawings provided by the students and the mentors were collected as part of the overall study data because they provided evidence of student learning outcomes in design and showed the progressive use of heuristic design strategies and problem solving procedures by students and mentors. Inferences were drawn about student learning outcomes by examining the development of the emerging student designs. Particular attention was paid to the students' use of sketching multiple alternate design solutions (indicating exploration of, and reflection on various ideas) and evidence of heuristic design strategies modelled by the mentors, such as CAD overlay elements and personal style characteristics. Sketches and drawings were used by all of the participants as communication tools in the student/mentor collaborative work sessions. In some instances they represented the rough workings of the mentors, created during work sessions. In other instances they showed the development of ideas by the students which were then introduced into the collaborative work sessions as their designs progressed. All of the participants used sketching to express ideas, develop explanations, to explore concepts in design and for reflection on learning outcomes as sought by the research questions of this study. For these reasons, I collected copies of sketches and drawings produced by mentors and students as part of the overall data throughout this study. The sketches and drawings showed in graphical form the processes and procedures followed by the participants in developing design solutions for the problems emerging from the authentic work projects.

Copies of student and mentor sketches and drawings were collected throughout all three phases of this study. Figure 2 (p. 71) shows one such sketch. Sketches like this were used to confirm student learning outcomes as seen by what they produced as compared to what they said to have taken place in the work sessions. By comparing data from interviews, observation sessions and drawings, I was able to follow the students' design development and develop an understanding of how that was influenced by their interaction with the mentors in the work sessions. Using this information, I was able to examine emerging trends in what the participants said or demonstrated as their approach to the work, with a view to understanding learning in the design office situation.

In Phase One, more than 60 sketches and drawings were collected and examined. Analysis of student sketches assisted in the interpretation of other data about student/mentor collaborative work sessions by providing visual evidence of design development and the use of heuristic design strategies and problem solving methods. An example of one such sketch is shown in Figure 2 (p. 71) to demonstrate the kinds of data about student/mentor design activities that were used to confirm what the students said had taken place in their collaborative work sessions.

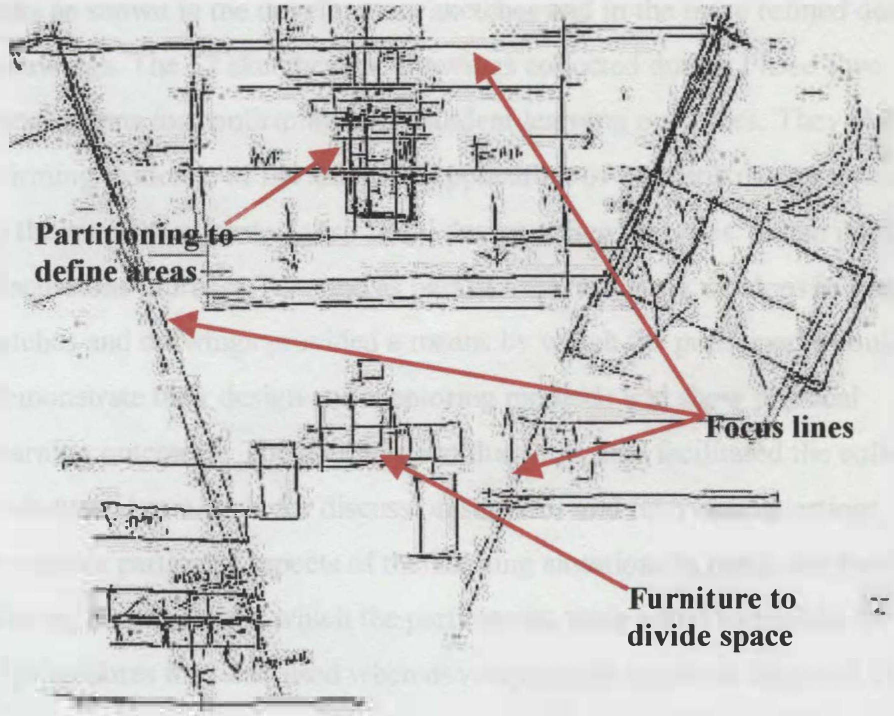


Figure 2. Example of Student/Mentor development sketch.

This sketch is typical of others used to explore ideas in work sessions. It shows how focus lines have been used to create the broad design concept, as well as outline detail of how spaces within that design might be organised using furniture (see bottom centre of sketch) or rooms to be created using partitions (see top centre of sketch). The methods used in this type of sketching I observed to be rapid and minimalist, allowing the designer to present and explore many different ideas quickly without being bounded to any particular solutions. The object of this form of sketching was said by the mentors to create forms open to reflection and exploration of multiple solutions that follow a central theme for the design as determined by the client brief. The design is developed using minimal description and sketching to communicate ideas explored by the designer in metacognitive ways.

From the outset of this study I was aware both from my own experience as a designer and from findings that emerged during transcription and analysis of student journals and interview data that sketches and drawings were important communication tools for the study participants. For these reasons, I have made extensive use of sketches and drawings collected from the students and the mentors to assist in my analysis of other data collected.

Having the students' and the mentors' sketches and drawings available during the interviews provided opportunities to discuss the methods used by them to resolve design problems as shown in the development sketches and in the more refined design presentation drawings. The 52 sketches and drawings collected during Phase Two provided a visual means for confirming some student learning outcomes. They also provided confirming evidence of the students' application of heuristic design strategies introduced by the mentors as part of their usual design office practices. When used as the basis of discussions in Phase Two and as part of observed work sessions in Phase Three, the sketches and drawings provided a means by which the participants could explain and demonstrate their design and mentoring methods and show physical evidence of learning outcomes. The sketches and drawings also facilitated the collection of other data when used as a basis for discussion sessions and interview questions formulated to explore particular aspects of the learning situation. In particular they were useful for initiating discussions in which the participants were asked to explain the processes and procedures they had used when developing the solutions depicted. During these discussions, in addition to the audio-taped record of events, I also made notes linking the sketches to participant comments regarding how and why they did particular things in the designs, as depicted in those sketches. I did this in order to record parts of their explanations that they presented using minimal line sketches that were that were in themselves insufficiently complete or too abstract to warrant inclusion as separate data. I observed the use of rough sketching as part of the usual language of communication used by all of the study participants for explanation building and for visualisation and reflection on design ideas, during work sessions. For this reason, I specifically recorded aspects of its use in my journal notes during interviews, and observation sessions.

Data about student learning design methods were collected by comparing sketches they produced at the beginning of the authentic work project with those they produced further into the student/mentor collaboration. Using these sketches enabled me to develop multiple perspectives of the learning situation by comparing verbal descriptions of what took place with the graphical record seen in the progressive sketches. This aspect of using sketches is explored in detail as part of data analysis in Chapter Five.

Scale models

Scale models of building designs or parts of buildings were used by most of the mentors to assist student learning. Photographs of student models were collected to confirm aspects of student learning outcomes based on their successful application of design knowledge and methods. This was also done because some mentors and students used scale models of buildings or building elements to explore concepts and to develop design ideas in a three-dimensional format. In Phase Three of this study, all of the student/mentor collaborative teams made use of models of existing design projects to demonstrate and explore design ideas. Two of the student/mentor teams produced models of the students' final designs. The students and the mentors used these models during work sessions as tools for exploring new ideas, design strategies, problem solving methods and for reflecting on pathways followed in the design process. The use of scale models to assist visualisation of design concepts and to assist students and mentors to communicate design ideas emerged as an important aspect of student learning in a design office. A photograph of one such model is shown here in Figure 3 (p. 73).

Figure 3. Photograph of a scale model.

Data collection using journals

Prior to the commencement of each phase of this study, I discussed with the student participants their use of journals to record events, circumstances and personal views relating to their design office/mentor experiences. The students were fully informed of the intended use of these journals as part of the overall study data and all gave their written approval for the use of any information recorded in those journals to be used in this thesis and any subsequent publications.

By the end of Phase Three, a total of 32 journals were collected and transcribed for use as part of the overall study data. In Phase One, 22 students and one lecturer provided journals, in Phase Two five students did likewise and in Phase Three all four participating students provided me with their journals. From these journals I obtained useful data about what the students said were important learning events and outcomes from their work with the mentors. These data were transcribed verbatim for analysis.

Although the students' journals collected in Phase Two and Phase Three were small in number and not comprehensive, they provided the students' perspective on the study situation and other information about what the students said were important learning experiences. These data assisted my understanding of the study phenomena and helped me to develop answers to the overarching research questions.

Conclusion To This Chapter

The use of a diverse range of data gathering methods in this research study provided data about many different aspects of the overall study phenomena. Having multiple data sources for individual events allowed for triangulation of data. Member checks were conducted using informal interviews following work sessions and at the conclusion of each of the three phases of the study.

In-depth investigation of many features of the learning situation that emerged as part of findings from analysis of the study data was made possible through the various sources of data available at different stages of the study. As new data were collected using various methods, it was possible to develop different perspectives on the situations under examination. This facilitated the integration of different data collection methods and often led to confirmation findings that emerged from analysis of data collected earlier in the study.

The diversity of data collection methods and the prolonged data collection period produced an extensive body of data. In many instances similar or overlapping data, concerning various events in the study phenomena, were collected from different sources and at different times throughout the study period. In my role as researcher and being the data collection instrument in this study, helped me to respond to trends emergent from those data. This led me to modify collection methods and develop new ones to refine and enhance data gathering, as the study progressed. Using this approach led to more informed research methods, which enhanced the overall richness and relevance of the information gathered over the duration of the study.

This Chapter begnn by describing the data collection methods used for each of the three phases of this study. Each of these data collection methods was then discussed in detail with reference to the kinds of data collected and the relevance of that material to the research questions. Examples of typical data collected have been used to explain how the study structure and data collection methods were relined in response to themes that emerged as data transcription and proceeded as part of each new phase of the study.

Finally, the relative importance of some data collected, using methods such as telephone conversations and student journals, that were small in number but regarded by me to be important to understanding how student learning took place in the study situation, were discussed.

In the next Chapter, the methods used for analysis of each different data collected for this research are discussed.

CHAPTER FIVE

ANALYSIS OF THE STUDY DATA

Introduction

In this chapter, methods used to analyse the study data are described. As analysis is inextricably entwined with results, relevant emergent findings and results are also presented. The approach to analysis of the study data used here is based on inductive analysis methods us described by Patton (1990, p. 40) who contends that inductive analysis is characterised by "immersion in the details and specifics of the data to discover important categories, dimensions and interrelationships".

Analysis of the study data commenced with the first data collection and continued with each new set of data collected throughout the study. This Chapter begins with a discussion of the how the data were analysed and the reasons for using the methods chosen. The primary method of data reduction was coding, with summaries and tables also being used to organise and refine the analysis. Phase One data consisted mostly of student journal entries. Phase Two data were mostly interview-based although other data from informal discussions, telephone conversations and sketches were also coded. Phase Three data were mostly collected using direct observation and video recording of student/mentor work sessions. Other data were also collected during Phase Three using interviews and sketches created by students and mentors as part of their design development and as key communication tools in collaborative work sessions.

This Chapter details the creation and development of coding categories used for analysis of data collected in each of the three phases of this research study. How emergent findings influenced the subsequent development of other data coding categories to represent common trends thought to affect student learning is also discussed. A reflexive approach was taken to data interpretation and the progressive development of index tree structures by merging coding categories in response to emergent findings. The Chapter concludes with discussion of the analysis methods used for interpreting Phase Three observation-based data and ways for using this to confirm findings that emerged from analysis of data from the first two phases of data collection.

Coding

The overall process of data analysis was one of coding from raw data to eventually generate themes. The process of analysis began with coding, which involved creating categories by assigning words or phrases to transcribed text units. For the purposes of data analysis, the text unit used was the sentence. Using full sentences for coding helped to maintain context and meaning in themes that emerged when subsequently examining data for the frequency of occurrence, similarities, differences and associations about linked events and activities.

Analysis began by first printing text files in which every text unit, referred to hereafter as a data unit, was numbered. Each numbered data unit was then coded using both manual and computer based methods, utilising categories established during data transcription, as well as others that emerged during analysis. Data coded, using categories developed throughout this process, were then compared and summarised to establish common themes eventually leading to findings about learning in the study situation.

The use of categories for coding data in this manner was based on methods suggested by Richards & Richards (1995), who contend that a category may be considered simply as part of a hierarchical system for organising or coding data. Coding categories were arranged using index tree structures which provided a labelling, retrieval and organising device for exploring the study data (Holsti, 1969). NUD•IST (1998) software was used to arrange coding categories and other code names developed "in-vivo" from words or phrases used by the participants when describing their learning experiences (Strauss & Corbin, 1990, p. 69; Richards & Richards, 1995). Burns (1995, p. 288) argues that this approach is "part of the analytic induction method where the general statement about the topic is constantly refined, expanded and modified as further data is obtained". Analysis of data using coding methods in this way is based on the view that "coding is analysis" (Miles & Huberman, 1994, p. 56).

Data were analysed using categories based on:

- event codes for specific activities undertaken by the participants, such as student/mentor work sessions. For example, Index Tree Four category *1.4: Entry To The Culture Of Practice*;
- situation codes, that is how the students and the mentors in this study define settings in which their collaboration operates. For example, Index Tree Four category *2.2 Team Based Learning*;
- process codes, being the stages of the building design process in which mentoring activities take place. For example Index Tree Four category *3.1: Common Design Office Practices;*
- strategic codes, relating to how the study participants carry out their tasks and roles. For example Index Tree Four category 3.2: *Learning Methods Using Coaching;* and

- subject perspective codes, documenting how participants think about their situation in this study (Burns, 1995, p. 290). For example Index Tree Four Category *2.1 Confidence*.

During transcription of student journals and interview recordings, I made use of codes and memos to describe frequently occurring data about events, learning situations, learning strategies and personal perspectives regarded by me to represent important aspects of the study situation. I then used these codes and memos, along with the research questions and the key elements of a cognitive apprenticeship learning approach to develop additional coding categories.

Coding was an ongoing process in which each unit of data was classified using categories to represent emerging themes. In all, four index tree coding structures were developed for analysis of the study data. Index Tree One (see Table 5 and Appendix D) was used for Phase One (the pilot study) data. The other three index tree structures evolved during analysis of the main study data as new categories were created or merged with others in response to emergent themes, from which findings were developed. Index Tree Two (see Table 6 and Appendix E) was used for coding data from Phase Two, first round interviews. Index Tree Three (see Table 7 and Appendix F) was used for coding data from Phase Two, round two interviews, as well as re-coding of round one interview data. Index Tree Four (see Table 8, p. 94 and Appendix G) was used for the final analysis and reduction of all Phase Two data, as well as for the exploration of themes and emergent findings through comparison of Phase Two data with Phase Three data.

Following transcription of data from journals, notes and interview tapes, into computer text files, each file was introduced into NUD•IST (1998) software for the initial purpose of generating reports having numbered text units for coding. Manual methods were first used to code data into categories. Manual coding took place by assigning colours to each of the coding categories, then using coloured pens to highlight numbered data units judged by me to fit into each category. This method provided a means for seeing at a glance the frequency and distribution of data units coded in particular categories. Using these coloured text files, I was able to compare similar data from different sources about the same or similar events, as well as to examine trends and emergent findings. This approach to analysis of the study data was also guided by the principles of content analysis which Patton (1990, p. 381) argues is "... the process of identifying, coding and categorising the primary patterns in the data".

Having established preliminary coding categories based on themes that emerged during manual coding of the data, the computer based coding tools in NUD•IST (1998) software were then used to code the data in categories organised according to Index Tree One (see Table 5 and Appendix D). Further analysis of the data then took place using "key-words-in-context" (KWIC) methods (Ryan & Bernard, 2000, p. 775) to determine the frequency of occurrence, similarities, or associations in data about particular events in the learning situation. This led to the emergence of "themes" that described the study phenomena (Ryan & Bernard, 2000, p. 780). The KWIC analysis of the study data were used in conjunction with manual coding of the data. This approach was used because using KWIC searches alone was thought to be inappropriate due to their generating many returns that did not fully provide the context and rich description of events present in data units or groups of data units. Manual searching of category reports allowed me to embrace whole categories of data while examining the context that individual data units have within the coding categories of the index tree structure. Findings that emerged from analysis of Phase One data were used to develop a more comprehensive Index Tree structure for coding Phase Two data so that KWIC searches could be more effectively conducted.

During analysis of the study data, themes were developed by grouping frequently occurring data regarded by me to be similar in content and about learning in the study situation. Using this approach, four main themes that together represented the overall learning situation were developed, along with others based on categories created to code data about multiple aspects of student learning that emerged during analysis. For example, KWIC searches showed that *sketching* and *talking* occurred together in data units 64% of the time and individually a total of 35% of the time. For this reason *sketching* was included in a theme about communication, along with *discussion* and *articulation* resulting in Index Tree Four categories *1.1*, *1.2* and *1.3*. Other data about the use of *sketching* indicated its use as a design exploration tool, regarded as a usual office practice and as a method used by mentors during coaching sessions for reflecting on ideas or pathways followed in design development. In response to findings that emerged about the multiple applications to which sketching methods are applied, data about these were coded in categories such as *3.1 Common design office practices* and *4.2 Reifying knowledge in design office learning*, which represent themes that emerged during coding.

Grouping of categories having similar or related data to develop themes that represent different aspects of student learning allowed me to refine each of the four index tree structures used to code data. Analysis of data in this way allowed comparison of interview-based data about what the students and mentors said took place, with my observation of actual student/mentor work sessions.

Throughout the data analysis process, new categories were defined as other data were collected or emerged during analysis (Holsti, 1969). With the development of Index Tree Four, I was confident that categories structured around the four main themes that emerged during analysis, were capable of accommodating all data collected in ways that "represented the purposes of the research, were exhaustive and mutually exclusive" (Holsti, 1969, p. 95).

Findings that emerged from analysis of each new data set collected were used to guide the development of new structures for coding subsequent data. This approach gave flexibility to the coding structure when responding to emergent themes and findings. It also ensured that the coding structures I developed were appropriate to the overall study phenomena. The processes used to develop and refine each of the four index-tree coding structures used for analysis of the study data is discussed next, in the context of each of the three data collection phases.

How index tree structures evolved during data analysis

There were four index tree structures used for the final coding of the study data. These evolved by refining and merging index tree structures and categories developed during earlier analysis of data. In this section, the methods used to develop categories are discussed, along with examples of data from which some of the categories and index tree structures were created.

Data collected during Phase One consisted mostly of verbatim transcription of student journal entries and researcher journal notes created during discussions the mentors and lecturers. Analysis of these data took place by coding and comparing data from each of the participants. Where codes were seen to be frequently occurring, the categories used to code them were grouped into themes representative of events or activities regarded by me to affect student learning.

For example, a theme that emerged from analysis of Phase One data suggested that the lecturers mostly focussed on the kinds of activities that the students undertook and what potential learning outcomes they promoted. The following comment made by one of the TAFE lecturers is typical of many similar comments made by mentors and other TAFE staff:

> The thing you really need to look at here is what are they actually doing for themselves and what will they do as a team. You know, are they

> working on real projects like you have to in an office, not just going for the ride. They need to be doing things all the time or they get bored and let others do the work. (Lecturer 2, Planning discussion)

From this and other similar data, the theme *Activities* (see Table 5) was established with categories for coding data about the kinds of activities that the participants said took place during their design project experiences. Much of the data collected from student journals in Phase One of the research described a diverse range of activities they had experienced. Some activities described by students in their journals as important learning experiences took place in the design office setting, while others occurred on the building site or during social contact with other students and mentors. The following extract from one student journal includes references to design activities in the social setting, the building site and the design office.

> We had a really top day today. Our design group spent some time with Wally (mentor) and the client just having lunch and talking a bit about the design, but we didn't do any real work. Later we went up to the site and that was really inspiring, just seeing the view and having the client tell us what he wanted in the design. When we went back to Wally's design office we did some rough sketches of our ideas and each had a chance to shoot all the others' ideas down. We also had a few beers and that really helped get the whole thing going. (Student 18, personal diary journal entry)

KWIC search methods were used when analysing these data to identify emergent themes. New categories were created for frequently occurring codes about different aspects of student experiences regarded by me to influence learning. Working in this way allowed me to retain the meaning and context of the data units identified in the KWIC searches, by coding with these other data units that supported or differentiated those data. For example, for the *Activities* theme discussed here, I created sub-categories that enabled coding of new data according to *Group Activities, Design Activities* and *Site Visits*, as shown in Table 5 (p. 84).

A second theme to be developed during transcription and initial coding of frequently occurring data units found in Phase One data focussed on stimulation in the study situation. Findings that emerged from preliminary analysis of data coded in categories developed to represent this theme suggested that the mentors were mostly concerned with how the experience of working on authentic projects affected student learning and how students might apply their knowledge and skills to other design projects. The following comments made by Mentor 1a are typical of other similar ones made by mentors throughout the entire study:

> I think that what is really important here is what affect does doing a real design project, in a real design office setting have on them (the students)? What I am looking to see is whether or not they get fired up and enthusiastic. Are they pumped up by being creative, or just going through the motions of knocking out a design using the same tired old methods that we all know will give a design of some sort. I want them to be free thinking and innovative; anyone who comes to my office won't survive if they can't think for themselves. (Mentor 1a)

Comments such as these led to the development of Index Tree One categories, *2.1 Stimulation* and *2.2 Freedom In Design* for coding data about how the role of stimulation in student learning using mentor supported authentic design projects. These and other categories, established in a similar manner, were combined to form Index Tree One (shown in Table 5), which was used for coding Phase One data.

Student journal based data about learning events that took place in Phase One were compared with other data about the same events, obtained from informal discussions and post design project interviews with the students, mentors and TAFE staff. Examination of data thus coded included comparing the frequency of occurrence of data in individual categories with the overall data to determine common trends or themes in participant responses regarding learning experiences. In addition, the intensity or passion (Strauss & Corbin, 1990) with which some participants expressed their views was recorded in my field notes which were included as part of the overall data analysed. The intensity of responses was considered to be of importance because of the artistic disposition of the design discipline and the often highly charged presentation of points of view observed being used by the participants throughout this study.

Phase One, data analysis took place using progressively refined coding structures that provided ways for comparing data initially coded in broad categories, with data coded in other categories created to address specific elements thought to effect learning. Findings from this process were then used to further refine coding categories to represent emergent themes for analysing the study phenomena. Constant comparison of data during coding made it possible to gain new perspectives on the material and to differentiate between learning influences. This also enabled me to keep the meaning and context of data intact so as to stay attuned to the respondents' views of their realities by developing inductively my interpretation of the overall study events (Strauss & Corbin, 1990).

As other data were collected throughout each of the three phases of this study, they were transcribed and coded using categories developed as described above. Sketches collected as part of the study data were used to compare what the participants said they had used in their design solutions, with what was evident in the rough workings and refined presentations shown in their actual drawings.

Generally, data were analysed by:

- coding the frequency of occurrence of data units or participant responses and expressing this as a percentage of the overall data units coded;
- comparing and contrasting data through KWIC searches to determine relationships between events and experiences thought to affect student learning; and
- the intensity of responses.

Detail of analysis of Phase One data

Data collected using student diary journals in Phase One were coded in categories developed to represent the following four themes:

1 Activities:

Mentor supported design activities experienced by the students.

2 Affect:

The affect of design experiences with a mentor on student learning.

3 Learning:

Learning outcomes that emerged from student/mentor collaborative experiences; and

4 Application:

Students' perceptions of how newly acquired knowledge and skills could be applied.

Phase One data were coded using categories to represent these themes, as structured in Index Tree 1, (Appendix D) shown here in Table 5 along with examples of typical data units coded in each category. Comments about how these were used to refine data collection in Phase Two and Phase Three of this study are also shown. Each of the four coding categories shown in Table 5 has the total number of data units coded (for that category) shown adjacent. Also shown is the average percentage distribution of data units for each sub-category.

Table 5.
Index Tree One Coding of Phase One data

Categories Used For Coding Phase One Data	Data units coded	Example of typical data units coded in this category	How these data were used to develop Phase Two and Phase Three of this study
1. Activities	290		
1.1 Group activities	47%	Everything we did today we did as a team, we helped each other all the way (data unit 136)	Developed interview questions to explore team activities. Selected a two designer team for six Phase Three office observation sessions
1.2 Design exercises	13%	We weren't restricted in any way; it was really great that we could design anything we liked (data unit 171)	Focussed part of each Phase Two interview on individual expression in the design projects used. Selected Mentor 5 (open creative approach) for study in Phase Three, based Phase Two interview and information from TAFE staff.
1.3 Site visits	40%	Visiting the site of Wally's house and having him talk about it made me think that anything is possible if you are inspired and dedicated (data unit 435)	Developed interview guide questions for Phase Two to explore the use and value of site visits
2. Affect	251		
2.1 Stimulation	65%	The experience that I gained from Bluff Knoll gave me the will power to push myself to do something that I thought wasn't possible; then seeing the dome house made me see that anything possible can be built even if it looks impossible (data unit 452)	Developed interview questions aimed at exploring how mentors sought to stimulate students and how students considered the (mentor) experience stimulated them. Post observation session interviews Phase Three addresses this closely
2.2 Freedom in design	35%	Because we were given such a free hand with the design, I am now more confident to do abstract designs and to express my ideas openly (data unit 476)	Collected design sketches and drawings to examine the diversity of ideas explored by each student/mentor team

Table 5 continued on next page

Categories Used For Coding Phase One Data	Data units coded	Example of typical data unit coded in this category	How these data were used to develop Phase Two and Phase Three of this study
3. Learning	240		
3.1 Situational factors	26%	Being in that setting showed me how important it was to get the orientation right. Karri Mirs individual housing had it wrong and was really uncomfortable to be in. (data unit 520)	Compared interview data and student drawings from 10 different design offices to determine any major differences in design practice outcomes
3.2 Mentor influence	42%	Working with Wally inspired me, the experiences add up to the philosophy that you only design what you have seen, heard, felt (data unit 694)	Developed interview questions to target the nature and degree of mentor influence over the student designs.
3.3 Input by others	32%	Talking to Cameron about my design was fantastic because he gave me more of an insight into his views and design ideas like advantages and disadvantages and things to change to get it to work (data unit 342)	During Phase Two interview questions were used to explore the role of others in the design office team. In Phase Three the two designer team in one office was observed working with a student in 6 work sessions
4. Application	222		
4.1 Evaluating ideas	79%	Doing this gave me a new way of thinking about materials and form. I now have a greater insight on mud brick construction and solar design and how to best use windows and doors to create space (data unit 666)	Questioning of students on their use of self evaluation and reflection on design methods acquired during the mentor supported project
4.2 Self development	21%	I learned that if I put my mind to whatever challenge I have I can accomplish it. Working with the mentor opened up my mind to a completely different way of designing (data unit 426)	Questioning of the students about their views on how the experience had changed their design practices and what they saw as the next stage of development and application of their recently acquired skills

This coding structure was refined as new data emerged from discussions between myself, TAFE lecturers, mentors and the students. Trends that emerged from analysis of the Phase One data assisted me to identify the kinds of activities that students said had helped them to learn. This led to the development of other possible lines of inquiry to be explored in Phase Two and Phase Three of this study. These data provided the stem for interview guide questions developed for data collection in Phase Two and were used to refine the research study structure and data collection strategies.

Member check interviews which I conducted as discussions with three TAFE lecturers and three mentors following the completion of Phase One assisted me in confirming emergent findings, as well as identifying other aspects of the study situation that needed to be explored in subsequent phases of the study.

Analysis of Phase Two data

In this section, the methods used to analyse Phase Two data are discussed. Firstly, the development of the index tree structures and coding categories used for analysis of Phase Two data are discussed in general. Then, a detailed explanation is given for the development of two Phase Two coding categories in order to make clear the processes used for interpreting data. The manner in which findings that emerged from analysis of Phase One were used to explore to develop and refine categories used for coding of Phase Two data is also discussed.

In Phase Two analysis began with coding data collected in the first of two rounds of interviews. Categories used for analysis of Phase Two data were developed from the research questions, Phase One categories, as well as from preliminary findings emergent from analysis of Phase One data. Data collected during the first round of Phase Two interviews were analysed using Index Tree Two categories, shown in Table 6 (see p. 88, and Appendix E). Following each Phase Two interview, data were transcribed verbatim, then coded. This approach allowed me to continuously analyse each new data for frequently occurring responses and emergent trends that guided the exploration of other aspects of the study phenomena. Introducing new categories and refining coding using existing ones allowed analysis of the overall study phenomena in categories that together represented the purposes of the research and provided a framework for coding all Phase Two data. Table 6 shows Index Tree Two, developed using this approach and used for analysis of the first round Phase Two interviews. Included in Table 6 are comments (in the far right column) that indicate the derivation of Index Tree Two coding categories, most of which have their roots in Index Tree One, as shown in Table 5 (p. 84).

Data collected in the second round of Phase Two interviews were coded using categories developed from Index Tree Two, but organised into a new structure, Index Tree Three (Appendix F). The development of new categories used in Index Tree Three were guided by information obtained in member check interviews conducted with students and mentors following each round of Phase Two interviews, during Phase Three observation sessions. Some categories used in Index Tree Three were then merged with others regarded to have similar data and other new categories were developed to form Index Tree Four (Appendix G), which was used for the final coding of Phase Two data.

Table 6.
Index Tree Two – Phase Two First Round Interview Data Coding Categories

1 Personal views & experiences	1.1 Authentic experience	1.1.1 Design style (6.7%) 1.1.2 Design application (4.1%) 1.1.3 Design concepts (6.1%) 1.1.4 Design strategies (4.5%) 1.1.5 Innovation (5.4) 1.1.6 Accessibility (1.1%) 1.1.7 Location/site (1.6%) 1.1.8 Experiences (3.7%) 1.1.9 Office practices (3.6%) 1.1.10 Resources (1%)	This group of categories were developed from the Index Tree One "Activities" coding categories
	1.2 Collaboration	1.2.2 Progress issues (2%) 1.2.3 Negotiation (3.8%) 1.2.4 Confidence (3.4%) 1.2.5 Confidence (1.7%) 1.2.1 Insecurity(2.2%)	This group is developed from Index Tree One categories: 3.2, 3.3, 4.2
	1.3 Metacognition	1.3.1 New ideas (3.5%) 1.3.2 Shared knowledge (3.8%) 1.3.3 Problem solving (6.5%) 1.3.4 Tacit knowledge (2.7%) 1.3.5 Thinking (2%)	This group was developed from Index Tree One categories: 2.1, 2.2, 3.3, 4.1
2 Design office and mentor practices	2.1 Cognitive apprenticeship elements	2.1.1 Modelling (3.5%) 2.1.2 Coaching (3%) 2.1.3 Reflection (1%) 2.1.4 Scaffolding (3%) 2.1.5 Articulation (4.8%) 2.1.6 Exploring ideas (2.5%)	This group of categories is based on key elements of a cognitive apprenticeship approach
	2.2 Communication 2.3 Culture (3%)	2.2.1 Discussion (3.8%) 2.2.2 Sketching (6.1%)	These categories were developed in response to frequently occurring data

Note: Categories shown in this index tree structure were used for analysis of Phase Two round one interview data. The figures shown in parenthesis indicate the percentage of data unit retrievals for each category used for coding first round interview data.

At the conclusion of the first round of Phase Two interviews, all data collected up to that time were analysed. Analysis took place as described earlier for Phase One data by using both manual coding and KWIC text string searches of category reports generated using NUD•IST (1998) software. Coding of Phase Two, round two, interview data was conducted in the same way as that used earlier, but also guided by findings that emerged from analysis of those earlier data, as well as the overarching research questions of this study.

For example, analysis of first round interview data showed a higher response rate, when compared to the average 4.54%, for the overall data coded by participants for data coded in Index Tree Two categories *1.1.1 Design style (6.7%), 1.1.3 Design concepts (6.1%), 2.1.5 Articulation (4.8%) and 2.2.2 Sketching (6.1%)* (see Table 6, p. 88). When interpreting these results, I considered that learning in the study situation was influenced by the particular design style of the mentor and the manner in which design concepts were visualised and communicated using articulation and sketching. To investigate this further in the second round interviews, I prepared new interview guide questions constructed to probe more deeply the use of these elements. Analysis of data collected in the second round interviews took place using coding categories developed from Index Tree Two, as well as many new Index Tree Three categories as shown in Table 7 (p. 91). Using the example just described, the following new categories were created for Index Tree Three:

- Category *2.1.5 Mentor style* – Derived from Index Tree Two category *1.1.1 Design style*, but also incorporating data collected in second round interviews that focussed on aspects of how mentors design and their approach to working with a student in the design office.

Merging existing categories with new categories allowed the scope of analysis for particular aspects of the study situation to be redefined through reflective procedures, thus facilitating more exhaustive study of the phenomena. For Example:

- Category *2.3.6 Conceptualisation*, was developed for Index Tree Three by merging some data previously coded in Index Tree Two category *1.1.3 Design concepts*, with new data collected in round two interviews using questions intended to explore in greater detail the role of design concepts in student learning.

This process of using new data to refine and extend the inquiry continued throughout the second round of interviews. Following each interview, data were transcribed verbatim from the interview tapes. These data were coded using Index Tree Three. Data collected in the second round of interviews embraced new aspects of the study situation. Coding of Phase Two data was thought by me to reach "saturation" when all new data introduced through verbatim transcription of the second round of interviews were readily coded using existing categories (Charmaz, 1990, p. 520).

Table 7 (p. 91) shows Index Tree Three, used for the initial analysis of Phase Two data. Index Tree Three was developed using coding categories from Phase One Index Tree One, Phase Two Index Tree Two and from findings that emerged from analysis of those data. Categories shown with an asterisk (*) are those from which new categories were created for the fourth and final, index tree developed for analysis of Phase Two data. In this way Index Tree Four was developed by redefining, merging and collapsing categories, then re-coding data to focus emergent findings to explore aspects of the data thought to be significant to the overarching research questions.

Table 6 and Table 7 show the Index Tree structures used for the initial coding of Phase Two data. Percentage figures shown alongside the coding categories of Index Trees Two and Three indicate the level of data coded in each category as measured as a percentage of the overall units of data coded. These figures provide an indication of the distribution of the overall data in each index tree. Included also in each Table is a list of the categories from which each index tree was developed, as well as some categories that were collapsed or merged in order to create new ones. Data coded in eliminated categories were re-coded into new ones, or merged with other similar ones. Analysis of data using some categories provided insights into the learning situation, but were not very significant to the overall understanding of the study as a whole. Categories identified as contributing little to the overall study were merged with others, or deleted if thought to be of little value. Mostly, categories showing less than 1% coding of the overall data units were merged with others, or deleted. How this changed the coding structures used for analysis of the study data is shown below in Table 7 (p. 91).

Table 7.
Index Tree Three – Categories used for coding Phase Two data

	Main Categories	Sub categories • Indicates categories used for final Index Tree. See Table 7, Index Tree Four	% of overall data units	Derived from Index Tree Two Category
1 People (Derived from 1.0 in Index Tree Two)	1.1 Communication (Derived from 2.2 in Index Tree Two)	•1.1.1 Articulation	1.38%	2.1.5
		1.1.2 Others	1.15%	1.1.7
		1.1.3 TAFE	0.38%	
		•1.1.4 Discussion	3.10%	2.2.1
		•1.1.5 Sketching	4.02%	2.2.2
		1.1.6 Transfer	1.11%	
		•1.1.7 Networking	0.19%	
	1.2 Attitudes (Derived from 1.1/1.2 in Index Tree Two)	•1.2.1 Expectations	1.26%	1.2.2
		1.2.2 Student Expectations	0.88%	
		1.2.3 Mentor Expectations	0.99%	
		1.2.4 Confirmation	0.31%	1.2.4
		•1.2.5 Confidence	1.91%	1.2.1
		•1.2.6 Mindset	1.72%	
		1.2.7 Bonding	0.15%	
		•1.2.8 Satisfaction	1.07%	
		1.2.9 Excitement	0.80%	
	1.3 Collaboration (Derived from 1.2 in Index Tree Two)	•1.3.1 Negotiation	3.10%	1.2.3
		1.3.2 Accessibility	0.69%	1.1.6
		1.3.3 Balance	1.15%	
		1.3.4 Respect	0.80%	
		1.3.5 Entry Skills	1.15%	
	1.4 Learning (Derived from 2.1 in Index Tree Two)	•1.4.1 Learning with mentor	1.99%	
		1.4.2 Experience	4.55%	1.1.8
		•1.4.3 Modelling	2.26%	2.1.1
		•1.4.4 Coaching	4.63%	2.1.2
		•1.4.5 Scaffolding	3.10%	2.1.4
		1.4.6 Skills	1.68%	
		•1.4.7 Preparation	1.42%	
	1.5 Enculturation (Derived from 1.1 in Index Tree Two	1.5.1 Entry to culture	0.65%	
		1.5.2 Social Contact	0.96%	
		1.5.3 Bonding	0.57%	
		1.5.4 Behaviour	0.31%	
		•1.5.5 Office Expectations	1.87%	

Table 7 continued on the next page

Index Tree Three Used For Coding Phase Two data

	Main Conceptual Categories	Sub categories * Indicates categories used for final Index Tree. See Table 8	% of overall data units	Derived from Index Tree Two Category
2 Design Office and Mentor Practices	2.1 Approach	*2.1.1 Office Practices	5.62%	1.1.2
		2.1.2 Brief.	1.15%	
		2.1.3 Resources	2.49%	1.1.10
		*2.1.4 Innovation	2.45%	1.1.5
		2.1.5 Mentor style	3.94%	1.1.1
		*2.1.6 Ideas Justification	1.91%	
		2.1.7 Creativity	1.84%	
		2.1.8 Aspirations	0.38%	
		*2.1.9 Support	0.99%	
		2.1.10 Global	0.50%	
	2.2 Experience	*2.2.1 Standards	0.77%	
		2.2.2 Tacit knowledge	3.02%	1.3.4
		*2.2.3 Strategies	5.70%	1.1.4
	2.3 Metacognition	*2.3.1 Ideas	2.14%	1.3.1
		2.3.2 Shared Knowledge	2.41%	1.3.2
		*2.3.3 Reflection	1.34%	2.1.3
		2.3.4 Problem Solving	3.21%	1.3.3
		*2.3.5 Explore apply	3.56%	2.1.6
		*2.3.6 Conceptualisation	2.03%	1.1.3
		2.3.7 Thinking	1.64%	1.3.5
		*2.3.8 Visualisation	1.61%	

Data transcribed from the second round of Phase Two interviews were coded along with all of the previously coded Phase Two data, using categories developed for Index Tree Four. This process involved re-coding earlier data, merging and differentiating categories from Index Tree 3 regarded by me to hold similar data and this led to the development of hypotheses und preliminary findings that were explored further during Phase Three. The manner in which new categories were developed from Phase Two data is now discussed with reference to the following example interview excerpt in which Student 18 talks of his design office experiences:

> As the design got going a bit we spent a lot more time at her office working together refining things. She would give me some ideas about where things should go then I would sketch it out and often she would want me to change it again – there were lots of changes and design ideas that we tried out but ended up not using for one reason or another. While we were working she was always talking about why she did things in

> particular ways and she was always sketching and sort of thinking out aloud as she went through the reasons for things not working or whether to include them or not in the design. That really helped me to understand how to design like she did. (Student 18)

Several aspects of student learning using cognitive apprenticeship methods as defined in this thesis are evident in this example. The first is the collaborative nature of the working relationship that developed between student and mentor; "*we spent a lot more time at her office working together refining things*". Data about student/mentor collaboration were coded in Index 4 categories *1.4, 2.2, 3.2* and *4.2*. Another element in this example, "*sketching and sort of thinking out aloud*" was observed to be a practice common to all of the participating mentors. For this reason the use of sketching together with articulation of the reasons for working in particular ways when problem solving in design was thought to be a significant construct when coding data and was represented in multiple categories. In Index Tree Four these included *1.2, 1.3, 3.1, 4.1* and *4.2*. Coding data in this manner assisted me in understanding relationships between the various activities used by the mentors to make visible to the students their tacit knowledge, usual design procedures and problem solving methods.

Data, about how students developed problem solving skills and how they used heuristic design strategies modelled by the mentors, were collected from examples like the one used here; "*she went through the reasons for things not working or whether to include them or not in the design*". Data such as this were coded in Index Tree Four categories including *1.2, 3.1, 3.2, 3.3, 3.4* and *4.3*. Again, data of this type were useful in understanding how the mentors made visible their tacit knowledge and how they applied decision making procedures in design in the context of their everyday culture of practice activities.

Table 8 (p. 94) shows Index Tree Four which was developed using new categories devised to code data units representative of emergent constructs, along with other categories developed in each of the earlier index trees, or from merging multiple categories in order analyse groups of data. Index Tree Four was used to focus analysis of all data collected up to the end of Phase Two, in ways thought suitable to provide the most detailed representation of the overall study phenomena. In particular, categories were developed to explore data about the events and to explore relationships between mentor design office procedures and mentoring methods thought to facilitate student acquisition of knowledge and skills in design.

Table 8.
Index Tree Four - Used for final coding of Phase Two data

Coding Categories Used To Represent Themes	Sub-categories for coding data	% of overall data units	Derived from Index Tree Three category	Merged with Index Tree Three category
1 Communication	1.1 Discussion	3.10%	1.1.4	
	1.2 Articulation	5.38%	1.1.1	
	1.3 Sketching	4.02%	1.1.5	
	1.4 Entry To The Culture Of Practice	9.33%	1.1.7	1.1.2 1.3.4 1.5.1-4
2 Attitudes	2.1 Confidence	6.39%	1.2.6 1.2.5	2.1.8 1.2.4
	2.2 Team-based Learning	2.10%	NEW	1.2.7 1.2.9 1.3.3
	2.3 Office expectations	5.38%	1.1.2	1.1.1-3 1.5.5
3 Mentor Supported Design Office Practices Affecting Learning	3.1 Common Design Office Practices	12.6%	2.1.1 2.1.9 1.4.7 2.2.1	2.1.2 2.1.10 1.2.1-3 1.4.6
	3.2 Learning Methods Using Modelling	10.8%	2.2.3 1.4.3	1.3.3 2.1.5
	3.3 Learning Methods Using Coaching	10.2%	1.4.4 2.3.1	2.3.2 2.1.6
	3.4 Learning Methods Using Scaffolding	9.6%	1.4.5	1.3.2 2.1.3
4 Collaborative Design Office Experience And Learning	4.1 Developing A Creative, Innovative Approach To Design	6.29%	2.1.4 2.1.7	1.3.5
	4.2 Reifying knowledge In Design Office Learning	9.22%	NEW 1.4.1 1.2.3	1.1.6 2.2.2
	4.3 Visualisation, Exploration, Reflection and Design Style	8.15%	2.3.3 2.3.5 2.3.8	1.3.5

Analysis of Phase Three data

Following analysis of data collected during Phase Two of this research study, data collection began in Phase Three using direct observation and video recording of student/mentor work sessions. Direct observation of students interacting with mentors in the design office was conducted in order to:

- confirm preliminary findings emergent from analysis of Phase Two data which was mostly based on what the mentors and the students said they did; and
- explore the learning situation in other ways with a view to finding new aspects of student learning.

Data gathering in this part of the research centred on direct observation and video recording of design office based work sessions involving four students and five mentors working in four different design offices. The five mentors studied in this part of the research were selected because their working practices and approach to mentoring was considered by me to be representative of those of the general group of mentors who participated in Phase Two of this study.

Coding of Phase Three video data was based on a minute-by-minute analysis of the video recordings of 12 work sessions, using categories derived from Index Tree Four, shown in Table 8 (p. 94). Additional coding categories were introduced where it was thought that activities or events in the observed work sessions needed to be analysed in greater detail. The complete list of categories used for coding Phase Three data is shown in Table 9 (p. 96). Data were analysed using methods based on content analysis (Holsti, 1969) by coding the frequency of occurrence of activities and events observed during analysis of the video data recorded for each category, expressed as a percentage of the overall work sessions times.

Additional categories were introduced to the coding structure in response to new aspects of the learning situation that emerged during analysis. This approach was used in order to maintain consistency in analysing data to ensure construct validity when recording observed behaviours and skills modelled by the study participants in the learning situation (Gonczi, Hager, & Anthanasou, 1994). It also assisted me to examine in detail aspects of the study situation that emerged during analysis and regarded by me to influence learning. In Table 9 (p. 96) the frequency of occurrence of events and activities observed for each of the four student/mentor teams is shown as a percentage of the overall data units coded in each category. Since multiple activities were observed to occur within each minute of the video record of the work sessions, the percentage figures quoted in Table 9 (p. 96) and throughout this thesis represent the occurrence of each activity within each minute and therefore the sum of these is greater than 100%. The percentage figures provide a guide to the frequency of occurrence of activities or events in the overall data for each work session. These data were compared to the mostly interview based Phase Two data, with a view to confirming common themes in learning events and mentoring practices.

Table 9.
Phase Three video recorded work sessions data

Coding Categories	Stem Tree 4 code	M4 %of Time	M6 %of Time	M3 %of Time	M1,1a %of Time	Average
		Mentor number				
Culture of practice						
Student/mentor bonding	1.4	7%	14%	89%	100%	53%
Contact with others	1.4	10%	70%	13%	87%	25%
Access mentor/facilitics/others	3.2	0%	38%	18%	56%	28%
Office archives/resources		0%	5%	15%	5%	6%
Interaction	1.4	10%	41%	89%	100%	60%
Evaluation (skills)	3.1	10%	0%	22%	12%	11%
Preparation	3.1					
Student – sketches	1.3	30%	28%	21%	82%	40%
Mentor/sketches	1.3	1%	0%	21%	1%	6%
Mentor/examples	1.3	10%	11%	26%	15%	16%
Mentor/own works	1.3	9%	11%	31%	9%	15%
Student materials		2%	0%	15%	62%	20%
Planning/Job planning		27%	3%	30%	46%	27%
Knowledge transfer	4.2					
Declarative	3.1	31%	27%	59%	41%	40%
Procedural	3.2	29%	51%	48%	62%	48%
Tacit	3.1	28%	35%	79%	57%	50%
Office practices	3.1 3.2	21%	43%	35%	28%	32%
Design	4.1	40%	59%	24%	21%	36%
Associated/discipline related		7%	3%	13%	0%	6%
Heuristic strategies	3.1 3.2	50%	46%	30%	26%	38%
Problem solving	3.1 3.2	28%	51%	39%	37%	39%
Style Development	4.1	15%	19%	11%	24%	17%
Student presenting ideas	3.1	8%	24%	23%	26%	20%
Mentor Analysis/ideas	3.2	27%	22%	50%	43%	36%
Student Analysis/ideas	3.2	10%	16%	23%	25%	19%
Discipline Content/facts	3.1	0%	41%	77%	32%	38%
How is learning taking place	4.2					
Modelling	3.3	29%	24%	14%	23%	23%
Coaching	3.4	42%	57%	83%	60%	61%
Scaffolding	3.5	22%	22%	32%	21%	24%
Articulation	1.2	65%	46%	65%	73%	62%
Discussion	1.1	35%	70%	83%	59%	62%
Sketching	1.3	65%	43%	47%	57%	53%

Continued on next page

Coding Categories	Stem Tree 4 code	Mentor number M4 % of Time	M6 % of Time	M3 % of Time	M1, Ia % of Time	Average
Explanation Building	4.2	42%	57%	60%	55%	54%
Notes		3%	14%	19%	2%	10%
Sketches – existing	1.3	11%	27%	23%	3%	16%
Site visits	3.1	0%	5%	2%	1%	2%
Questioning/Defending	3.1 3.2	26%	41%	40%	27%	34%
Pattern matching	3.1 3.2	2%	8%	22%	9%	10%
Multiple solutions	3.1 3.2	33%	32%	49%	41%	39%
Reflection	4.6	13%	11%	22%	32%	20%
Exploration	4.6	52%	27%	38%	34%	38%
Testing	4.6	10%	8%	20%	23%	15%
Justify	4.6	6%	14%	10%	20%	13%
Accept/Reject	4.6	9%	16%	9%	29%	16%
Time management	3.1	10%	11%	12%	10%	11%
Office set	3.1	21%	54%	68%	18%	40%
Tips and techniques	4.2	49%	8%	40%	61%	40%
Mentor reviewing work	3.1	18%	16%	34%	49%	29%
Identifying Design Keys (Brief)	3.2	18%	14%	28%	10%	18%
Inspiring new thought	4.1	44%	38%	33%	54%	42%
Visualising Conceptualising	4.3	61%	32%	30%	51%	44%
Confidence	2.1					
Mentor	2.2	14%	11%	99%	100%	56%
Student	2.2	19%	11%	85%	100%	54%
Student participant	2.3	37%	24%	70%	91%	56%
Student as observer	2.3	68%	3%	35%	15%	30%
Apprentice designer role	2.3	86%	38%	98%	100%	81%
Student designer role	2.3	14%	0%	0%	0%	4%

Analysis of each minute of the work sessions showed that at any one time many different activities and events were taking place, with overlapping conversations and sketching as each participant contributed to the design collaboration. This type of activity required a broad yet detailed recording structure in order to portray relationships between participants and individual contributions made by each that were regarded by me to influence learning. For these reasons, the coding structure used for Phase Three data is more detailed than that used for Phase Two and is mostly derived from Index Tree Four and findings emergent from analysis of data coded with that structure. In order to portray the occurrence of events and activities observed throughout the work sessions, the frequency of these has been shown as a percentage of the overall video recorded work sessions duration. Data analysed in this way showed the time given to each event or activity as a measure of the overall observed study phenomena. This allowed comparisons with Phase Two data about what the participants said they did or what they said took place in other similar situations.

For example, every participant said that articulation was one of the most important aspects of learning in the design office situation. Phase Two data coded in Index Tree Four category *1.2 Articulation* indicated that 5.38% of the overall data units coded in Phase Two were about the participants' use of articulation. This level of coding is above the average for Phase Two categories, which was 4.54%. When comparing this to Phase Three data, it can be seen that data about the participants use of articulation was observed to occur during 65% of the work session time. In this way, data coded in each of Index Tree Four categories were compared to Phase Three data coded in Table 8 (p. 94). This allowed confirmation of findings, emergent from Phase Two data and also assisted exploration of other aspects of the study situation leading to new emergent findings.

For example, Mentor 1 made the following comment:

> ... we are very much a talk and on the board office, talk and sketch. We find that from their point of view and from our point of view it is a lot easier to explain things when you have a pencil in your hand and you just talk and sketch as the ideas unfold.

From this and other similar data I developed the Phase Two categories *1.1 Sketching*, *1.2 Discussion* and *1.3 Sketching.* Phase Two data coded in each of these categories were close to the average (4.54%) when considering all categories used for Phase Two data. In Phase Three additional coding categories were developed to explore in greater detail how the study participants used discussion, articulation and sketching were used by. The categories used and the frequency of data units coded using them, expressed as a percentage of the overall work session times are show in Table 10 (p. 99).

Table 10.
New Phase Three coding categories

Phase Two Data Category	% Of Overall Data Units	Phase Three Data Category	Phase Three Data Sub-category	Average % Of Overall Time Used
1.1 Discussion	3.10%	Discussion		62%
			Questioning/Defending	34%
			Inspiring new thought	42%
			Mentor reviewing work	29%
1.2 Articulation	5.38%	Articulation		62%
			Explanation Building	54%
			Multiple solutions	39%
1.3 Sketching	4.02%	Sketching		53%
			Student sketching	40%
			Mentor sketching	6%
			Using existing sketches	16%

Analysis of Phase Three data in this way allowed exploration of elements within each coding category and this assisted me in understanding the overall study phenomena. Using the example shown in Table 10, data coded in the category *Discussion*, identified in Phase Two as an important part of the student/mentor collaborative work sessions, were explored in greater detail using three new Phase Three sub-categories. The first of these, *Questioning and Defending*, was observed to occur during 34% of the duration of the work sessions. Aspects of student/mentor discussions observed to be about inspiring new thought were coded in the second sub-category, *Inspiring new thought*, which showed 42% of the duration of the work sessions. The third sub-category of *Discussion* used for coding Phase Three data was *Mentor reviewing work*. Data coded in this category occurred during 29% of the overall time for the work sessions. I concluded that these three aspects of discussion were important elements of student/mentor collaboration in the work sessions. In particular, the relatively high level of coding in the category *Inspiring new thought* confirmed what most of the mentors said during Phase Two was of vital importance to their working practices. For example, Mentor 4 when commenting on his approach said:

> ...when a student comes in here I try to first of all inspire them and give then a structure to work with that may take them on that journey of discovery and lead them almost anywhere they want to go, you know, leave the destination open.

Analysis of the video recordings of the observed work sessions commenced immediately following the first observations. As the analysis continued and following every new observation session, I discussed preliminary findings from these data and from analysis of earlier work session data, with the study participants. The immediate feedback provided by the study participants in these discussions facilitated member checks on my interpretation of the study situation and guided the focus of further investigation of the study phenomena.

This assisted me in maintaining rigour in the study methods and contributed to the validity of the findings when used in cross checks utilising information I had recorded in my research journal during video recording of the work sessions and during informal discussions throughout the study. Member checks, to confirm my interpretation of the participants' comments concerning learning events they had experienced, were also conducted during informal discussions with all of the Phase Three participants. The immediate feedback provided by the study participants assisted me to refine the inquiry techniques and to explore new or emerging themes noted as important to the learning situation. Video recordings of the work sessions were viewed multiple times in order to re-analyse and to confirm ideas, activities and themes emerging as important to the overall understanding of the dynamics of the student/mentor collaborative interactions.

Findings that emerged from analysis of Phase Three data were used to refine Index Tree Four as used for the final coding of Phase Two data. Taking a reflexive approach when dealing with Phase Three data allowed me to confirm findings emergent from analysis of Phase Two data and to then go back and re-examine data coded in Index Tree Three categories from different perspectives. Using this process, I collapsed or merged some Index Tree Three categories, as indicated in Table 6 (p. 88) and Table 7 (p. 91), to develop the Index Tree Four coding structure shown in Table 8 (p. 94), as used for the final coding of Phase Two data. In the next Chapter, each Index Tree Four category is discussed along with examples of data and findings that emerged from analysis.

Conclusion To This Chapter

This Chapter began by presenting the methods used for the organisation and analysis of data in categories developed to reflect themes that emerged during data collection and transcription. Development of the Index Tree coding structures used for analysing the study data was also discussed. With each new phase of this study, the

Index Tree coding structures created using broad coding categories were progressively refined to permit analysis of data in constructs that emerged from the exploration of new aspects of the study situation. This led to four different Index Tree coding structures being developed using conceptual coding categories derived from the overarching research questions and shaped by cognitive apprenticeship (Collins, et al., 1989) learning methods. The influence of preliminary interpretation of the study data during transcription and initial coding was also described in relation to the development of conceptual coding categories based on emergent themes and the evolution of new categories in response to emergent findings.

The interpretation and analysis of data recorded during observation of design office student/mentor work sessions and the role that this played in the development of findings was also discussed.

In the next Chapter, findings have been presented along with examples of data units coded for each of the categories developed for Index Tree Four (see Table 8, p. 94), along with a discussion of how those data were interpreted and synthesised with other data. Interpretation of events and activities, observed in the study situation, led to the development of hypotheses about how learning occurs in a design office where a cognitive apprenticeship approach to learning was applied.

CHAPTER SIX

RESULTS

Introduction

This Chapter presents findings that emerged from inductive analysis of the study data when seeking to understand the "multiple interrelationships among dimensions that emerge from the data" through "activities and outcomes" from experiences in the study setting (Patton, 1990, p. 44). Coding categories arranged according to Index Tree Four have been used here as headings to present themes that emerged and to present emergent findings. The presentation of findings is supported with examples of typical data coded for each category, along with explanations of how data were interpreted using inductive analysis methods to determine student learning outcomes. At the end of each category, a summary of findings that emerged from analysis of data coded therein is presented.

Findings presented in this Chapter are grounded in direct experience of the study situation. They have been used to develop answers to the research questions, as detailed in the next Chapter of this thesis. At times, attempts to quantify propositions about the study events and learning outcomes for students are made with the use of the words *some* or *most*. The former refers to findings emergent from the exhibited behaviour of less than 25% of the sample and the latter to those that emerged from more than 75% of the sample.

Findings from analysis of Phase Three data, when used, are shown here as percentage times that represent the frequency of occurrence of various activities over the duration of the work sessions. Since multiple activities simultaneously took place during each minute of the work sessions, the percentage times quoted often indicate levels of occurrence, for several different activities throughout each work session, that collectively present as greater than 100%. This approach has been adopted to show the relative balance of events or activities observed to occur.

Findings presented here emerged from analysis of the study data by coding in categories developed to represent four main themes about the study situation. Final coding took place when the coding categories had been refined to a level regarded by me to be capable of accommodating all data collected in ways that " represented the purposes of the research, were exhaustive and mutually exclusive" (Holsti, 1969, p. 95).

Organisation of this Chapter

This Chapter is set out using each of the coding categories of Index Tree Four as headings under which emergent findings are discussed along with typical examples of data coded in each category. Table 11 shows the arrangement of coding categories in Index Tree Four

Table 11.
Index Tree four categories used for presentation of findings

Coding Categories Used To Represent Themes	Sub-categories for coding data
1 Communication	1.1 Discussion 1.2 Articulation 1.3 Sketching 1.4 Entry To The Culture Of Practice
2 Attitudes	2.1 Confidence 2.2 Team-based Learning 2.3 Office expectations
3 Mentor Supported Design Office Practices Affecting Learning	3.1 Common Design Office Practices 3.2 Learning Methods Using Modelling 3.3 Learning Methods Using Coaching 3.4 Learning Methods Using Scaffolding
4 Collaborative Design Office Experience And Learning	4.1 Development Of A Creative Innovative Approach To Design 4.2 Reifying knowledge In Design Office Learning 4.3 Visualisation, Exploration, Reflection and Design Style

The categories used to represent the four main themes are:

1. Communication;
2. Attitudes;
3. Mentor supported design office practices affecting learning; and
4. Collaborative design office experience and learning.

Findings from analysis of data coded for all phases using this structure are now discussed.

Theme One: Communication

The four sub-categories established under this theme were:

1.1 Discussion;

1.2 Articulation;

1.3 Sketching; and

1.4 Entry to the culture of practice.

Analysis of the study data suggested that discussion, articulation and sketching, were used by the study participants as a set of integrated communication tools. In this setting, *tool* means a cognitive tool used by experts in the discipline of their domain of practice (Brown et al., 1989). Findings that emerged about the role of discussion, articulation and sketching as communication tools for learning in a building design office and how student entry to the design office culture of practice contributed to student learning is now discussed.

Category 1.1 Discussion

In this thesis, *discussion* is regarded to include any verbal exchange between the study participants intended to assist knowledge acquisition, to explore opinions or points of view, or to learn processes and procedures necessary to the design process.

Analysis of the video recordings of Phase Three work sessions showed that during 62% of the time, the mentors and the students were engaged in discussions in which technical terms and descriptive language were used to communicate design ideas and methods typical of the mentors' usual culture of practice. Analysis of Phase Two data showed that most mentors used highly descriptive and jargon-rich language when discussing design office work practices and when providing explicit information about design situations, or interpretations based on their tacit knowledge. This led me to contend that discussion was used as a key learning tool in the design office situation. It appeared to be used in deliberate ways by mentors to assist students to acquire design procedures and declarative knowledge necessary to develop design solutions and to communicate them to others in ways typical of those of a professional designer.

Analysis of data like those presented in the following example suggested that much of what took place during student/mentor work sessions centred on the use of discussion for the purpose of introducing new information and design procedures for exploring emerging design concepts. The following comments made by Student 8 are typical of those made by most of the students when discussing changes they had made in their speech and behaviour as a result of working with a mentor.

> Having them (the mentors) just talk to you as though you are one of the staff helps you to learn all the right words to present yourself. You learn to put your ideas across and how to communicate with people like they do in the design office, like a real designer.

Student 16 described how she developed her technical vocabulary as follows:

When I first went in there I got a good idea of what their work

> involved by watching and talking to Barry and some of the others as they worked on a project that they were trying to get finished. They were really good at explaining to me design and construction terms that I hadn't heard before, or had heard of but didn't understand. That helped me get into their way of doing things because it was like learning a new language, once I understood what they were saying I could get right into their way of doing things.

Mentor 3 described this aspect of student learning as being:

> ...part of the working culture, just being in the office and learning to speak and behave like a designer by talking to the people working there and the clients or consultants who come in. That's how they pick up design language.

In Phase Two most of the mentors said that they used discussion methods to introduce new ideas and heuristic design strategies for resolving problems. Mentor use of discussion in this manner, as shown in the following comments made by Student 16, emerged as an important aspect of student acquisition of declarative knowledge. It appeared to assist learning by providing the information with which students developed declarative knowledge of design situations and tacit knowledge developed through application of procedures modelled by the mentors when applying their design strategies to the student project. Analysis of Phase Three data showed that discussions about new design ideas and methods for refining an emerging design took place between students and mentors during 38% of the work session times. When commenting on the mentor's use of discussion, Student 16 said:

> ...they kept talking to me about the design and usually suggested little changes or adding in things like verandah's and so on. They always gave me reasons for doing things in certain ways and little tricks for working out problems like traffic flow or design details that cropped up. They would get me to talk them through what I had done and then they would say have you thought about this or that and that usually meant working through some new stuff.

From comments such as these and other similar data, I determined that purposeful discussion was used by the students and the mentors to progressively introduce new ideas and to explore other aspects of the design in progress. Mentor 6 described his approach to working with Student 16 as follows:

> ...there were no great thunderbolts, it was mainly little clicks and penny drops along the way, you know, a process of building up one idea on top of another. We just try to introduce small new tasks for them to try whenever they look like they are ready to move up a level with the design, or to bring in some advanced elements that make it that bit special. You know, take it up a peg by talking it through first.

Working in this way, most of the mentors sequenced learning activities using tasks of increasing difficulty that addressed new aspects of the emerging design solutions. This was evident in the sketches produced during the work sessions by the students and the mentors as they worked through problems, emergent from the design project. During work session discussions, sketching was also used to assist explanation building. Activities involving discussion and sketching for the purpose of explanation building took place during 54% of the work session times. Discussions aimed at identifying key design elements or influencing factors occurred during 18% of the work session times. When describing how Mentor 27 used discussion and sketching to introduce and explain design ideas, Student 14 said:

> The whole time we just sketched and talked about the three sections and talked about what the relationships of each area would be to the overall design and what the room sizes should be. That's how I learnt to design from him.

Mentor 15 used a similar approach. He said:

> Garry (the student) was very good at explaining his ideas, but needed a lot of help to implement them in a design. He was also a good listener and that made our working together easy because all the way through we used discussion and sketching to work through the design of each of the rooms and how they should fit together in the final solution. I could talk him through by saying what was needed and why and he was then able to put it all together in rough form, which we would then refine.

Comments, such as these about the use of discussion and sketching, were made by most of the study participants during Phase Two interviews. From this I developed the view that discussion used together with sketching was the principal means of communication for the transfer of declarative knowledge about design situations and about the procedures used to resolve design problems. For example, Mentor 3 spent 83% of his work session times using discussion to provide explicit information about design and construction methods including interpretation of codes and regulations, planning guidelines set by local council and common industry practices for dealing with particular design details or situations.

Discussion and sketching were also used together during 62% of the work time to exchange information about design practices built on the mentor's tacit knowledge of building design facts and regulations and in the application of heuristic design strategies to resolve emergent problems. Here, tacit knowledge is regarded as the kinds of knowledge built from experience of multiple design situations in which problem solving strategies and explicit or declarative knowledge have been used to resolve emergent problems. For example, Mentor 1a explained his use of discussion and sketching for this purpose and as an integrated tool for communicating design ideas or working methods in his collaboration with Student 20 by saying:

> Talking and sketching are the communication tools of the trade here, people cannot talk and communicate if their hands are tied. Some individuals just can't seem to link it all together. We find that by sitting down and talking through the building sketching details as we go is the best way to get them up and going. We talked about every aspect of the design and sketched out ideas with him when we wanted something done in a particular way.

When Student 20 was asked about how Mentor 1a used discussion and sketching during their collaboration on the design project, he said:

> I think that talking and sketching and writing down the notes of things that he was emphasising definitely helped the most. Then coming home to do the sketches and then taking it back and talking about it in front of him. Also doing little sketches to explain ideas on top of the sketches, he did that a lot and that gave me something to take away and think on, you know, you could see it there on the sketch where we discussed it.

In this excerpt, Student 20 has mentioned that talking, sketching and writing down notes assisted his learning. He also commented he used notes and sketches for independent development of the design, then later for reflection and exploration of other ideas with the mentor through sketching over the top when explanation building. This is an example of student use of declarative knowledge, acquired during discussions, along with mentor modelled procedures for design development, to establish his own tacit knowledge based on application of the procedures learned.

Analysis of video recorded during Phase Three work sessions showed that sketching took place during 53% of the overall work time and note taking occurred during 10% of the work time. A detailed explanation of the role of sketching in the learning situation is provided later in this Chapter because it is so important, but it is mentioned here because of its relevance to the use of discussion.

The combination of discussion and sketching emerged as the principal means by which information was exchanged and how working practices for dealing with complex design problems were reified by the mentors. Student acquisition of explicit information about design methods and situations added to their declarative knowledge needed for applying heuristic design strategies modelled by mentors. Some mentors used discussion, supported by sketching, to inspire students to visualise and communicate how they imagined a design to develop. For example, during work session two in Phase Three, Mentor 4 discussed the setting for the design with Student 23 in the following way:

> Just imagine yourself waking up in the morning in this valley with the mist rolling in around the house and sun breaking through. What is it that you want from that room you are in? Do you want the room to be invisible so that you can reach out to the day without being bounded by walls? How about an overhanging balcony so that the house just touches the ground lightly like a Frank Lloyd Wright design. Try to visualise being there and imagine what you might feel when you experience that light and the smell of the morning in country air, away from all the shit that's in the city.

Responding to this later when interviewed, Student 23 said that he now had a new approach to thinking about design that was inspired by the visualisation method modelled by Mentor 4. This is regarded by me to signify the student's development of procedural knowledge based on methods modelled by the mentor. Commenting on this, Student 23 said:

> He (Mentor 4) just looked at the drawings that I had already done and said have you thought about what the client might experience living in this house? Then we put my drawings aside and just talked for ages about what it might be like being in that valley and the sort of lifestyle that people who want to build there might be after. That really made me think about things differently and to imagine a much more homely place to design.

Discussion used in this manner for visualisation of ideas and design development was observed to occur during 44% of the work session times. Mentor 6 described his use of discussion when visualising design ideas as a "verbal scribble" stage of the design process, essential to his practice. Describing this as his usual approach, he said:

> We just work our way into the design using this quick approach which gives us a verbal scribble stage between sessions on the computer. Jack (partner) and I sit down with these sketches and talk it through as we draw, this is the way anyone coming to this office would have to do it here. In this way we talk about the themes and where we want the design to go.

Student acquisition of ways for applying methods such as those described in the previous quote by Mentor 6 I regard as part of their development of tacit knowledge based on application of replicable procedures shown by mentors to be usual design office practices. Student application of design methods such as the "verbal scribble stage" described by Mentor 6 assisted them to work in autonomous ways when visualising and refining design solutions. This, I regard as in part the development of their procedural knowledge, as well as development of metacognitive ways for resolving emergent design problems.

Data such as those shown in the previous quotes suggest that mentors and students used discussion methods to express ideas that they had visualised and refined before committing to formal design drawings. Analysis of Phase Three data showed that during student/mentor work sessions the mentors' use of discussion for explanation building occurred during 54% of the work times. This usually took place in conjunction with questioning and defending of ideas or design procedures, which were observed to occur during 34% of the work times. Student learning through these kinds of experiences I regard as forming the basis of their tacit knowledge of design methods and procedures that utilise heuristic design strategies and declarative knowledge modelled by mentors. The main learning outcome for students working in this way was their acquisition of ways for applying design knowledge and practices in the context and culture of the mentors' everyday methods.

Most of the participants when interviewed during Phase Two said that discussion and sketching were used together at all stages of a design development. In the first of the student/mentor work sessions, the mentors used discussion during 36% of the work session times for design activities, while the students similarly used 19% of the time. In the last of the work sessions, the balance had shifted such that the students were observed to be using discussion and sketching 55% of the time and the mentors 17% of the time. Working in this way, the mentors were regarded by me to be *fading* their use of *scaffolding* to assist student learning as the students developed their knowledge and skills. As this occurred, the students appeared to be using their tacit knowledge, acquired through experience of using design information and strategies modelled by the mentors, in more autonomous ways to create innovative solutions to emergent design problems. Learning outcomes such as these were confirmed by comparing Phase Three data with Phase Two data such as those shown below in the comments made by Student 16, which show how she developed design skills by working in ways modelled by her mentors.

> When I went there I didn't feel confident to talk about my ideas and wasn't sure about how they did things there. That changed pretty quickly because although they took the time to explain a lot to me about their design methods, they also made me talk about mine and got me to explain every part of my design as it developed. That really helped me to be more relaxed about talking to them and by the end I think I was doing most of the talking and they just helped when I needed it.

Analysis of Phase Three work sessions showed that Mentor 3 kept Student 22 actively involved and contributing to the discussion of each aspect of the design at hand and the design processes introduced for resolving it. Mentor 3 used 14% of the work session time to discuss design processes and procedures for resolving problems emergent from the design process, with Student 22 similarly discussing methods he proposed to use, taking place during 17% of the work session time.

Commenting on what he considered were valuable aspects of working with Mentor 3, Student 22 said:

> It was just great the way that he talked through everything. He made me explain my ideas for doing something, then would come up with a couple of more ways of doing it. That really blew me away because I always then had choices for solving things. His explanations were really good because he talked about all sorts of design jobs of his own that were similar to mine. I learnt heaps just by talking with him about problems and ways of sorting them out.

From comments such as these, I concluded that the students acquired declarative and procedural knowledge by having mentors discuss and model their design practices.

Mentor 6 used a similar approach when working with Student 24. He began by demonstrating his way of narrowing down the design options available to only those applicable to the situation at hand. This he did by first listing, then discussing, regulatory or physical factors affecting the design situation. Then, using discussion and sketching together, he identified what he described as the main problem aspects of the design situation that needed to be resolved. Following this, he compared those problem design elements to other projects of his own that involved difficulties similar to those in the student project and discussed how he had resolved them in his own works. In addition to discussing the strategies and solutions that were appropriate to the student's design situation, Mentor 6 also explained the reasons why he thought the strategies would be suitable for decisions made throughout that process. Throughout the work sessions, Mentor 6 used questioning to keep Student 24 actively involved in the design process and to ensure his understanding of what was being presented. In this way, Student 24 acquired declarative knowledge of many different aspects of the design situation and procedural knowledge of ways to explore and resolve emergent design problems in the culture and context of the mentor's usual practices.

During 22% of the work session times, Mentor 6 established links between problems that emerged from the real work design project at hand, to his usual practices for dealing with similar situations. For example, he showed Student 24 drawings and photographs of his current design commissions, while explaining in detail his reasons for using particular construction methods or architectural features when detailing his solutions. This approach revealed the mentor's tacit knowledge of many complex aspects of the design situation in his own commission, as compared to the student project, as well as procedures he considered to be appropriate for resolving various parts of each of those projects. Working in this way, Mentor 6 reified his tacit knowledge of successful design procedures by matching problems that emerged from the student design project to those he had encountered and resolved in his own commissions.

In those same work sessions, Student 24 spent 70% of the time discussing his interpretation of the design problems and possible strategies that he might use in resolving them, thus articulating his tacit knowledge as well as the heuristic design strategies or procedures he regarded as appropriate for their application. The focus of such discussions was directed by Mentor 6 to understanding the many influencing factors found in any design problem and on exploring many different potential solutions before accepting any particular one for detailed development. In this way Mentor 6 introduced multiple ways for resolving the design situation. He also guided Student 24 through the exploration of multiple solutions to parts of the design project at hand by matching some elements of those designs to similar design office commissions that Mentor 6 had presented in his discussion of usual design methods. For example, Mentor 6 used pre-drawn CAD elements such as bathrooms and kitchen layouts to quickly demonstrate alternative solutions that could be used by Student 24 in his own design solutions.

Mentor coaching of students, in the use of problem solving approaches in this way, was regarded by me to be an effective means by which the students acquired tacit knowledge of design situations and procedural knowledge of ways to deal with problems that emerge during design development.

A summary of findings that emerged from analysis of data coded using *Category 1.1 Discussion* is as follows:

- work session discussions helped students to acquire a technical vocabulary and ways of speaking used in the design office culture of practice;
- discussions between students and mentors facilitated transfer of declarative knowledge about design situations, codes, regulations and practices;
- work session discussions facilitated student acquisition of ways for explaining design ideas and using processes, procedures and heuristic design strategies used by building designers to resolve complex problems;
- work session discussions exposed students to the mentors' methods of questioning, evaluating and defending ideas; and

- work session discussions assisted students to acquire ways of reflecting on design methods and creative ideas leading to exploration of multiple concept forms nod design solutions.

Category 1.2 Articulation

The second category used for analysis of the study data, *Articulation*, is based on the Collins, et al. (1989) teaching strategy of that name in which the "teacher encourages students to verbalise their knowledge and thinking" (Carver, 1995, p. 206). Data coded in this category also included mentor use of articulation to explain ideas and to express personal thoughts about design methods or reasons for using particular strategies. In this study, *articulation* is considered to be more than just talking or having discussions with others; here it includes students and mentors verbalising:

- personal thoughts and opinions when thinking about design ideas;
- reasons for using particular heuristic design strategies;
- ways for using problem solving strategies based on personal experience of similar problems or situations; and
- explanations or interpretations of design problem situations, the underlying reasons for using particular design strategies and possible solutions or decisions taken.

Most of the students and mentors when interviewed during Phase Two said that in building design it was important to express aloud personal points of view and reasons for using particular strategies when dealing with design problems. One reason for doing this was said to be so that others might readily understand why a design was being developed in a given way. Many other aspects of student and mentor use of articulation during work sessions arose during analysis of Phase Two data and these were coded in four sub-categories as follows:

- explanation building;
- questioning and defending of ideas;
- identifying design criteria; and
- development of multiple design solutions – this includes comparing emergent design concepts to commonly occurring situations and strategies typically used to resolve them.

Findings that emerged from analysis of data coded using these categories are now discussed.

Category 1.2.1 Explanation building.

During Phase Three work sessions, all of the mentors used articulation to develop detailed explanations of design methods based on the mentors' authentic design experiences. This kind of exploratory knowledge expressed by mentors when explaining their working methods is regarded here to be tacit knowledge. Such knowledge is regarded as having been built from personal experience in many different building design situations. Most mentors used articulation to link their tacit knowledge of design situations and problem solving methods, to problems that emerged from the authentic projects undertaken by the students. Working in this way, the mentors reified their typical design work practices in ways that helped students to understand how and why they tackled design problems in the ways they did.

Mentor use of this process included their articulation of the reasons for using particular working practices and thinking aloud when working with students on design problems. For example, some mentors modelled their ways for developing solutions to parts of a design by "sketching and talking through" (Mentor 1a) each stage of a design just as they would for any project of their own. For each design element explored, or method for resolving emergent problems applied, the mentors verbalised their thoughts about why they were using the methods modelled and how that impacted or affected other aspects of the design under development. This process usually also included anecdotes of successes and failures they had encountered. Working in this way, the mentors reified their thought processes and the reasons for applying heuristic design strategies in the context of their usual practice. Having modelled this approach to design, most of the mentors then encouraged the students to apply similar methods to their own design practices.

Throughout Phase Three work sessions, most of the students were observed verbalising their thoughts as they worked through design problems. Analysis of Phase Three data showed that articulation was used in this manner during 54% of the work session times. The following comment made by Student 14 is typical of other data coded in this category that indicated the use of articulation for explanation building by mentors and by students.

> ... he was good at picking up on ideas that I presented and talking them through with me. He would point out all the good and bad points that I perhaps hadn't seen and compare these to jobs he had done. He always explained to me the reasons for doing things in different ways by telling me about and how it had worked for him. That really helped me to explore new ideas a lot more than if I had done it alone. (Student 14)

In this example, the mentor is using his tacit knowledge to identify problem aspects of the student's design. By articulating reasons for resolving emergent design problems in particular ways, the mentors were thought to reify their tacit knowledge and to support it with authentic examples of successes and failures upon which they have built knowledge and procedures for addressing commonly occurring design situations. The manner in which this assisted student learning can be seen in the following comments made by Student 13 who said:

> The best thing with Barry was he knew exactly what to do and just got on with it. I was really lucky because he just talked very directly and clearly, he used his experience to explain heaps of things that you just don't normally see.

Another example of how some mentors used articulation for explanation building when working with students comes from comments made by Mentor 1. He described his approach as being based on providing detailed explanations of how something was done, along with personal reasons that detailed why it was done in a particular manner. Commenting on this, Mentor 1 said:

> I think what happens is you talk as you draw more, really explain yourself and your thoughts as you are drawing. When you are doing it for a student you need to talk it through so they know the reasons for what you are doing. Not just show them how to do it, but explain why for every step of the way using your experience of actual jobs to give real situations with real solutions.

When commenting on how his mentor described the reasons for adopting particular solutions to design problems encountered in his own design commissions in order to present ways for dealing with similar problems in the student project, Student 9 said:

> I had problems getting the roof to work so I suggested we use a valley gutter. He (the mentor) said that was a bit "iffy" because of leakage over the flashing. Then he pulled out the drawings of one of his designs to show me a detail that had worked for him. He talked me through all the reason why it worked and how in some situations it would not work, like where another valley gutter runs in at an angle and so on. I was then able to come up with a detail that avoided using a valley gutter and still looked OK on the elevation. It was not the same as his, but it had some of his ideas in it and it worked just as well. Listening to him talk about how he had sorted out similar problems in his own jobs helped me to learn his approach to design detailing and to then work it out for myself.

Data such as these led me to conclude that student and mentor use of articulation of personal design practices and the reasons for working in particular ways assisted in the transfer of tacit knowledge based on real design experiences. Examples such as the one shown above (Student 9) suggested that using articulation in this manner assisted students to acquire knowledge of procedures used by experts when applying heuristic design strategies in the context of the building design domain culture of practice.

Category 1.2.2 Questioning and Defending of ideas.

Analysis of Phase Three data showed that during 34% of the work session times, students verbalised their thoughts when expressing their reasons for using particular design strategies and to defend design decisions they has taken to refine solutions to problems that emerged throughout the design process. For example, most of the mentors used questioning early in each work session to encourage students to articulate the processes they had used to develop design solutions for the projects at hand and to verbalise how they had thought through emergent problems or applied strategies to resolve them. Student 13 said that he and his mentor made extensive use of questioning when exploring design ideas and when defending design strategies or solutions in this manner. Commenting on this, he said:

> ...he was great because he let me put up all sorts of ideas and we worked through them. He made me discuss and justify everything that I suggested, just as he did the same by always saying why he did things the way he did. We just kept asking each other why we each wanted to do things and then talked it through giving our reasons. (Student 13)

From data such as these, I concluded that student learning was enhanced when the mentors encouraged the students to articulate their thoughts about design and methods they employ in the development of solutions to problems that emerge from authentic tasks in design office situations.

Some mentors also encouraged the students to articulate their design processes in order to structure and sequence further learning activities. This approach supports the sequencing of learning activities as part of the design principles for a cognitive apprenticeship learning environment described by Carver (1995, p. 206). Mentor 4 said that he used questioning to encourage students to articulate their views as a means of identifying their level of understanding of design in order to set tasks with achievable goals for them to advance their learning. Describing how he used this approach, Mentor 4 said:

> I start by showing them some ideas and talking about my reasons for designing in the way that I do. Then I ask them what do you think? I make them get involved make them tell me their ideas. I get them to

> explain why they want to do it in a particular way. I look to see where they are in the big picture and if they are having difficulty in telling me how they got there. If their skills aren't there in place yet and their knowledge and experience is not necessarily there, then I get them going with little tasks that they can achieve and make them talk through every decision with me as they go.

This approach was observed being used during 34% of the work session times by all five Phase Three mentors when working with students. I concluded that the use of articulation by students and mentors as part of design exploration and during questioning and defending of design solutions, provided a means for the transfer of tacit knowledge and design procedures. Articulation used in ways described above by Mentor 4 to encourage students to "...make them tell me their ideas. I get them to explain why they want to do it in a particular way" assisted students to conceptualise and defend ideas and in so doing helped them to develop metacognitive ways for using design procedures for refining and expressing design solutions.

Category 1.2.3 Identifying Design Criteria.

Most of the students said that the first tasks set for them by their mentors was to identify key design criteria by interpreting the client design brief in terms of the functional requirements for the building. Analysis of Phase Three data showed that mentors and students together spent 18% of the work session times verbalising their views about key design elements and style. The following Phase Two interview excerpt is typical of comments made by most of the students when discussing how articulation was used for identifying design keys and style elements that led to their development of design ideas and working practices.

> ... when we got going together the ideas flowed. He talked about the client brief the kind of stuff that he saw as his personal design style. I also came up with some ideas that we worked through together. We looked at other things along the way and I thought maybe I could do that and that's how I came up with the design for my latest assignment using the same techniques that I used with the mentor. (Student 9)

This approach of using articulation to express how and why a design was being developed in particular ways was observed to occur throughout all of the Phase Three work sessions. Its use is regarded by me to be one means through which the students developed procedural knowledge in design, based on methods modelled by the mentors and reinforced by student application to their authentic design project. The following comments were made by Student 15 when discussing how his mentor provided information and procedures that helped him to develop design solutions:

> ... I had some ideas and took in some notes and sketches to that first meeting and we so we were able to talk about the brief. He was really insistent that we follow the brief exactly and incorporate it in our own designs so that the client can benefit from it, but it had to follow the brief all the way. He had a particular approach to doing the work that was very organised and structured. His method was to break the brief down into client needs, site requirements, regulations and orientation issues. It was all mapped out before we began to sketch-out any design ideas. That worked well for me because it gave me a plan to work to, where I could sort it out one-step-at a time. Each time that we got together he would help me to map out what I needed to do in preparation for the next session.

By working in this manner the students acquired ways for organising and applying client-brief focussed design procedures typical of the mentor's usual practices. Mentor sequencing of design tasks by using a structured approach as described by Student 13 (above) assisted student learning by providing order to the design process, with tasks organised around readily achievable stages.

Category 1.2.4 Multiple Solutions.

Most of the students interviewed during Phase Two and all of the students who participated in Phase Three, said that they explored multiple design solutions as a result of having mentors articulate and model ways of developing variations on basic design concepts. When commenting on how his mentor had introduced multiple design ideas and solutions during work sessions, Student 13 said:

> .. He had a lot of different ideas and different ways of putting it across. That was the great thing about it, he has had such a lot of experience he is able to say look I've tried it this way or that way and he gave me examples of where it worked or failed. I learnt heaps from trying out different ways of designing, for each part of the project.

The manner in which most of the mentors introduced multiple design methods or solutions was through rapid sketching of ideas, supported by articulation of the reasons for using or rejecting the ideas being explored. This manner of working also included explanation of the methods or procedures necessary to refine design ideas and to resolve emergent problems. When commenting on how his mentor helped him through the design process by modelling different techniques and supporting his ideas, Student 8 said:

> Having the mentor show you a few different design techniques they use and then support your ideas is really good because it confirms that you are on the right track, they are out there doing it for a living and they know what works.

Observation of Phase Three work sessions showed that the students and the mentors worked together in this way to exchange ideas, transfer knowledge about the situations being explored, the procedures for addressing emergent problems and the suitability of possible solutions presented. Information exchanged in this way was mostly tacit knowledge, which included design methods and regulatory requirements, as well as procedural knowledge about how to apply heuristic design strategies and problem solving processes. Analysis of Phase Three data showed that students and mentors together used 39% of the work session times exploring multiple design solutions by applying typical design office procedures which were supported by mentor tacit knowledge of other successful authentic design commissions.

As an example, Student 8 said that he and his mentor worked in this manner at first, then they independently developed ideas based on what each of them had expressed when articulating their individual design preferences. Student 8 commented:

> ...after we had each said what we thought should be in the design and put some ideas down together, we decided to work independently on sketches or ideas then we compared what we had done and put it together and decided what we could build from it, we did it together and the end design ended up being a mix of his and my likes.

Working in this way supports a cognitive apprenticeship approach to learning in that the mentor extended to the student the status of apprentice designer by working in collaboration with him on the design. He then provided sufficient guidance to initiate student independent application of design skills, before reflecting on the work produced and working collaboratively to refine solutions. This he did by articulating his views and encouraged the student to do the same, while applying multiple design strategies to the problems that emerged during exploration of the authentic tasks of the design project.

Observation of Mentor 3 working with Student 22 showed that together they used 65% of the work session time articulating their views about design, problem solving strategies and the reasons for working in particular ways. During these sessions, Mentor 3 focussed on providing personal insights into his ways for interpreting design problems and the strategies needed to resolve them. For example, at the commencement of each work session, Mentor 3 spent between 10 and 15 minutes describing in detail the progress of a current design office project, verbalising why he had used particular methods to resolve emergent problems. He also sketched for Student 22 numerous variations of proposed design solutions, explaining as he sketched his thoughts about the suitability of each, while pondering aloud other possible problems or solutions that emerged through that process. Working in this way he reified his tacit knowledge of many different design situations and working methods, as well as procedural knowledge of methods he employed to resolve problems emergent from authentic projects. When commenting on how Mentor 3 assisted him to acquire design knowledge and procedures, Student 13 said:

> What is really good also is that I am now working with Mario (an ex student/employee of the mentor in this collaboration) and I can see myself using many of the working habits and design ideas that I learnt from working with Barry (the mentor) and that makes it easy for me because Mario works in much the same way now. Yeah Barrys office is very similar in the way it does design work to Marios. They both use similar work procedures with their designs and they organise their time on a job just the same.

When Interviewed during Phase Two, Mentor 3 said that he always tried to talk students through design examples by verbalising the thought processes that he used to create and resolve designs. He also applied this approach to working with students on their own design problems. This he did by expressing aloud his thoughts when modelling ways for resolving emergent problems and when coaching students in their use of heuristic design strategies. Student 13 confirmed this aspect of working with Mentor 3, saying:

> He was great because he let me put up all sorts of ideas and we worked through them. He made me discuss and justify everything that I suggested, just as he did the same by always saying why he did things the way he did. He was really open about saying what he thought, even if sometimes the things he tried hadn't worked.

Coding of numerous data such as these indicated that most of the mentors used discussion and articulation to explain and defend design ideas or solutions. Most of the mentors also verbalised their reasons for adopting decisions in their own authentic design commissions when assisting students to explore multiple design solutions to address problems emergent from their design project. Some mentors also showed and explained examples of design failures by articulating the reasons for design decisions taken and the reasons why the design failed. In this way, the mentors reified their tacit knowledge of multiple design situations, as well as the procedures used to create and evaluate solutions for them. By using these methods, the mentors provid ' ways for the students to acquire declarative knowledge of many different design situntions, design strategies and design solutions, as well as procedural knowledge of ways for resolving similar situations that they were likely to encounter in their own projects.

Throughout the Phase Three work sessions, I observed Mentor 3 articulating his reasons for using problem solving strategies and design solutions in his own design office commissions. These he linked to similar problems that he and Student 13 had identified in the authentic design project on which they worked together. An example of how Mentor 3 reified his tacit knowledge of different design situations, methods and solutions for Student 13 is evident in the following interview excerpt:

> I started out by questioning him about how transportable houses are put together. I did this to find out what he knew, but also so that I could fill in the gaps so that we could both be taking the same language when we started to design it. I asked him things like: How do they fix the walls? How do they drop them on site? How do they do the stumping when do you use a slab base to build on or when to use steel girders etc? Then I talked about the structural problems and how they jack them up and so on, you know, the sort of things that you just pick up with experience of doing these jobs. The process we used in getting him going on the project was to first-of-all discuss generally the problems of transportables. Then I explained in detail how they are dealt with by industry and the reasons for doing things in particular ways. I also talked about industry standards and my own interpretation of good practice methods. Then I asked him to reflect on those and don't let it stop (the design process). He tuned into that pretty quickly and was soon asking me more questions than I was asking him.

In the example shown above, Mentor 3 began by using questioning to determine what the student knew about the design situation at hand, as well as to inform and encourage him to visualise the design situation problems by providing declarative knowledge about a number of key elements such as the fixing and placing of the building panels. He then went on to explain other aspects of the situation using tacit knowledge that he had developed from experience of similar authentic projects. Finally he discussed common industry practices and standards, *(Then I explained in detail how they are dealt with by industry)* flagging these for the student to reflect upon throughout the design process. This I regard as revealing his procedural knowledge of effective design methods typical of his usual practices.

During Phase Three, Mentor 3 was observed using this approach in two work sessions with Student 22. For 40% of the work session times Mentor 3 used articulation, discussion and sketching to provide tips and techniques (as evident in the example above) to support student learning. He also used similar methods to encourage Student 22 to reflect on design ideas and to express his thoughts aloud.

In the four different design office situations studied in Phase Three, activities in which students were encouraged to reflect on their work and articulate their reasons for design decisions they had made occurred during 20% of the work session times. From this and other Phase Two data, I concluded that articulation was used by the students and the mentors to exchange explicit information including declarative knowledge about design situations and working methods. Articulation was also used by students and mentors to express their tacit knowledge of successful design practices and procedural knowledge required for application of those practices to problems that emerged from authentic tasks. For example, Student 13 made the following comments:

> There are heaps of things that I learnt there with Barry that I now use. Perhaps not everyday, but usually you come across a little problem similar to things I did there and I find myself thinking of what Barry has said worked for that situation and then I try it out for the problem that's there and it usually works, or I can adapt it to suit the situation. I now use things that I learnt from his explanation of his design experiences in my work all the time.

Findings from analysis of data about articulation suggested that the students and the mentors used articulation to:

- explain aspects of tacit knowledge;
- express declarative knowledge about multiple design situations
- explain procedural knowledge necessary of application of design processes
- explain the use of heuristic design strategies and to provide reasons their application;
- provide insights into decision making methods employed for problem solving and the exploration of multiple design ideas or solutions; and
- reflect on and defend design decisions.

Category 1,3 Sketching

Analysis of Phase Two data suggested that sketching was regarded by most of the participants to be equal in importance to that of discussion and articulation as a tool for communication of design concepts, design strategies and solutions. Three aspects of the use of sketching presented frequently throughout the overall data analysis as key elements that support learning in the design office situation. They are:

- sketching used as a communication tool;
- sketching used in design office practices affecting learning; and
- sketching as used to scaffold student learning.

In this section, findings about the use of sketching as a tool for communication are presented. The use of sketching in design office practices affecting learning is discussed later in this Chapter in section 3.1.5 and as part of Scaffolding section 3.4.1. This approach was adopted in order to fully display the extensive role played by sketching in the study situation and to demonstrate the different ways in which sketching was used by the study participants in many different contexts.

Sketching as a communication tool.

Sketching was used by all of the study participants to explore, explain, refine and present design ideas. All of the mentors said that it was essential for students to be able to visualise design concepts and to be able to communicate their ideas using sketching and discussion. Commenting on this, Mentor 1 said:

> We are always drawing while talking with them (the students) and they need to be able to read your rough sketches. Unless they can follow sketched ideas, you need to spell it all out for them and that just doesn't achieve anything.

Most of the students when interviewed said that the mentors used drawings and sketches as an integral part of their work sessions. The following comment made by Student 14 is typical of many others found throughout the data:

> ... listening to his ideas, having him sketch and explain things, that was the most valuable part of communicating with him, that's how we gradually refined the design and worked through all the problems that came out of the brief.

Student 16 reported similar experiences when working with Mentor 6. She said:

> He sketched and talked all the time, in fact he sketched everything rather than describing what he meant. That's where I got a lot of my ideas; then I incorporated them into my design.

From these comments and other similar data I determined that sketching was used for the transfer of tacit knowledge and procedures used to create and develop design solutions by providing fast visual representations of concept forms and potential solutions. For example, Figure 4 (p. 123) shows how a plan form has been developed using quick sketching methods to show room positions, possible views from a balcony and a main entry foyer.

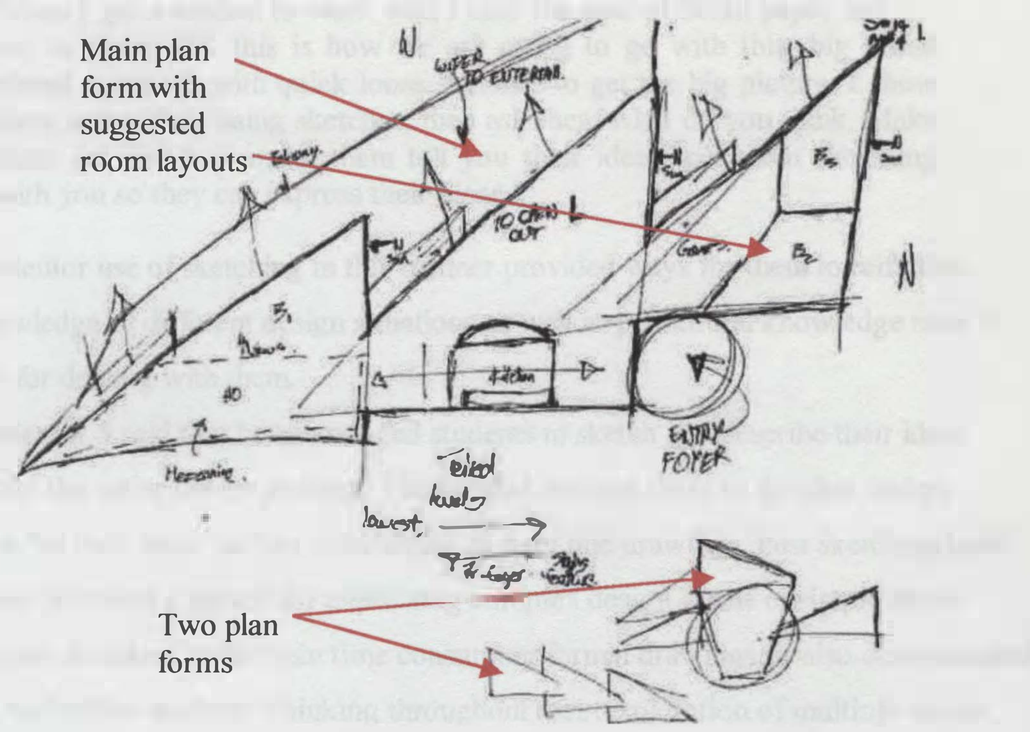


Figure 4. Quick sketch for exploring design concepts

At the bottom of the sketch, two different plan configurations have been explored with simple line sketches. At the top of the sketch, the plan forms are more developed with possible room layout being suggested. This use of sketching provided students with procedural knowledge of design methods used by the mentors when exploring multiple solutions. Sketching of this type was used by most of the study participants to explore design variations for the development of multiple solutions and construction details. Sketches produced for these purposes were also used extensively to show the development pathways followed in the design process and design ideas that had been accepted or rejected as part of refining final solutions. The following comments made by Mentor 1 during Phase Two interviews are typical of many others coded about the use of sketching as a communication and design development tool.

> It is a lot easier to explain things when you have a pencil in your hand and you just talk and sketch as the ideas unfold. Sketches are far better than just telling someone because they can be very specific and immediate.

Mentor 4 used sketching similarly, using it as a communication tool to encourage the students to participate in making sketches with him from the outset of their working collaboration. In this way he brought them into his culture of practice and design methods through talking and sketching. Of this approach, Mentor 4 said:

> When I get a student to work with I take the wad of detail paper and say to them: OK this is how we are going to go with this, big broad global approach with quick loose sketches to get the big picture. I show them some ideas using sketches, then ask them what do you think. Make them get involved make them tell you their ideas, get them sketching with you so they can express their ideas.

Mentor use of sketching in this manner provided ways for them to reify their tacit knowledge of different design situations as well as procedural knowledge used in methods for dealing with them.

Mentor 5 said that he encouraged students to sketch and describe their ideas throughout the entire design process. This he said assisted them to develop design strategies "in their head" before committing to hard line drawings. Fast sketching used in this way provided a means for expressing complex design forms in simple three-dimensional sketches, rather than time consuming formal drawings. It also demonstrated an audit trail of the students' thinking throughout their exploration of multiple design ideas, which was then used by the mentors and the students for reflecting on their design processes and solutions, leading to metacognitive ways for refining them. Mentor 5 described his use of this approach with Student 30 as follows:

> After we talked and sketched our way through the brief, she went away, did some sketching up of ideas, then come back with them. We went through them with her, sketching and talking about the reasons for using strategics for resolving each part.
> When she had developed the ideas further, she came back with an end result that she backed that up with sketches where she was able to say look I've tried this and tried that but it didn't work so I have come to this result.

Findings from Phase Three data showed that the mentors and students together used sketching during 53% of the work session times. Most of that time sketching was used for the exploration and development of design ideas using quickly executed concept style sketches, similar to that shown above in Figure 4 (p. 123), that provided only the minimal information necessary to communicate the ideas being considered. This process involved declarative knowledge and procedural knowledge of design situations and problem solving methods. Working in this way, the students and the mentors used sketching, backed up with discussion and articulation to communicate personal design experiences and interpretation of other similar design situations that they had used to develop, explore and refine solutions to emergent design problems. Working in this way assisted social construction of knowledge by the students through their interaction with experts using verbal and visual communication methods.

For example, in the design concept sketch shown below in Figure 5, the freehand sketching of ideas can be seen in all parts of the drawing, as well as over-sketching of ideas as new aspects of the design were discussed and explored by the student and his mentor.

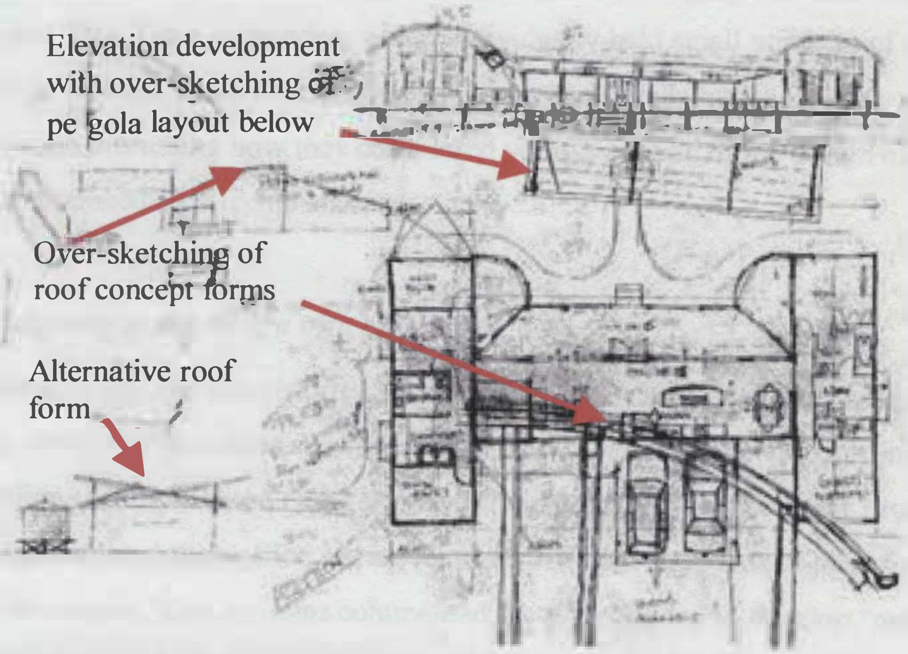


Figure 5. Concept design sketch showing exploration of ideas

Some key aspects of student/mentor sketching methods can be seen in Figure 5 (above). Two different roof forms have been explored, one a simple angled flat form shown in the bottom left, the other a curved form shown in the top left and bottom right of the sketch. This over-sketching of ideas is regarded as a common building design practice and was observed in use by all of the students and the mentors during Phase Three. It is noted here because the use of over-sketching was said by most of the mentors to be a successful way for quickly exploring ideas with students in a manner that communicated the three dimensional form of a building with few words of explanation needed. In this way, the mentors reified their knowledge of many different design solutions and communication their tacit knowledge of other successful applications of the design forms being explored with the students.

Findings about how sketching was used by the mentors and the students as a communication tool in the study situation are listed below.

Sketching was used as a communication tool for:

- visual communication of concepts, ideas, problem solving methods and solutions;
- exploration of multiple design forms and refining variations;

- showing a visual audit trail of design thinking and processes or procedures used in developing solutions;
- providing immediate feedback on concepts or ideas that emerge during design; and
- visual representation of three dimensional complex planer relationships.

Category 1.4 Entry to the culture of practice

This Index Tree Four category was developed by merging data first coded using seven Index Tree Three categories, which individually held small numbers of data units judged to be related. These data documented comments made by the students and the mentors when discussing how they considered various aspects of the design office culture of practice had affected learning.

Adapting to the design office situation.

Most of the students reported that they had made changes in their manner of speaking, behaviour and dress standards when they began working with a mentor in the design office situation. These changes, some students said, were necessary because they discovered that the design office setting required different standards of them to those of a TAFE classroom. Most students commented that they needed to develop "professional ways of talking and behaving" to feel accepted by others in the design office setting and this part of their learning. Commenting on how he adapted to the design office culture, Student 8 said:

> Just getting your neat clothes on and developing your communication, the way you put yourself across. You know, TAFE language is a bit fuck this and fuck that but when you are working in a design office you have to get into work mode and show them what you are made of. It helps you to learn to present yourself, you put your ideas across, you know, learn how to communicate with people.

Most of the mentors guided the students under their direction towards appropriate behaviour by involving them directly in work activities that embraced all aspects of their office culture. The most common approach to emerge from the study data was mentor modelling of speech and behaviour through interaction with other designers or consultants in the design office when the students were there with them. This often happened in student/mentor work sessions conducted in the open work areas of the design office where other designers could be observed and heard going about their usual activities. In situations such as this, students were able to see and hear others acting in ways typical of the office culture, as well as witnessing first hand interaction between the mentors and others who sought their attentinn during the work sessions.

Some of the mentors used more deliberate ways to involve the students in the office culture of practice. Four students in Phase Two and two students in Phase Three participated in authentic commissions being undertaken in the design office situations where they worked with a mentor. This provided them with real experience of working in a design team on an authentic project, as well as working with their mentor on their own authentic project. This type of experience was described by the students as being of great value to them in that it made them feel like a "real designer" working in real team-based office conditions. For some students who did not participate in the design office working commission projects, the mentors included them in other design office activities that provided them with insights into the broad practices of the office situation. For example, Mentor 1a said that he involved students under his direction in all office activities "just like any other employee or apprentice" so as to introduce them to all aspects of the office culture. Commenting on his approach in relation to working with Student 20, Mentor 1a said:

> He had to learn the whole office culture warts and all. This gave him heaps of indirect feedback about what we do and how we do it. We did not just sit him down and say this is how it is. He worked as part of our team, not just as a visitor to a project.

Most of the students who participated in design office activities other than their own project said that it had helped them to feel accepted into the mentor's culture of practice and assisted their learning by providing knowledge of office practices and made communication with others there easier. When commenting on how his experience in the design office had been made easier by working with others in the design team there, Student 8 said:

> I was a bit nervous at first going into the mentor's design studio but they made me feel accepted and that really helped me get into working with them, not like I was just a student but as a designer like others on their staff.

Mentor modelling of the use of technical language and team-based collaborative working practices during work sessions was reflected in student behaviour observed during some Phase 3 work sessions. Activities, such as these, in which students interacted with others in the design office, took place during 25% of the work session times. As an example, when interviewed during Phase Two, Student 14 said that he had carefully observed how his mentor talked to him and others in the design office. He commented further that he used his observations to modify his own behaviour and language when interacting with his mentor and the other design office staff. Commenting on how this helped his learning, Student 14 said:

> The guys in the design office don't talk and act like you see in a TAFE classroom. If you want to get taken seriously in the office, you have to be professional in your behaviour and how you talk. When I did that all of the people there accepted me as an equal and didn't talk down to me like you sometimes get when people think you are just a student. I was accepted as a designer and that was great, it helped me to communicate with the people there and I didn't feel like an outcast. I was able to talk to them about my design work and get loads of help or ideas when I got stuck. I didn't try to pretend that I knew it all and that was good because I was allowed to make some mistakes without getting bagged. They don't expect you to be an expert on the first day.

Analysis of Phase Three data showed that during 81% of the work session times the mentors extended to the students the status of apprentice designer by involving them in decision making and having them assume ownership of the design problems and solutions. Part of this acceptance into the design office culture of practice involved the students in developing a professional approach to time management and making commitments to getting work done to industry standards by nominated deadlines. This emerged as an important aspect of developing appropriate behaviour standards for the students. Student 8 made the following comments on this aspect of his design office experiences:

> The experience changed my presentation of myself. Communications with other people and also time management and being aware that when someone asks for a design, doing it within the time available. In TAFE there is no punishment for not getting it done on time but when a real designer is involved you want to make a good impression, you know you are looking for work and you want to make the best impression that you can. You always want to hand it in on time.

Analysis of Phase Three data showed that during 11% of the work session times, the mentors encouraged the students to develop and apply time management schedules as used in commercial design practices. Mentor 3, at the start of his first work session with Student 22, used the time schedule he was following for a current design office commission as an exemplar for the student to follow in setting target dates for stages in their collaborative project. In another design office, Mentor 1 provided a copy of the standard time management sheet created for one of his current projects for Student 25 to use as a basis for the management of her project. In some design offices, the time management schedules were created using the same quick sketching methods used for developing design ideas. An example of this type of schedule produced by a student is shown here in Figure 6.

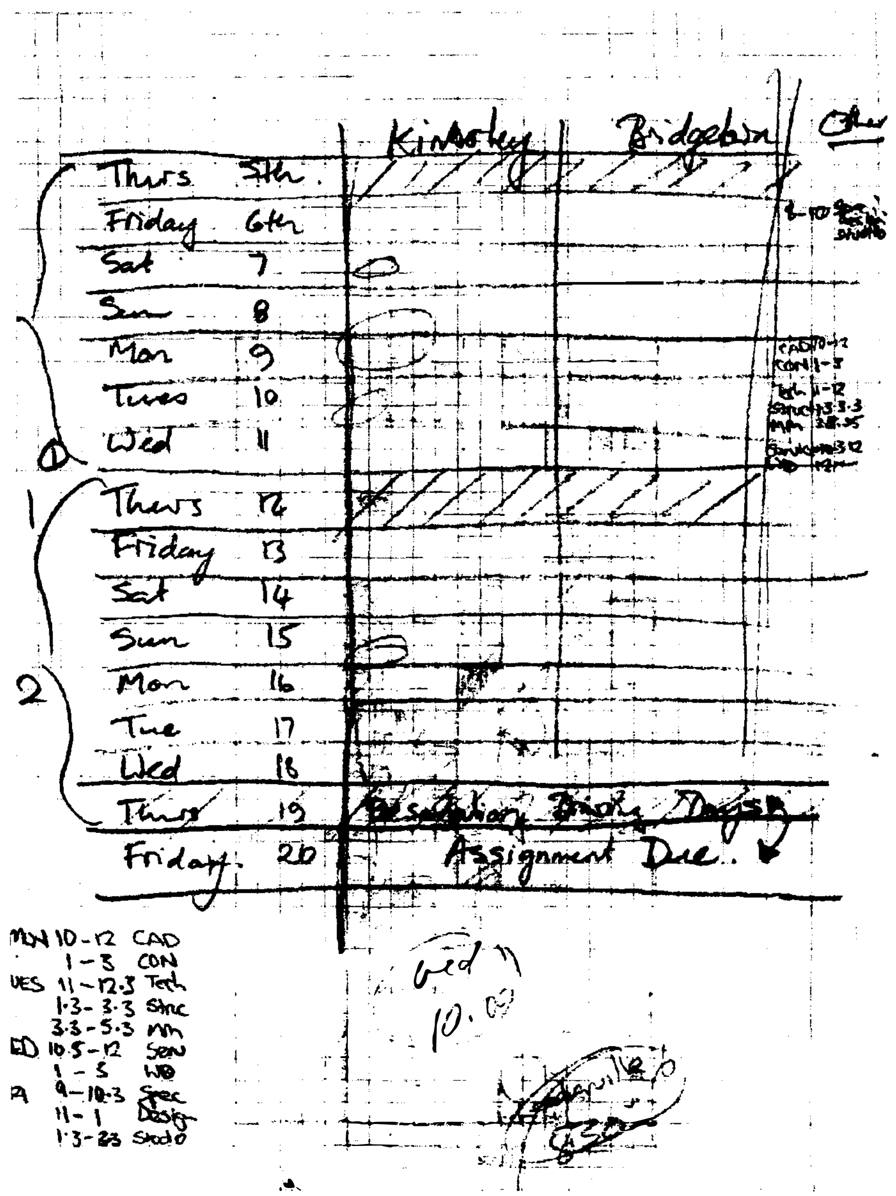


Figure 6. Time schedule for design project.

Learning to use the methods and processes typical of the design office culture of practice was said by most students to be an essential part of their assimilation into the design office setting. This they often said was necessary in order to make the best use of the facilities and resources offered there and to allow them to work in the same manner as their mentor by using the technical language modelled by him for communication. Mentor 1 said of his office practices:

> We talked about why our office does it this way, its the practicalities of such things that can shape the way we present our designs and how he had to present his.

When I observed Student 24 working with Mentor 6 and others in that mentor's design office, it was clear that he was treated as a fellow designer and was given respect for his contributions to his own student project, as well as other in-house projects about which his views were sought. This, Student 24 said in a post observation session interview, boosted his confidence "enormously" and helped him to feel empowered to express ideas openly even if they were his "most radical wacky" ones. He said that in so doing his work became more adventurous, creative and innovative. When discussing how being accepted by his mentor assisted his learning, Student 24 said:

> What was really great about working with him (the mentor) was that he treated me like a designer, not like I was just a student there on prac'. When I put ideas, even if they were a bit off the planet, he would get excited by it and throw in some of his own that were just as wacky. That made me feel like I could try just about anything and so I then came up with some pretty innovative ideas. We didn't use too many of them, but he still encouraged me to keep pushing the edges out.

Data such as these led me to conclude that working on authentic tasks, using practices modelled by mentors gave the students confidence to explore new and innovative ideas similar to those they had seen being successfully implemented by the mentors in their authentic design commissions. This assisted the students to develop their problem solving ability when dealing with problems that emerged from their own authentic project solutions and when using methods they had seen modelled by the mentors.

Analysis of Phase Three data showed that most of the mentors involved the students in activities similar to their own design problems during 54% of the overall work session times. This they did by basing all design problems used on authentic situations drawn from their own design office commissions and the students' authentic design project. Most of the students interviewed during Phase Two said that working with a professional building designer on authentic projects gave them more of a passion to succeed because of their perceived accountability to the mentor and to the profession. Mentor 2 said that he sought to lift student interest in their design work to the highest level so as to "get the most out of them". He described his approach as follows:

> What I was hoping to get back from him was for him to be wanting to get involved more and getting into it not just as a task but more as an obsession.

Mentor 10 also commented on his office practices approach to learning. He said:

> The key to success in building design is to enjoy what you are doing, to have a real desire to do it.

My observation of this aspect of students working and learning with a mentor in the design office led me to conclude that most of the mentors motivated the students to develop a passion to succeed in design and to be accountable to their mentor and other team members. Analysis of Phase Three data coded about this aspect of student learning showed that during 54% of the Phase Three work session times, students were engaged in activities in which they showed excitement and confidence in what they were doing. This supported what some students and mentors said had occurred during Phase Two. For example, Mentor 4 described how he deliberately sought to motivate students in order to engage them in the design project. Mentor 4 said:

> ... within the first few minutes if they haven't been excited I make sure that they are. The excitement is very much about the self and self motivating, how you feel about yourself and this industry, for me its about what it gives me and has done over the years of being a designer.

When discussing how he used the authentic design project to develop student enthusiasm he also said:

> The project for the student becomes a story in itself and they usually get a buzz out it, they enjoy it and that's what needs to happen, they need to feel a part of the process not just doing it.
> When a student comes in here I try to first of all inspire them and give then a structure to work with that may take them on that journey of discovery and lead them almost anywhere they want to go, you know, leave the destination open.

Mentor 4 went on to say that he sought to develop team spirit as follows:

> ...we now have them on board, they are part of a team and they want to win. The enthusiasm is really important I dont want them to be a spectator. OK, then they can go beyond what they are expected to do! That student was doing things he had never done before based on what I had shown him. The environment, the whole approach he loosened up, he was so excited, that was my approach.

Although not all of the mentors sought to motivate the students in this way. Findings here have suggested that all of the mentors made conscious efforts to motivate and encourage the students by demonstrating their own preparedness and enthusiasm to work with them. The level of dedication and enthusiasm shown by the mentors for tackling the student design project surprised some students and inspired them to give their best effort to the tasks. For example, the following comments by Student 9 are typical of many similar data coded about how mentor attitudes and enthusiasm led to student learning.

> I was really pleased to see that a designer of his standing had taken out his precious time to work on something for me so I felt really special that he had done that.
> As soon as we met each time we both got straight to the point and didn't waste any time. I just wanted to put in that bit extra to make the most of what I had learnt with him. Had I just done this project by myself I think I would have just bashed out the first idea of a design and sketched it up without really working it through and knowing that it was the best solution for that brief This was a great working experience and I learnt heaps in a short time about design and how the industry goes about getting projects done in an office. He inspired me to have a go and it wasn't all just me sponging on him, in the end I felt that I was able to come up with ideas and solutions using what I had learnt.

This led me to conclude that student confidence was boosted and they felt enthusiastic about working at their best level when mentors demonstrated their willingness to accept their ideas and were keen to work collaboratively in developing design solutions with them.

Other design office social interaction skills.

Most of the mentors indicated that they considered successful design practice required more than just problem solving skills and innovative ideas. Some mentors said that being able to work in the everyday culture of practice of the design office also required skills in communicating verbally and visually with others. They also commented on the need for building design students to develop what they described as people skills in order to work successfully with a mentor or a client. The following comment made by Mentor 1a is typical of others made by most of the mentors interviewed during Phase Two of this study:

> They (the students) really must develop people skills because this industry is all about selling your ideas to people who often cannot read technical type drawings. If you can't communicate successfully one-on-one with a client then you might as well forget it, you won't make it in this industry.

Being accepted as a designer by a mentor and others in the design office emerged as an important aspect of student learning. It assisted students in developing working relationships with design office personnel who provided a constant source of information and support for them throughout their design office project experiences. This social construction of knowledge emerged as a key element of student learning in the design office setting. Student learning was assisted by their observation of mentor interaction with clients and other professional consultants. Activities like these provided a model for students to learn what some mentors described as essential "people skills" as used in design office practice and promoted student enthusiasm for working with others in the design setting.

Social Contact.

Most of the mentors involved also on the importance of the students' learning from the outset to relate socially, as well as from a work based perspective, with all those with whom they have contact through the design office. Even casual contact in the office, on site, or over the telephone with clients, consultants or other design staff, demanded good communication skills. This was made clear to many students starting out to work with their mentor and was presented to them as a necessary part of their learning to be a building designer. Mentor 10 made the following comments:

> In any business you are selling your services and you need to have an edge to survive and part of that is building up a relationship with the people you work with and that working environment and culture is what you build your business on and communicate through. Business sort of melts into the social thing and most of the clients come back again when they get to know you and the way that I work. Social interaction is very important in making those links in the network that business relies on to survive.

Student 14 when discussing how Mentor 10 included him in the social activities of his design office and how collaboration with others and contacts he made in that setting helped him in his work said:

> I tend to work independently but it was really good to work in a team approach and see how others do it, you get a lot more ideas and see how other people solve things. Being with Jack gave me a good idea of what it is like to be under a boss and to have others around you who you have to be a bit careful of how you talk to them and what might be OK in the office. They had social breakfasts and lunches there and that was good to be able to meet and talk to some of the people who you would see around the office but not know what they did. It was a good way of finding out who to ask when you got stuck or just putting a face to a name that had come up when I was working with Jack (the mentor) and he mentioned someone I should talk to.

Some of the mentors in larger design practices noted that social interaction between colleagues helped to break down barriers created by the management hierarchy and this opened the way for a great deal of incidental learning or ease in communication in the workplace. Findings from analysis of Phase Two data have suggested that student learning was enhanced when they worked in design office situations in which they could interact with other designers and observe them in action. In some situations this led to others in the workplace providing advice and support to the students, or as in some instances, merely being able to observe other designers in action provided models upon which they could construct knowledge. Commenting on the importance of having a wide contact group to assist student learning, Mentor 4 said:

> You need the interaction with others to bounce ideas around and sometimes it is better that students go into a large work environment where they can get ideas from many people rather than just one.

Student 13 supported this aspect of learning from others in the design office. He said:

> Just talking to some of the others there and getting their ideas on things and a few hints was great.

In some offices the interaction between staff is more structured than in others. Mentor 5 said:

> Where I used to work everyone would stay back at the end of the day and have a few drinks and you would get to know everyone a lot better. That made it a lot more comfortable working with them because you felt you were able to talk easily with them about work stuff. Quite a lot of design problems got sorted out during those times because it was relaxed and informal and you could get together with people that during the work-day times might otherwise be out on jobs.

Some of the students said that by participating in informal or casual exchanges with others in the design office, they had learnt much about the design and problem solving methods used by them. In the four design office situations used for the observation of student/mentor work sessions in Phase Three, all the mentors included the students in activities with others in the work setting. These activities included participation in conversations with consultants from other disciplines like engineering, design sessions with other designers in the office, social interaction with clients and others during which work matters were discussed. Through their involvement in activities such as these, students were exposed to many different aspects of the design office culture of practice and were able to experience first hand the manner in which other participants interacted. Having personal experience of the broad spectrum of design office activities assisted student entry to the culture of practice and provided learning opportunities based on authentic situations with all the dynamics of design focussed people.

Student entry to the culture of practice and development of their social construction of knowledge took place by:

- students adopting a professional manner of speaking including not swearing and the use of a technical vocabulary; dress standards based on smart casual wear as typical of the design office;
- students participating in the broad scope of design office activities;
- observation of others in the design office;
- using job management schedules as modelled by the mentors;
- being accepted by the mentor and others in the design office as a designer; and
- development of a passion for design and a desire to achieve professional status as modelled by the mentors and others.

Theme Two: Attitudes

The manner in which knowledge transfer and learning were influenced by the study participants' attitudes towards different aspects of the learning situation and events is reported here. Data were coded in the following three Index Tree Four categories:

2.1 *Confidence;*

2.2 *Team-based Learning;* and

2.3 *Office expectations.*

Category 2.1 Confidence

Most of the students indicated that before starting work with their mentors, they were concerned that they did not have the skills to design at the levels expected of them. This, along with other concerns they had about working with an expert in a commercial design office setting, caused some of the students to feel a lack of confidence and anxiety at the possibility of being embarrassed or ridiculed for their lack of skills. Establishing confident attitudes towards the mentor, themselves and the design office learning situation emerged as an important step for most of the students and the mentors when commencing the design project working collaborations.

Most students reported that their early lack of confidence in their own abilities was quickly dispelled when they found that the mentors treated them as fellow designers and were prepared to accept their design ideas. For example, Student 16 commented that Mentor 6 had encouraged her to speak out in work sessions to present her design thoughts and this had given her the confidence to interact with the design office staff. She said:

> I was a bit nervous at first going into the mentor's design studio but they made me feel accepted and that really helped me get into working with them, not like I was just a student but as a designer like others on their staff.

Throughout the data other comments similar to these were made by most of the students. From these I determined that mentor acceptance of students as fellow designers boosted student self-confidence and helped to develop positive attitudes that potentially assisted their learning. Most of the students reported that they were inspired by working with a mentor and that the duties and responsibilities required of them in the design office setting had led them to taking a more positive outlook towards their studies in general. When commenting on how working with Mentor 6 had boosted his confidence, Student 24 said:

> We worked together on the design all the way through. He was great at giving me support and tips on how to make it all work, but he did not try to make it his design, or to make me change anything so long as I could defend it. I felt more confident with it as I worked it through because he kept an eye on things and just chipped in when it was needed. In the end I felt satisfied that this was my work and that I had done it as well as any of the guys in that design office might have done.

Comments such as these led me to conclude that student learning was assisted by having the mentor take a guiding role with the design project while also encouraging the students to have a sense of ownership of the design. This assisted the students to explore different ideas safe in the knowledge that the mentor was keeping a watchful eye on them to avoid serious error being made. I concluded also that mentor practices that assisted student confidence led students to become more adventurous and innovative with their design ideas.

The following comments by Student 13 suggest that having his mentor show confidence in his ability to complete the design project assisted him to learn more about design by having the confidence to tackle the tasks with enthusiasm. Of this Student 13 said:

> Because he (the mentor) was so confident about doing the design with me, I just wanted to put in that bit extra to make the most of what I had learnt with him. I tried out all sorts of different ideas because he encouraged me to take a risk with design rather than just go with easy solutions. If had I just done this project by myself I think I would have just bashed out the first idea of a design and sketched it up without really working it through and knowing that it was the best solution for that brief.

Comments such as these were made by most of the students when discussing their design office experiences. From data such as these I concluded that most mentors modelled self-confidence and confidence in the students' ability to achieve their design goals. This approach I regard helped to foster in the students positive attitudes and enthusiasm to achieve well. When comparing Phase Two data about what the students said they had learned about design from the mentors, with the design solutions shown in their drawings, it was evident that they had developed innovative design solutions that were accepted by the mentors to be of industry standards. From this, I concluded that a key student learning outcome to emerge from mentor practices aimed at fostering enthusiasm and confidence was student innovation and striving for excellence in their design solutions. This aspect of student learning was explored further in the analysis of Phase Three data.

Affording students the role of designer was a common practice amongst the mentors and this led to the students developing self-confidence and positive attitudes towards giving their best effort to the work at hand. During 85% of the Phase Three work session times, Mentor 4 gave Student 23 the leading design role in activities they undertook together. This approach facilitated an atmosphere in which the student and the mentor were observed to be interacting freely in a relaxed manner, exchanging ideas and each contributing to the discussion and exploration of design concepts. When discussing how he encouraged Student 23 to be confident throughout their collaborative design activities, Mentor 4 said:

> The project for the student becomes a story in itself and they usually get a buzz out it, they enjoy it and that's what needs to happen, they need to feel a part of the process not just doing it. If they are not excited by it when they first come in, then I make sure that they get excited pretty quickly, I get them feeling confident in me and in themselves to get the job done.

Student 23 commented that the enthusiastic approach taken by Mentor 4 in their work sessions gave him confidence in the mentor's ability to resolve problems that emerged during the development of his design project. Mentor 4 described his approach to encouraging confidence and enthusiasm as follows:

> ... once you have established the environment the expectation, the excitement, the enthusiasm starts to flow from there, it sets the goal or focus or leadership aspect.

In each work session, Mentor 4 gave non-judgemental feedback and positive reinforcement to Student 23 for the ideas he presented. For example, when Student 23 showed Mentor 4 sketches of design ideas he had developed independently between their work sessions, Mentor 4 immediately praised his efforts. He did this by singling out parts of each of the design ideas presented for special comment, then linked these to the design project at hand by over-sketching to demonstrate how they might be applied. Ideas presented in this way by the student were examined and used either in part or in full depending on their suitability and on other factors such as practiculity for constraction, aesthetics, cost and the like as discussed by the mentor during their evaluation. Using this approach assisted Student 23 to learn how and why Mentor 4 used his tacit knowledge and procedures to refine design solutions as applied to the student's own design project.

Working with students in this manner I regard as in keeping with the principles of cognitive apprenticeship by providing ways for the mentors to use their tacit knowledge to evaluate student works while using articulation to explain their reasons for accepting or rejecting design elements or solutions. This approach also assisted learning through coaching in ways similar to that reported by Carver, (1995, p. 207) who contends that it involves the "teacher keeping tabs on the students as they work independently so that guidance, redirection and correction can be provided as necessary".

Mentor 4 said that he used praise and positive reinforcement to "bring out the best in the students" and to encourage them to explore creative ideas without fear of embarrassment. Commenting, at the end of Phase Three, on this aspect of working with Mentor 4, Student 23 said:

> What really helped me was having him treat me like I was a real designer and let me put up all sorts of ideas that were sometimes a bit off the planet. We would go through them together and he'd say what might work and what might be a bit hard to build, but always giving me reasons for his ideas. He never put me down or laughed at my stuff. I felt like I could have a go at all sorts of things and rely on him to keep it practical 'cause he had been there before me.

Analysis of Phase Three data revealed that during 81% of the work session times, students participated in activities in which they took the role of apprentice designer and showed confidence in their verbal exchanges with the mentors when presenting, discussing and exploring design ideas. Feedback from the students to the mentors also emerged as an important aspect of developing confidence in their collaboration. Commenting on this in relation to working with Student 13, Mentor 3 said:

> Burry was very good at giving me feedback on what he was thinking and that really made it (the team collaboration) work and that was great.

In Phase Three, on average, the mentors spent 36% of the work session times analysing student works to provide feedback, while spending 42% of the time to inspire new thought based on what was emerging from the design collaboration. For 34 % of the work session times, the mentors used questioning to encourage students to explain their reasons for using particular design procedures or solutions and another 20% of the work session times to have the students present their design solutions.

The experience of working with a design mentor was said by most of the students to give them confidence to explore ideas outside of the ways they were used to in their TAFE courses. Student 9 said that he had a great sense of satisfaction at having worked successfully with a professional designer and having been treated as a designer. He expressed the view that by gaining confidence in his ability to design, he had learned to be more creative and adventurous with ideas and had been inspired to achieve excellence in his work generally. Findings from the study data suggested that student learning in a design office situation is assisted when mentors encourage positive, confident attitudes towards working collaboratively with students and provide reinforcement for creative, innovative ideas even when they may have limited application to the tasks at hand. Student enthusiasm for design was enhanced when their own design ideas become part of solutions that are supported by mentors and regarded by them to be of design office or industry standards.

Feeling a sense of achievement and satisfaction at having successfully completed a design project with a mentor was said by most of the students to have given them confidence and a desire to apply what they had learned to new design challenges. This emerged as an important learning outcome. Producing a design that was almost entirely their own work and having that accepted by a practicing building designer led to student satisfaction and validated their learning. Many commented that in so doing they felt confident and empowered to take on other design challenges. Student 8 said:

> After working with a mentor you get the satisfaction of knowing that you have completed a real project and done it well because it has been assessed by a real designer.

Student 9, when commenting on how he had developed confidence and a positive attitude towards his work as a result of working with his mentor, said:

> I feel more confident and positive about what I am doing. Before that I would do my designs and I'd think I would wonder if this will work and I'd think no that's just a shit idea, but now he has broadened my horizons a bit and now I think hang on maybe that might work and I'll try it out.

From comments like these and other similar data, I concluded that students developed confidence in their use of creative design methods and autonomous ways of applying heuristic design strategies and problem solving methods modelled by mentors in their collaborative work sessions. Student development of self-confidence emerged as an important aspect of their learning because it assisted their progress towards independent or autonomous use of design knowledge and procedures.

Findings that emerged from analysis of the study data suggested that student learning was assisted by them having confidence in their mentor and in their own abilities. The following aspect of working with a mentor in the design office situation emerged as assisting learning by developing student confidence:

- being accepted by the mentor as a fellow building designer;
- having a mentor model confidence in the student's ability to resolve complex design problems;
- mentor use of non-judgemental, positive reinforcement, in feedback when assessing, coaching, or scaffolding the student's work;
- mentor support for student presentation of original ideas and design strategies;
- mentor encouragement of reflective practices when self assessing design ideas;
- mentor support for student defence of ideas; and
- autonomous use of design strategies and procedures by students as modelled by the mentor.

Category 2.2 Team-Based Learning

Analysis of Phase Two data indicated that most of the mentors used a team-based approach to design, in their everyday practice and when working with students. When commenting on how he encouraged students to participate in a team based approach to design Mentor 4 said:

> ... they have to be part of the team and it doesn't matter what part they play at first but you have to drag them into the game and give them a go ... if you can get them to feel OK about working with others and baring their soul, then they can learn from their mistakes and from others by being part of the process, not just a spectator.

Some students said that although they had worked in small groups on design projects at TAFE, they mostly worked individually on design developments, with didactic instruction from lecturers shaping their design solutions. Student 8 expressed the view that such an approach fostered an attitude of "waiting for answers" rather than working it out with other group members. Student 8 said:

> ... with a teacher relationship you are too spoon-fed ideas, whereas you put your ideas across to a mentor you are making yourself open to criticism and really testing your ideas. It makes you work a lot harder for a good solution when you know that you have to defend it to others in the design office.

These comments are typical of many others that emerged from data collected from interviews with students during Phase Two. Most of the students said that they changed their approach to design from the individual-oriented instructional methods used in TAFE classrooms to using the team-based methods modelled by the mentors. Data about this change were coded along with other data about how students used their interaction with design team members to test ideas and to learn new ways for refining them. This was done in order to determine student learning outcomes when using team-based design methods.

Findings that emerged from data coded in this way suggested that student participation in team-based activities with professional building designers working on authentic commissions, as well as the student projects, helped students to construct their knowledge of design and to autonomously implement design procedures modelled by the mentors. For example, Student 14 said that before working in collaboration with his mentor, he had always taken an individualistic approach to his design work and had not experienced the team-based approach of exploring and refining design ideas, as modelled by his mentor and others in the design office. Commenting on how he now preferred a team-based approach to design, as a result of working with his mentor, Student 14 said:

> I tend to work independently but it was really good to work in a team approach and see how others do it, you get a lot more ideas and see how other people solve things.

An example of how a design was changed from a simple rectangular form to having angled wings is shown in Figure 7 (p. 142). This sketch shows a student design over which a mentor had sketched rooms at an angle to make use of views and to create a courtyard space to provide weather protection for windows on the side of the building subject to the prevailing winds. The angled section drawn in heavier, darker lines show the mentor's oversketching. This is how most of the mentors introduced new ideas to the students and at the same time kept the basic form of their original design concepts.

This illustrates also the team-based methods used to develop the student's design solution.

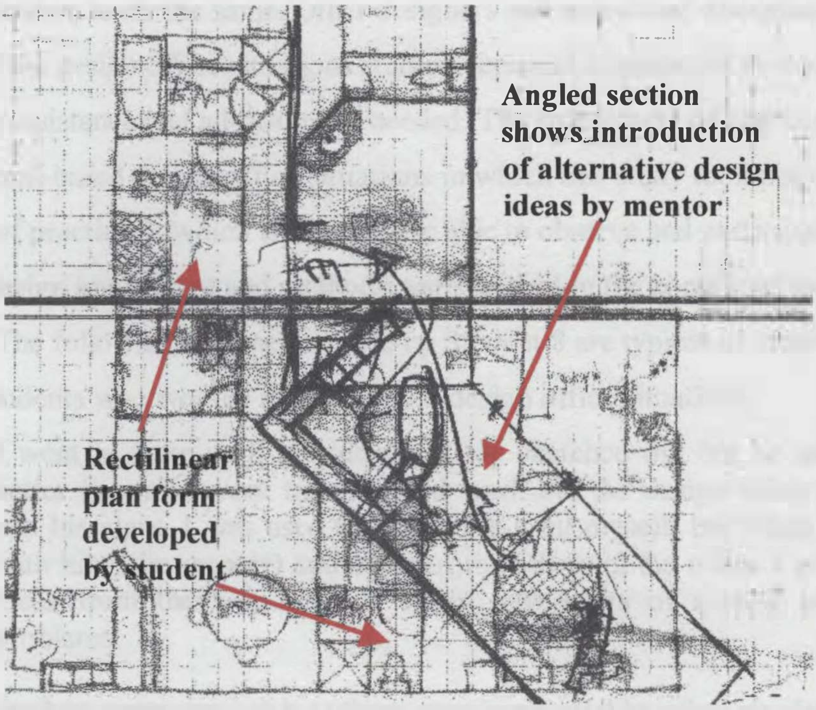


Figure 7. Sketch showing introduction of ideas by mentor

Most of the students suggested that they felt a greater sense of accountability when working with a mentor and that the team-based nature of the working collaboration encouraged them to give their best effort to the tasks. Some said that they did not want to "let the mentor down" or to appear to be superficial in their approach to the work. Most of the students said that they sought to make the most of their collaboration with the mentors and to achieve excellence in design. When discussing how her mentor had inspired her to be confident and creative with design, Student 16 said:

> Right from the first time that I went there he made it clear that we were going to work together as a team and that he was keen to see my ideas going into the design. I was not confident at first to say what I really wanted because he was the expert and I was a bit shy and thought that he might laugh at my ideas. What was great though was he encouraged me to throw in all sorts of ideas just as he did and we would sort them out together and sometimes have a bit of fun with some of the crazy ones that we each came up with. After while I felt confident to try just about anything and that's how I came to develop my final design. Because he encouraged me, I felt really keen to come up with something special. In the end we were both a bit surprised with the result. It was tops.

From data such as these I concluded that student learning was enhanced when mentors applied team-based design practices to working with them on authentic projects and demonstrated their commitment to excellence with an expectation for the student to do the same. Other designers and associated discipline consultants in some of the design office situations studied here also contributed to student learning by offering assistance and advice when needed. The community of practice found in most of the team-based design office situations in which this study took place provided a culture of practice in which students were able to observe and participate in activities in which design knowledge and methods were applied in the context of the domain.

The following comments made by Student 8 are typical of others made by most of the students who worked in team-based design office situations.

> I went in there with my ideas already sketched out but he said it was better for us to work together and work out the design using my ideas and his ideas. I was used to just doing it all myself, but when I worked with him (the mentor) and some of the others in the office I got a lot of ideas from them and also I learnt new ways of sorting out design problems.

Student comments such as these were supported by other similar data collected during Phase Two interviews with mentors, most of who said that the building design industry is run on team-based methods. The following comments made by Mentor 11 are typical of other data provided by most of the mentors when commenting on the team-based nature of their working practices and student mentoring approach:

> In this office we do everything as a team. Every time we do a job we are going through a design process and when students come here they become part of the team and they learn the office practices and the way we do things. Right from day one they become a part of the team in the office and they start doing parts of the jobs in hand straight away and their own design project is just one part of that. That's how they learn to design, real hands on experience as part of a team; that's how the industry works, they need to know that to survive.

Most of the mentors similarly commented when discussing the role of team-based design methods in student learning. Other data showed that even in design office situations where there is just one designer working, team methods still apply because building design requires input from many other consultant disciplines. This means that a building designer working "alone" is still part of a wider community of practice that may include engineers, electrical consultants, plumbing consultants and a host of others. Students working in office situations where they had contact with other designers or consultants were able to discuss with them design strategies and acquire knowledge necessary for the application of them to emergent problem situations.

Commenting on this aspect of introducing teamwork methods to Student 29, Mentor 12 said:

> My design office is a one-man show, but I rely on up to 10 or more other consultants on every job to deal with structural problems and a host of other specialist areas of the design. When Kerry came here to do her design project she got quite a surprise at finding that I did not have all the answers, but they were there if she got on the phone or walked into Ron's office next door. She discovered what it means to be part of a design team each time she needed specialist advice or another opinion.

During the video recorded Phase Three work sessions, the mentors in three of the four design office situations assigned other members of their staff to become part of the design team to assist with mentoring students under their direction. In the fourth office, the mentor did not have other office staff, but instead on two occasions included consultant experts in the work sessions to provide alternative points of view or expert advice about particular aspect of the design being developed by his student. By having these arrangements in place, all of the students in Phase Three were supported in their design development by a wider community of experts operating using a team-based approach organised by the mentors.

Having multiple points of view and team-based methods for resolving design solutions as provided by the mentor and other experts assisted students to learn design methods in the culture and context of everyday building design practice. Being part of the design team and sharing ownership of the emerging design with others also led to students feeling a sense of ownership of the design outcomes and enhanced their desire to contribute in the work sessions. Commenting on this aspect of working in a team-base manner with her mentor and others, Student 25 said:

> All the way through I felt really well supported because there were always at least four of us in the team working together on the design. Sometimes the team make-up changed when one or other of the guys were off on other jobs and someone from the office would stand in for them. That was really good too because they would usually have different ideas or little ways that they liked using for design and I picked upon them and used some of it in my final project. When I worked in the office with the others, I often saw and heard them working through similar problems that I had in my design. They did it just like in the sessions I had with my mentors; they all helped each other and were constantly debating how different things needed to be done and what you needed to know about building methods to do it. There were some pretty hot discussions also and I learnt a lot about how the office works from that too.

Team-based design office experiences like those described above by Student 25, assisted student learning by helping them to acquire declarative knowledge such as regulatory requirements, as well as explicit information about building methods and materials. Other design information about situational factors was also learned from others when they expressed their tacit knowledge of successful design practices and procedural knowledge about the application of design methods or processes used for resolving problems in design.

In Phase Three, activities in which students worked with the mentors as a team were observed to take place during 53% of the time and with others in the design office during 25% of the work session times. Learning to become a team player in the design office situation was noted by some students to be a valuable part of the overall experience for them. Commenting on how working with Mentor 10 had helped him to learn about team-based design methods, Student 14 said:

> Being with Jack gave me a good idea of what it is like to be under a boss and to have others around you. Everything that I did there happened as part of a team, either with Jack or one or more of the others in the office. Although I did work alone some of the time, there were always others working near me who I could ask advice of. Sometimes just listening to them talking together about problems in their own design jobs helped me a lot also. I could see from what they were talking about how they sorted out problems like the one's I had in my design project. That helped me a lot.

Being part of the design team and being part of the community of practice in the design office provided Student 14 with insights into many different aspects of design practice the wider context of the construction industry. This is mentioned here because he commented further that having a positive attitude towards sharing design ideas with others helped him to acquire knowledge about their design experiences and problem solving strategies which he then used in his own works. Much of what took place during the work sessions involved the mentor or others modelling their design practices, then coaching the students in ways to apply what they had demonstrated and explained along with examples of authentic situations they had resolved using the methods being presented.

The following comments by Mentor 7 when discussing how a student under his direction was introduced to his team-based design office methods are typical of many others coded in this category. They sum up several aspects of team-based design office experience that assisted student learning.

> When they are working with the mentor they will pick up design ideas but mostly they pick up techniques for doing things, particularly different

> ways of presenting things as we do here in the practice. She was right there in the office working alongside the guys as they produced the jobs. I sat down with her and some of my other design staff and got her to go through the drawers and have a good look at how we do it here.
> She saw it happening (the design process) from a three-sheet project to a twenty-five-sheet project.
> We were mostly trying to get her to understand the basics of working through a design brief as we would do it here. We showed her the stages of a project from the freehand concept drawings and sketches, then to the CAD sketch, then to the working drawing and specification. We also ran through how we develop the perspective drawings from the CAD wire-frame model. (Mentor 7)

In this quotation, Mentor 7 has made note of several aspects of team-based design office learning. First, he comments on how students "pick up design ideas" and presentation methods from others in the design office. This I regard as learning tacit knowledge and procedural knowledge. Then, he mentions the use of "the drawers", meaning the file drawers holding copies of "office set" drawings used to document the development and presentation of authentic office commissions. Information contained in those "office set" drawings when explained by others in the design office team, I regard as providing many different learning opportunities. These include: declarative knowledge of design situations, tacit knowledge based on the assisting mentors' experiences with those projects and procedural knowledge presented through explanations of the methods used to develop design solutions, as well as the reasons for using those methods and accepting the design outcomes.

Findings about how the use of team-based methods in the design office situation assisted student learning are as follows:

- providing students with opportunities to work in design office situations where they can witness and participate in all aspects of usual design office practices including exchanges with expert consultants in disciplines associated with building designer and construction;
- making available design office personnel to ensure continuity of support in work sessions when the principal mentor was not available provided students with a community of practice having multiple sources of knowledge and expertise to assist learning; and
- including students in teams working on authentic design office commissions in ways that allow them to make a contribution to design solutions and to the processes used to develop them.

Category 2.3 Office Expectations

Analysis of data, from student journals and Phase Two interviews, indicated that most of the students and the mentors entered into the authentic design project having expectations about their own and each other's performance and responsibilities. Most of the mentors expressed intentionality in their approach to how they would use the collaborative work situation to assist students to learn how to create a successful design solution. Similarly, most of the students said that they had set out to make the most of the learning opportunities they expected to find when working with a mentor in the design office situation. Findings that emerged from coding data about how participant attitudes affected student learning in the design office situation are discussed here using the categories *Student Expectations* and *Mentor Expectations*.

Student expectations.

Most of the students entered into their work with a mentor with a very positive outlook and were rewarded to find that the mentor viewed their collaboration similarly. The following comments made by Student 13 reflect similar views to that expressed by all of the students who participated in Phase Three of the study.

> When I first went there (design office) he (the mentor) told me straight out that his main aim was for the students to get the most out of it. He was not very concerned with winning any prizes, his main concern was for the student to get benefit out of it and any real work experience is good experience. That's my outlook as well so we had the same goals in mind.

Analysis of the study data suggested that the students anticipated that the mentor would be focussed assisting them to learn to design. This had encouraged them to enter into the collaboration with a learning focussed attitude. Student 13 commented:

> I knew before I even met him that it was going to be good experience and a lot of work, but having such a chance to work with a real designer in a real office environment was just what I wanted. Having him to set the guidelines was what I had hoped for because it allowed me to get the design done, but without having to work on a whole lot of stuff that was perhaps not necessary.

Most of the students made comments, in their journals and when interviewed, that showed that they had very positive expectations about working with a mentor and this assisted their learning. Student 14 said:

> This was a great working experience and I learnt heaps in a short time about design and how the industry goes about getting projects done in an office.

Student 16 also commented that although nervous about working with a mentor at the start, her attitude changed and she became more confident in her own abilities as their working relationship developed and she saw that the mentor had a positive view of her skills. Of this aspect of her learning Student 16 said:

> He really put me at ease by accepting my ideas and helping me to develop them. I felt like a real designer then and it was really good to know that I had some knowledge and skills that others out there did not have and they sought my views, that me feel more confident in my own ability to do the work. I went there anticipating that something special would come out of working in that office and it did.

Findings from analysis of data coded in this category indicated that most of the students went into the student/mentor collaborative project having a positive outlook and a preparedness to dedicate themselves to the work. This led me to conclude that having a positive attitude to working with a mentor in the design office situation assisted student learning.

Mentor Expectations

When interviewed during Phase Two, most of the mentors said that they expected the students to be enthusiastic about working in a design office setting and that the students would make an effort to capitalise on the learning opportunities available there. In recognising this, most of the mentors set out to show their willingness to provide a valuable learning situation for the students by preparing resource materials and clearly defined procedures for developing their design skills and knowledge. For example, Mentor 3 said of his approach:

> I knew that the student coming to the office was working as well as doing his TAFE course, so he was pretty hard pushed. I took the opportunity to operate professionally and do my homework. First of all I made myself familiar with the brief so that when he came to see me for the first time he could see that I was prepared for him and I could immediately begin guiding him through the design process. I expected to get the show on the road straight away and I wanted him to know that he was expected to perform right from the outset also. If he saw that I expected that of myself, then he might also expect it of himself. That's pretty much what happened. He got straight into it as I had hoped.

The approach described above by Mentor 3 was similar to that used by most of the mentors when trying to establish work-focussed expectations with the students. One view expressed by most of the mentors suggested that mentor modelling of positive attitudes towards the work led students to adopt similar attitudes when replicating the mentors' work practices. For example, the following comments made by Mentor 10 are regarded by me to typify the approach taken by most of the mentors:

> I knew that this was a voluntary project and I didn't want to put the student under too much pressure because he had other assignments to do also. I did expect though that during the times we worked together that he would be totally focussed on the project and follow through on the advice I was giving. I found that by showing him I was enthusiastic about the project and by making clear my expectations of coming up with a good solution, he responded well by setting his own goals to match mine. As the project progressed, he set himself even higher expectations and came back with a lot more than I first thought he could achieve.

Analysis of data such as these led me to conclude that when the mentors expressed to the students their expectations about their responsibilities or performance in the design collaboration, the students responded by aspiring to meet them. As suggested above by Mentor 10, this encouraged students to aspire towards achieving higher levels of performance in the work session collaborations. Some mentors began with high expectations of student performance and this resulted in their using work session practices that pressured the students to extend themselves. For example, Mentor 7 said:

> We put a bit more pressure on them (the students) to be creative. We assume that they have learnt a certain amount of design skills at TAFE and have got the basic where-with-all to put together some sort of plan. So we get straight down to design so as to get several quick solutions together to choose from.

Even though Mentor 7 was keen to pressure the students in order to get them quickly into using his design strategies, he said that he did this knowing that they also needed to be well supported in their efforts. This was necessary in order to "not stifle their creativity" and needed to be done in ways that built their self-confidence. Of this approach he said:

> Most of the time the ideas are there but they (the students) are too shy to say, "this is what I think". They have this expectation that you will do it all for them. Some of them will express their ideas, but others are not confident to speak out. You have to first-of-all get them to the point where they are confident enough to speak out and to back up their design solutions with reasons why they think it is good or will work. I build that into my teaching strategy with them. I know that at first they will be a bit quiet and I'll have to create that expectation of involvement in them.

Most of the mentors said they expected the students to be at least an equal contributor to their collaborative work sessions and design solutions. When anticipating that the students may not at first be prepared to take an equal role in the design development, some mentors planned their activities to ensure the students engaged with the tasks from the outset. This approach, which was common to most of the mentors, was centred on creating for the students the expectation that they had to come up with most of the answers in the work sessions. The following comments by Mentor 10 are typical of what most of the mentors said about this aspect of their work with the students in the design office situations:

> I decided that I was not going to just give him answers on how to do it all, I wanted him to do the work for himself. I said to him what do you think that they (the client brief) are asking here, what do they want? I tell them that you should always reflect on the work that you do and look to how you might do it better next time, you should never give up on trying to improve anything particularly in the design business.

Data such as these led me to contend that most of the mentors made a conscious effort to influence student expectations and to foster positive attitudes towards design practice in order to assist learning. Analysis of data collected from student interviews support this view. For example Student 13 said:

> Oh yes be told me straight out that his main aim was for the students to get the most out of it. He was not very concerned with winning any prizes, his main concern was for the student to get benefit out of it and any real work experience is good experience and that's my outlook as well so we had the same goals in mind. He said he would support me all the way, but I had to come up with goods, not just let him have all the answers.

This view is one that is well supported in data from the mentors who mostly saw their role with the students as one for providing authentic design experiences with comprehensive support to explain the effective application of their design methods. The following comments made by Student 14 are typical of those expressed by most of the students and also in keeping with what most of the mentors said was their approach when working with the students:

> I went in there feeling really enthusiastic about working with a mentor because I thought that it would be a good chance to see how the industry works from the inside without actually being in a job situation where you don't get the chance at first to do design. Working on this project was great because I was treated as a designer right from the start and you don't get that as a student and you don't get that in your first job, usually you get stuck doing some part of a project and that's all. I went in there

with the attitude that this was a big chance for me to get some real experience and to prove myself to a real designer.

Although there were some differences in the working methods used by various mentors, generally most of them engaged with the students by extending to them the status of apprentice designer and structured the work sessions to replicate their usual practices when working with other staff. This they achieved by introducing new concepts or designs tasks with small increases in the levels of difficulty in a sequence that mirrored the development of the students design project and problems that emerged as each new element was addressed. For example, Mentor 6 said that he structured learning tasks for students under his mentorship as follows:

> I find the best thing is to get them here in the office working on some of the projects that we have under way so that they first of all find out where everything is and how we go about creating and refining design solutions. We get them to actually do little design and detailing tasks like laying out bathroom areas or cupboards, then sketching up construction details base on our "office set" drawings so that they build knowledge of our ways in small steps. I try to pick things out of our projects that give them elements they can use in their project. That way I can see when they are ready to move to the next level. Eventually they work through all the basis steps that we use to build up a design and with that they do their own.

The level of difficulty of the tasks introduced in this way by the mentors was influenced by their expectation of what the students might achieve as their skills developed and they adapted to the design office culture of practice. For example, the approach taken by the design team of Mentor 1 and Mentor 1a sought to keep the students busy and focussed, but not to overburden them and stifle learning. Of his use of this approach, Mentor 1 said:

> You have got to make them (students) do the work, but it is vital to keep it light and enjoyable otherwise they learn nothing. You need to have them feel enthusiastic about what they are doing; they need to feel ownership of the design and have you there as a source of information and back-up for when small problems become mountains to climb.

Mentor 4 said that he introduced students to design by first building their enthusiasm and excitement for the work. He expressed the view that by having students feel part of a team, they developed ownership of the design problems and solutions and in so doing developed greater enthusiasm to resolve them and pride in the end result. This, he said led to their becoming fully involved in the work which helped them to acquire tacit knowledge of design methods by applying the information and procedures that he introduced during work sessions.

Most of the mentors engaged with the students by expressing to them their enthusiasm for design. They also developed with the students an expectation that their collaboration would be founded on self-development through involvement in the design tasks of their collaborative project.

Analysis of the video record of Phase Three work sessions showed that when the mentors modelled an enthusiastic approach to introducing and exploring innovative design ideas, the students reacted similarly and expressed their creativity in an enthusiastic manner. During my observation of six Phase Three work sessions, in which Mentor 1 and Mentor 1a worked with Student 25, I noted that both of the mentors and the student equally contributed to the "brainstorming" of design ideas. Throughout all of those work sessions, the mentors also provided information, design strategies and positive feedback to Student 25 by using small design tasks to address various aspects of her emerging design solution. Each of these tasks introduced new challenges, information or problem solving techniques necessary for resolving problems that emerged from the main design project being developed. When interviewed earlier they said that they expected of the students under their direction the same level of enthusiasm and involvement that they modelled during the work sessions. This approach was clearly evident in Phase Three data, which showed that activities in which the student engaged with the mentors took place during 100% of the work session times. They said their main expectation was to have the student think about their work rather than wait for solutions to be provided. This was a part of their overall strategy to give ownership of the problems emerging from the project to the student and to have them in turn take responsibility and ownership for thinking through and developing the solutions. On this point Mentor 1a said:

> We want them to be able to think, we don't want to have to hand feed them and the big problem is getting someone in here who keeps saying what do I do now? We want someone who goes away and thinks well maybe if I do this, we don't care if they make mistakes, but at least it show that they are thinking about the problems. It is easier to work with someone who will explore ideas rather than wait for you to give them to them.

The following aspects of how student and mentor expectations affected learning emerged as findings from analysis of the study data:

- student anxiety about having inadequate skills and mentor domination of the design process were dispelled by mentor confidence in students and their willingness to give students apprentice designer status;
- mentor use of a sequenced approach to design removed student anxiety over work loads and knowledge/skills development;
- constructive feedback by mentors and acceptance of student ideas built student confidence to be innovative and to explore new design ideas;
- mentor expectations about student performance were met by affording students apprentice designer status by having them undertake small easily achieved design tasks to build knowledge and skills needed to address problems emergent from their main design project. This encouraged student ownership of emerging design solutions; and
- mentor modelling of enthusiastic attitudes towards design led to student development of similar attitudes and willingness to contribute.

Theme Three:

Mentor supported design office practices affecting learning

Findings from analysis of data coded in themes represented by Index Tree Four categories *3.1 Common design office practices* and *3.2 Learning methods using modelling* are now discussed, along with supporting Phase Two and Phase Three data.

Category 3.1 Common Design Office Practices

Analysis of data coded in this category took place using eight sub-categories. Data coded in each of these sub-categories focussed on mentor practices that assisted students to acquire declarative knowledge about mentor processes, design situations and regulations, as well as procedural knowledge required for implementing design methods and strategies used by experts to resolve emergent problems in authentic projects. The sub-categories used are:

3.1.1 Preparation for design – the brief and other factors;

3.1.2 Questioning and articulation of ideas;

3.1.3 Selection and use of resources;

3.1.4 Learning Using "Office Set" Methods;

3.1.5 Sketching as a design office practice affecting learning;

3.1.6 CAD overlay sketching;

3.1.7 Explanatory notes and drawing annotations;

3.1.8 Multiple perspectives from consultants and others;

Findings that emerged from analysis of data coded using these categories are now discussed, along with supporting data from Phase Two and Phase Three.

Category 3.1.1 Preparation for design.

Analysis of Phase Two data suggested that most of the mentors modelled a methodical approach to preparing for a design project. Most of the mentors interviewed during Phase Two said that they started by showing students how to break down a client design brief into simple structured processes and procedures to address each problem or design criteria. As the students demonstrated that they could resolve the problems being presented, the mentors introduced other aspects of the design brief that incorporated new design tasks of increased difficulty for the students to apply the problem solving methods they had been using. Working in this way, the students developed their tacit knowledge and acquired declarative knowledge about the design situation and procedural knowledge of ways for dealing with problems embedded in the authentic tasks determined by the project brief.

Mentor use of sequenced tasks structured around design office procedures used to resolve design problems of increasing difficulty emerged as a key element in student learning in design office situations. The following comments made by Mentor 3 when discussing his approach to working with Student 13 are typical of others made by most of the mentors when interviewed during Phase Two that led me to conclude that introducing students to design using this approach was a common practice.

> I did my homework with the brief before he came to see me. I wrote down all the key points from the brief to outline what it was that we were setting out to do. I had it planned out in small easy stages that gradually covered the more difficult aspects of the design that I knew would emerge as we got further into refining a solution. During our first meeting I showed him how we would do it by using these notes that I had prepared (*see notes in Figure 8, p 155*) for him so that he had a clear idea of what we were doing and in what order. These notes were on the table and I said we start by looking at a three bedroom one-bathroom design with a courtyard, just a quick analysis of what the design brief required.

The notes referred to by Mentor 3 are shown below in Figure 8 (p. 155). They provide declarative knowledge about the design situation which was used by Mentor 3 as the basis for discussion and modelling of design procedures he said that he typically used for resolving problems usually encountered in design situations like the ones found in the authentic student project. Working in this manner, the mentor reified his tacit knowledge of design procedures and provided declarative knowledge for students to use as advance organiser for dealing with their project.

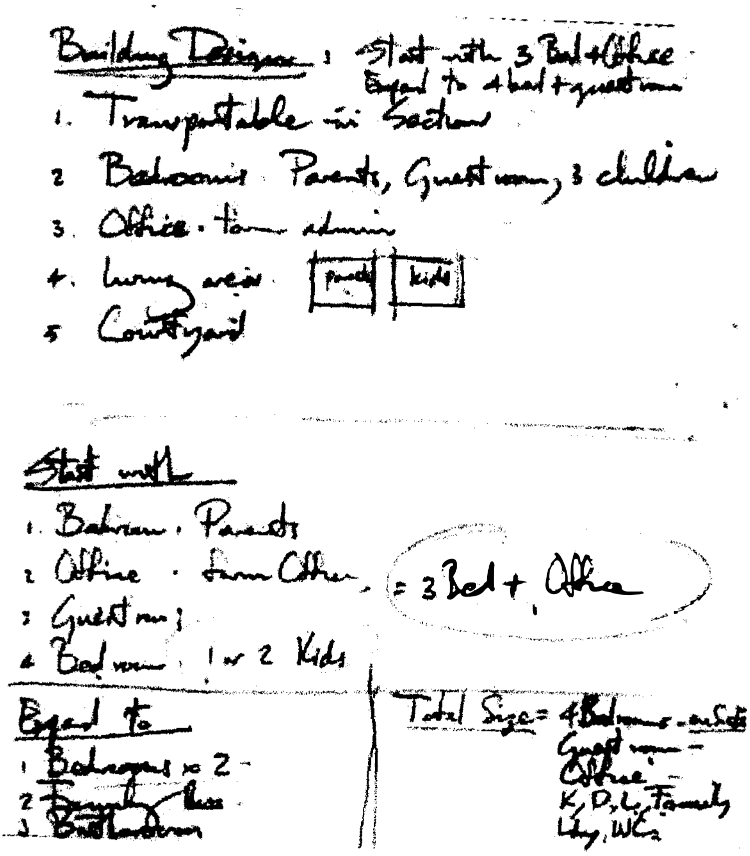


Figure 8. Notes used to initiate the design process.

Student 13, when asked about how he and Mentor 3 began the design project confirmed what Mentor 3 had said of his approach. The student also added that he immediately felt confident in the mentor because the mentor had already prepared a "plan of attack" for the design and gave him a clear process to follow in developing it. Of this approach Student 13 said:

> I had some ideas and took in some notes and sketches to that first meeting and so we were able to talk about the brief. He had already been through the project requirements and was really insistent that we follow the brief exactly and incorporate our own designs so that the client can benefit from it, but it had to follow the brief. Then he worked through some ideas with me using notes that he had already made from the brief and suggested how to find information about each part to sort out any problems. It really helped just having a path to follow and knowing that if I got stuck he seemed to have all the answers.

A similar approach was used by Mentor 7 who also started by breaking down the client brief for students while engaging them in the design process by encouraging their contribution of ideas when building the structure to follow in the development of a design solution. The following comments made by Mentor 7 show his way of guiding student learning by first providing declarative knowledge of the design situation, then clarifying this using tacit knowledge to explain various elements before implementing procedures to initiate creative, innovative use of the information gathered.

Mentor 7 said:

> We'll start out with a concept by first starting out with the brief, break down the brief into manageable increments so that they understand every part and have a handle on it otherwise you can't do anything. Once I am comfortable that they are at that point, then we start to get some ideas down and I am bouncing some ideas off them and getting them to think.

Analysis of Phase Three data showed that all of the Phase Three mentors used a similar approach. They each began by encouraging the students to discuss and sketch their ideas. Then they introduced their own sketches and notes to extend the investigation of the project brief by combining the two sources of information and thereby created a team-based working situation. Mentor and student sketches and notes used for this purpose were kept to succinct statements sufficient only to guide design development (see Figure 10, p. 159). In later stages of the design process, sketches and notes became more detailed to reflect the increased demand for explicit information necessary for use in defending design methods used and solutions presented. Analysis of student sketches collected later in the design process suggested that the students had acquired from the mentors design knowledge and procedures needed to create and resolve solutions to the complex design problems that emerged from the authentic tasks embedded in the design project. An example of such a sketch is shown in Figure 9 (p. 157).

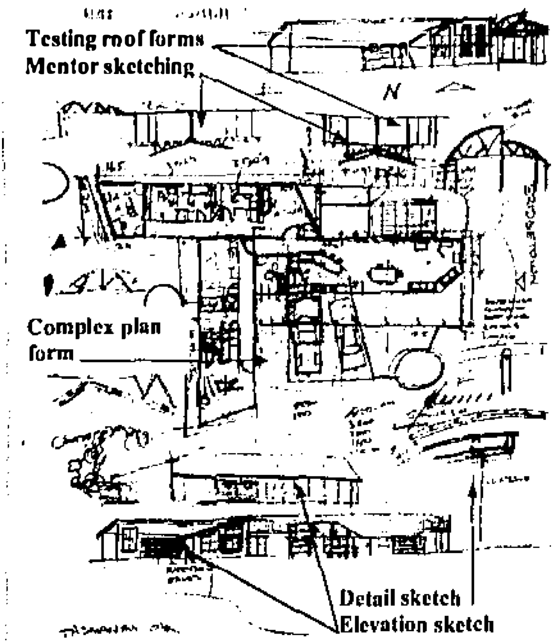


Figure 9. Student sketch detailing design ideas

In Figure 9 several aspects of the design development can be seen. A complex plan form has been developed in the centre of the sketch and around this different elevation and roof forms have been explored along with construction details for a curved roof as well as a butterfly styled flat roof. This sketch demonstrates how the students applied the design methods modelled by the mentors. Evident in this sketch also is mentor scaffolding as seen by the upside-down butterfly roof form at the top of the sketch. That drawing element is upside-down because the mentor, who was sitting across the table from the student, sketched directly on to the student's drawing. This occurred as the student was explaining and sketching his ideas when presenting and defending them to the mentor.

In each of the Phase Three design office situations, the mentors spent between 20-30 minutes of their first work session developing the information and design process for the students to follow. This mostly took the form of discussion and sketching of ideas with notes annotating design factors and reasons for using particular strategies to resolve problems that emerged during analysis of the brief. Data from interviews with the mentors and the students indicated that they regarded the sketches and notes as important resources for later reference as the design is developed. Of her experience of this approach, Student 16 said:

> He talked about all his design ideas and explained why he did things the way he did and why it worked for the areas that we were designing for. He then made me write up a brief kind of thing setting out all the different points that we had to consider in the design. He said that this would give us a list of every little thing that needed to be worked through like the tropical conditions and cyclones and all that sort of thing.

Most of the mentors used a structured, client brief, focussed approach when introducing students to their design office practices. They did this by breaking down the client brief to establish design criteria and explicit information about the design situation. From this, students acquired declarative knowledge about key aspects of the design as well as procedures recommended by the mentor for addressing each aspect of the design process. Figure 10 (p. 159) shows a typical breakdown of the client brief with notes and sketches representing the seeds of design ideas to explore.

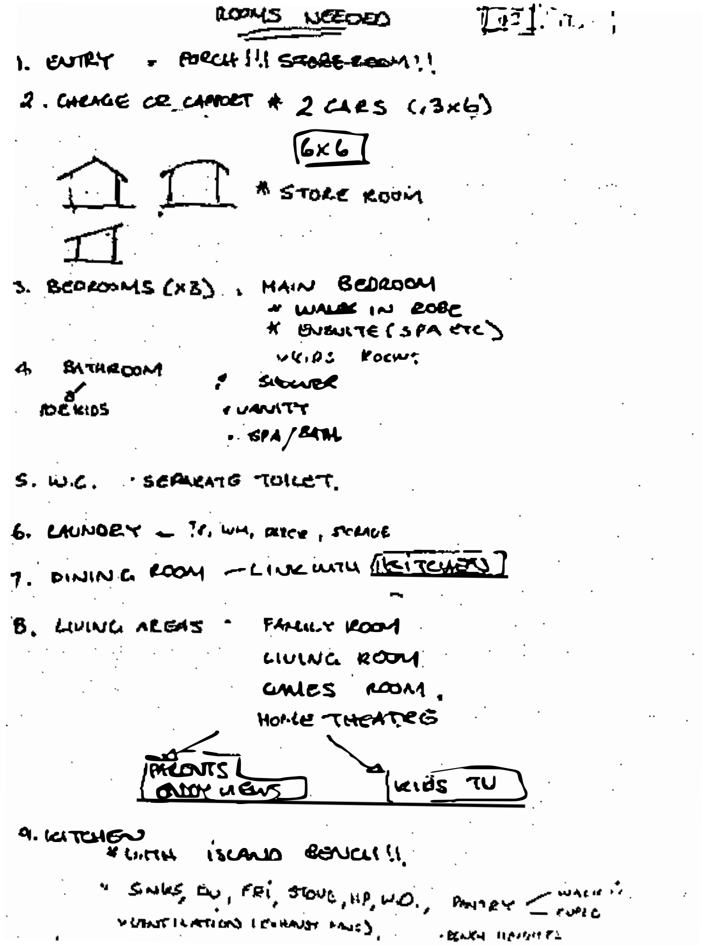


Figure 10. Notes used to represent client brief and organise design process

Working in this way, students acquired declarative knowledge specifically about the design situation and learned new methods appropriate for resolving problems emergent from the tasks presented by the brief. Mentor application of their usual design methods led to student acquisition of procedural knowledge necessary for their use of mentor defined design practices. The sketched exploration of design ideas shown in Figure 9 is representative of the design methods modelled by most of the mentors and shows how Student 18 applied those methods.

Category 3.1.2 Questioning and articulation of ideas.

Questioning (and articulation) of thoughts about design ideas, design strategies, problem solving methods and possible solutions, emerged as a key part of every student/mentor exchange. Analysis of Phase Three data showed that activities involving questioning and defending of ideas backed by articulation of personal views and supporting argument occurred during 34% of the work session times. In most of the design offices, the mentors began by encouraging the students to articulate their thoughts on various aspects of design and to sketch their ideas. Generally the mentors initiated design discussions, then encouraged the students to take the dominant role using questioning to explore problems that emerged from the authentic design tasks. Findings from analysis of data about this aspect of mentor practices suggested that student learning was enhanced by mentor questioning methods that encouraged the students to reflect on their work and to defend their design methods and decisions. Commenting on how he used questioning and sketching to explore, develop and defend design solutions, Student 13 said:

> Towards the end I was doing a lot more of the talking to put my point across and justifying why I wanted to do things and he would discuss it and question me about why I wanted to do it that way.

Questioning emerged as a key cognitive tool that enhanced student learning when used by mentors and students during exploration and defending of design ideas. All of the mentors used questioning to encourage student articulation of their thoughts about design ideas, problem solving strategies and solutions. For example, Student 18 said:

> She (the mentor) asked me questions all the time wanting me to explain why I thought things should be done in a particular way. I worked out pretty quickly that if I was going to put something into that design, I had to have a reason for doing it because I knew that she would want to know why. That was great, I learned heaps about design that way because if I couldn't work it out or defend it, then she would step in and suggest a few different ways and then make me justify which one to use.

The use of questioning to determine understanding of the design situation or methods used was also said by Mentor 2 to be an important way of determining completion in a design. Mentor 2 escribed his approach to using questioning to evaluate student works as follows:

> I say to the students, you know you have the solution when every question you ask yourself has the answer sitting right there on the paper

Mentor 3 said that he used questioning to monitor student understanding of design situations and methods encountered during their collaboration. He also encouraged students to question every aspect of their own work and to question others in order to acquire knowledge and skills needed to resolve problems in their own design project. Commenting on one of the students under his direction Mentor 3 said:

> He was good because he was prepared to listen and ask the right questions, he got involved in the discussion and didn't just sit there, he was a participator and that was brilliant, it was a three way discussion. I could see him learning new design methods every time we worked together. In the end he was able to tell me how he had gone about each part of the design and why he had used the solutions presented.

Analysis of Phase Three data showed that the students and mentors used questioning along with sketching and discussion during 82% of the work sessions times to explore and defend design methods and solutions. During these sessions, students were required by the mentors to sketch their design ideas while responding to the mentors' questions about how they might be applied to the design task at hand. When commenting on his use of this approach, Mentor 1a said:

> From my point of view I like to look at what they are capable of drawing, I like to see the standard of work they can turn out, that gives me more insight than anything else. They also must be able to explain why they want to use particular ideas and how they are going to make them work. You know, they have to say it out aloud, tell me how to build it.

The manner in which Mentor 1a used questioning with Student 25 at the commencement of the design project used in Phase Three was confirmed through analysis of the video record of the first work session. In that session, Mentor 1a questioned Student 25 about her interpretation of the design brief and encouraged her to use quick sketches to communicate her ideas. This approach assisted students to visualise their design ideas and to learn ways for communicating and defending them to others using tacit knowledge they have acquired through their development of those designs. When discussing how this had helped her to prepare for the design project, Student 25 said:

> Having Neil make me talk about my understanding of the brief and to show them the first design ideas I thought of really helped me to get started on the design and to show them what I was capable of. Once I started sketching out ideas they just joined in with ideas of their own. That was great, I immediately felt like I was accepted as a designer and that got me fired up to give it my best shot. They got me to explain and defend every idea I suggested before it was accepted as part of the final solution.

Used in this manner questioning assisted student learning by having them take responsibility for learning through the defence of their ideas when presenting them to the mentor in the work sessions. Throughout each of the Phase Three work sessions, I observed all of the mentors making frequent use of questioning to encourage the students to analyse problems that emerged from the design. The mentors also used questioning to encourage the students to articulate their thoughts when explaining and sketching their reasons for resolving design problems in the manner that they did. This manner of using questioning and sketching was applied as a usual procedure when ideas were presented, or when problems emerged from the design process as typical of everyday practice. Such procedures were applied at every stage of the design process to encourage students to discuss and to defend their design ideas. It was also a key method used by all of the Phase Three mentors to generate new ideas and to encourage student exploration of variations or multiple solutions in design. Working in this way assisted students to acquire new design skills based on their tacit knowledge of many different situations and methods explored throughout the work sessions.

As the students developed confidence in their working collaboration, I observed them making greater use of questioning of their mentor, rather that taking the more passive listen and answer approach seen in some design office situations at the beginning of the design project. From this I concluded that as the students gained confidence and took a more active role in the design process, the balance shifted from a mentor-focussed use of questioning to initiate and explore design ideas, to the students taking a leading role.

Category 3.1.3 Selection and use of resources.

Another design office practice to emerge as an important element for learning design was the use a diverse range of resource materials by mentors to stimulate exploration of ideas, to introduce new concepts and to scaffold students through difficult problems that emerged from the design project. The use of resources to scaffold student learning is discussed later in section 3.4.

The kinds of materials used as design resources included such things as:

- travel brochures for colour and settings;
- design and architectural journals;
- photographs and drawings used in advertising;
- codes and regulations;

- exemplar drawings; and
- construction detail standards.

The manner in which these kinds of resources were used by each of the mentors varied, but mostly they were used to stimulate new thought and to inform design decisions.

Use Of Resources – Different mentors' methods.

Analysis of the video recordings of Phase Three work sessions showed that Mentor 4 used photographs and drawings of his own projects to introduce his design style and working practices to Student 23. For 21% of the work session times, Mentor 4 used such resources to model what he described as his usual design office practices. Mentor 3 used an approach focussed on detailed construction drawings and work files, called the "office set", showed his usual design procedures. He used these and other materials to explain his problem solving strategies during 43% of the work session times.

In contrast, Mentor 6 made very little use of completed projects to demonstrate design ideas, but instead used parts of other designs in "office set" documents to demonstrate and explain how he applied different strategies for resolving problems the emerged during development of those designs. Mentor 6 used this approach during 11% of the work session times. The use of resource materials in this manner assisted student learning in several ways. First, it provided declarative knowledge of various design situations; secondly it revealed the mentors' tacit knowledge of how heuristic design strategies were applied during the design process; and finally, it made available procedural knowledge of the methods the mentor had used to resolve emergent design problems. In addition to using design elements to demonstrate design procedures and to explain the reasons for using them, Mentor 6 also used pre-drawn CAD based design elements and CAD component libraries to rapidly produce multiple design variations. When discussing how Mentor 6 made available resources that she said had assisted her learning, Student 16 said:

> They had a big library of books and pamphlets and drawing sets that I could use for ideas and details or partial solutions; there was heaps of stuff to use. They had a full CAD library of details and complete kitchens and bathrooms that I could slot into my design. That was great because I could try out a lot of ideas quickly with them and build up the design in easy stages.

Student 31 said that Mentor 17 had used "office set" exemplar drawings to show and explain how and why he dealt with a range of problem design situations that were similar to those he faced in his authentic project. Mentor 17 used these materials to reify his tacit knowledge of many problem situations, in his own design commissions along with the methods he had used to resolve them. In addition, the mentor detailed procedural knowledge of how he applied heuristic design strategies and problem solving methods when developing the design solutions shown in the "office set" exemplar drawings. The use of this approach by Mentor 17 assisted Student 31 to acquire declarative knowledge of multiple design problem situations, as well as procedural knowledge about ways to resolve them. When analysed, the design drawings produced by Student 31 confirmed that he had applied knowledge and procedures modelled by Mentor 17 and had learned ways for resolving problems that emerged during the design process. Student 31 said that he had based his design practices on the methods he had learned from Mentor 17 as explained by him using authentic commission drawings as exemplars. Of this approach Student 31 said:

> ... he gave me some drawings of house designs for country areas like the ones we were looking at. Then he went through how he had made each of them suit the local conditions. I used quite a few of the ideas that we talked about in them to build my own design. I also used his way of linking each part in so that the traffic flow worked and the orientation was right.

Most of the mentors used a diverse array of non-context specific resources to stimulate ideas, introduce concepts and to scaffold student learning in the resolution of a design. For example, Mentor 4 used travel brochures to demonstrate the colours and landscape of the areas for which the student project was being designed. Mentor 6 used photographs of spider webs to demonstrate symmetry in design and focus lines. Mentor 3 used a gardening catalogue to suggest colours and textures for the student to use in presentation drawings for the project. He also used a mail-order fashion catalogue to cut out illustrations of people to use in the presentation drawings to set the scale of the buildings.

Commenting on how he used various resources to assist Student 29, Mentor 7 said:

> This place is full of examples they can pull out of the drawers and use to develop their own ideas. I gave Carol a lot of CAD files of entourage and presentation stuff that we use so she could just plug those into her presentation and I said to her you will find this in almost any CAD based office like ours, it's a resource that the industry uses.

When Student 29 was interviewed later, she said that she had made extensive use of the CAD elements provided to produce five different design concepts from which she developed one final solution. She contended that the value of this process to her learning lay in the speed with which she was able to explore design variations and the flexibility that CAD methods offered for manipulating the design and viewing it from any direction. This she said assisted her in visualising the three-dimensional design form and this helped her to understand the spatial relationships and traffic flow.

The main use made by mentors of materials such as those mentioned above was to stimulate student thinking about design and to provide simple ways for them to quickly explore and present their design ideas. Although some differences were evident in the manner that each mentor used resource materials such as exemplar drawings, the common theme to emerge was that they all used similar materials. It is clear also that they all used the "office set" as the main means for exploring ideas and for implementing procedures for problem solving in design. Most of the students said "office set" drawings provided by the mentors were an important source of information for the development of their own designs. In addition, they not only showed ways for resolving design problem situations, but they also showed the development pathways followed by the designer and thereby gave them insights into the processes used to explore multiple design ideas as the final design form was refined. When commenting on how she created and used her own "office set" drawings in this manner, Student 16 said:

> ... I worked through layers of sketches to develop my design using the same methods they did in what they called their "office set". In that way I could see the design progressing and also see where we had tried things out and then gone another way. I had all the information in that one set of drawings and could go back over it at any time to try out little things that had come up earlier but not been fully worked through.

Many similar comments were evident in other data coded in this category and from these I determined that the use of "office set" drawings was a practice common to all of the design office situations studied and was a key tool for knowledge transfer and assisted students to learn new design procedures. For example, Mentor 6 said:

> The "office set" has it all. Everything that you want to know about how we developed a design, what the client wanted, what the council said we could do, every idea we tried out, how we resolved all the problems, it's all there. When anyone comes into our office to work, the first thing we do is sit down with them and go through the "office set" of any current commission. From that we can explain every aspect of our working

> practices, the standards that we work to and expect of them and the design style for which this office is known. It's the same when students come here. We teach them from the "office set". That's where they get information, that's where they see our methods applied. OK we also need to explain it all for them at first, but it's a steep learning curve before theyare using the methods we use in our everyday practice.

Findings that emerged from analysis of data about the use of different resource materials by mentors suggested it assisted student learning by facilitating their acquisition of declarative knowledge about many different design situations and led to the transfer of tacit knowledge about design procedures for resolving emergent design problems. The use of a diverse range of resource materials by mentors emerged as a key element in student learning when applying design practices in ways typical of the design office culture of practice experienced by the students during their collaboration with the mentors.

Category 3.1.4 Learning using "office set" methods.

The "office set" is a bound volume of sketches, drawings, notes and other materials such as trade literature, photographs and the like created by building designers for each new design commission and used for the development of design solutions. It documents all of the elements explored throughout the design process, along with notes and references linking concepts or possible solutions. Drawings, developed by progressive overlaying of translucent sketches used to explore design variations form the core of each "office set" and these are used by mentors and students to reflect on the progress of a design task and to review ideas in order to refine emerging solutions. The "office set" was seen in use in every work session during Phase Three of this study. It was a tool used by mentors to provide students with declarative knowledge about many different design situations and procedural knowledge of ways for using design methods typical of their usual practices. It was also used by mentors to coach students in the application of design office heuristic design strategies and problem solving methods. This occurred by mentors demonstrating and articulating how and why they used design elements documented in the "office set" for resolving emergent design problems. For these reasons the "office set" was a key tool used by students to acquire tacit knowledge about design and to learn design methods used by experts to resolve problems.

Most of the mentors and the students said that they commenced their designs by first producing rough sketches that defined the basic geometry of the design concept conceived by them to address the criteria defined by the project brief. In using this approach, the students made use of declarative knowledge and design procedures acquired during work sessions with the mentors. By overlaying each sketch with layers of translucent "butter paper", they then developed variations and refinements to the design with the aid of the underlying forms. For this part of the design process, the students used tacit knowledge built from their use of information and methods modelled by mentors who used exemplar drawings and simple design tasks to demonstrate and explain their usual design procedures. When discussing his use of "office set" overlaid sketching methods for teaching students to design, Mentor 6 said:

> When you use overlays on CAD drawings in the "office set" you can see the subtle shifting of areas as the design gets sorted, you can see the geometry evolving as the design is refined from one layer of sketching to the next.

This view is also well supported in data collected from most of the other mentors. In addition, most of the mentors also said that they used quick sketching methods to create overlay "butter paper" sketches on "office set" drawings for all phases of design development and when teaching students to explore and progressively refine design ideas.

To confirm this, analysis of Phase Three data showed sketching was used during 53% of the work session times and this took place simultaneously with mentor and student articulation of the reasons for each design decision taken. Other factors, such as regulations, construction practices, situational requirements and style preferences, that influenced design decisions were also discussed, sketched, or placed as notations on the "office set" drawings during those times. Information recorded in the "office set" in this manner added to the declarative knowledge available for students using those drawings and provided the basis for mentors to explain their use in usual design practices, thereby reifying their tacit knowledge for students to use. The "office set" approach to progressively build on and refine design solutions was used by most of the mentors and students. Initially it is used to simply document ideas and information, but as students visualised their design ideas, it was used more as a design tool and vehicle for the expression and exploration of creative forms.

Analysis of Phase Two data show that the "office set" sketching approach to design used by Mentor 6 and Mentor 6a, who together mentored Student 16 and Student 24, was representative of the methods used by the overall group of mentors studied. For this reason, the following interview excerpt in which they discuss their use of this technique has been included here as an example. Much of what is revealed in this interview excerpt shows how these mentors introduced their work practices and reified their tacit knowledge and heuristic design strategies when working with the students. The approach used by Mentor 6 and Mentor 6a is representative of that used by most of the mentors. A key aspect of this approach is the use of mentor articulation of the reasons for using particular design methods or for accepting different design solutions. This assisted students to develop tacit knowledge about which practices are appropriate to their own design project tasks and why they are used in particular ways.

> Mentor 6a: We would start with a global picture of the design and progressively resolve it through talk and sketch to iron out all of the details. That's where the "office set" comes in. Each sketch or note that goes in there is part of the overall design process. Having it there to see at any time means that students can go back and reflect on what they have already explored and perhaps use parts of it to try another pathway in design, or resolve part of some parts of their design that have become barriers. It's all about having control of the process, we have a tried and true methodology that progressively builds up the design using layers of drawings one over the other. You need to remain true to the geometry of the design and that is where Steve and I work well together, I can pick up his work at any time and see where he is coming from. We just set small steps or stages of the design to resolve one at a time so that the whole thing builds progressively. That works well with students because they are then not overwhelmed with all of the problems at once.
>
> Researcher: How do you communicate this to a student who is trying to learn how to design?
>
> Mentor 6: I think that you have to separate it out and say what are you doing; are you drawing or are you designing? You first have to identify what the student is doing are they drawing or are they designing, if you are just drawing then you have no chance of learning to design, that s just a mechanical skill, design is different.
> If they are not designing then go away and look at some trees, change the pattern of thinking. You see with drafting you are taught to look really closely at something, design is taking a view from a satellite and then coming back in progressively to look at the details.
>
> Researcher: In what ways did you guide students towards using your design methods?
>
> Mentor 6a: We make each part of the design one small easy step at a time so that they can readily achieve it. You just get them to fly lower and lower to examine the design in progressively greater detail. When they do this the detail starts appearing more and more. That's what the "office set" is best for, building up layers to explore new ideas and to resolve them, that's how we get the students to learn to design.
>
> (Mentor 6 and Mentor 6a).

In Phase Three the mentors used "office set" materials to provide the students with declarative knowledge about different design situations, tacit knowledge about their own experiences in design and procedural knowledge of how various design methods could be applied for resolving problems that emerged during the design process. This took place during 32% of the work session times. When commenting on how Mentor 3 used "office set" drawings to assist his learning, Student 22 said:

> Barry was great in the way he always seemed to have some drawings there that showed me three or four different ways of sorting out the problems that came up in my design. I think he must have done it all before because his drawings had all the answers and you could see how he got to them because he still had all the rough sketches there and he would talk me through how and why each one came about.

Analysis of data such as these led me to conclude that mentor use of "office set" drawings facilitated student learning. In particular it assisted the students to acquire procedural knowledge necessary for implementing heuristic design strategies when reflecting on design problems. This led to student development of design solutions. Mentor use of "office set" drawings also provided ways for them to reify their knowledge of many different design situations, heuristic design strategies and solutions they had used. This assisted transfer of tacit knowledge and helped students to acquire declarative knowledge and design procedures which they then used to resolve problems that emerged from the development of solutions to their authentic design project. This was clearly evidenced in the resulting design solutions presented by the students for assessment by a panel of expert judges. Findings from this process are presented later in this thesis.

Category 3.1.5 Sketching: A design office practice.

Earlier in this Chapter the extensive role that *sketching* played in building design practice was discussed in relation to its use as a communication tool. In this section, findings from analysis of data about the use of sketching affecting learning are presented along with examples of supporting data. In another part of this Chapter, findings about the use of sketching as a tool for scaffolding learning are presented. This three part analysis and presentation of findings about the various applications of sketching in learning building design has been taken in order to address all aspects of its use in answering the research questions.

The use of sketching as a design tool was said by most of the study participants to be an essential part of learning in a design office, because it provided immediate visual representation of ideas or concepts as they emerged during design development. Analysis of Phase Two data indicated that sketching was initially used to make visible declarative knowledge about design situations, including regulatory requirements, physical features of the design setting, style elements, construction details and elements of the client brief. When design development commences, sketching is used to create, explore and refine design solutions. Throughout the entire design process, all of the mentors studied used sketching to demonstrate and to explain their use of heuristic design strategies and problem solving methods to students. The mentors used sketches to facilitate student acquisition of procedural knowledge for use with design practices modelled by them. Sketching was used when coaching students to ensure the clarity of explanations when applying design methods to the development of their own design solutions. This facilitated transfer of tacit knowledge based on the mentors' design experiences and procedural knowledge necessary for implementing their usual design practices. For example, Student 14 said that he had acquired ways to resolve design problems by having his mentor sketch and explain strategies for dealing with emergent problems as follows:

> ... listening to his ideas, having him sketch and explain things, that was the most valuable part of conununicating with him, thats how we gradually refined the design and worked through all the problems that came out of the brief. I used the methods that he has shown me, to work out problems in my design. I sketched out ideas like he did so that I could keep overlaying new ideas or details that made it all work.

The immediacy of the visual feedback provided by quick sketching methods used by the mentors made visible to the students the mentors' design ideas and problem solving methods. Analysis of Phase Three data showed that the students used sketching as an integral part of discussion and articulation during 40% of the work session times when communicating ideas they had visualised and refined during the design process. Like the mentors, the students used sketching to present their ideas and problem solving strategies and in so doing demonstrated their learning outcomes in a form that was readily understood by the mentors. Sketching used in this way provided the students with a means to demonstrate how they had resolved problems that emerged during the design development and to articulate their reasons for decisions taken throughout that process. This aspect of using sketching provided important insights into how knowledge was transferred in this learning situation as sought by the research questions. In Phase Three work sessions, the mentors used sketching 38% of the time to communicate many of their heuristic design strategies and problem solving methods.

Freehand sketching emerged as being the principal method used by building designers to communicate ideas or concepts and to explore and refine these in metocognitive ways. In respect of using sketching when mentoring students, Mentor 1 said:

> I think what happens is you talk as you draw more, whereas if you were drawing for someone else you might just sketch it out. When you are doing it for a student you need to talk it through so they know the reasons for what you are doing, not just how to do it.

During six different Phase Three work sessions I observed Mentor 1 working in this manner. Mentor 1 used sketching together with detailed description to present information, heuristic design strategies and problem solving procedures during 65% of the overall work session times. When working with Mentor 1 during these sessions, Student 25 used sketching during 30% of the time to explore, refine and communicate design ideas, based on the information and design methods presented by Mentor 1. From this and other similar exchanges I observed during Phase Three work sessions, I concluded that sketching was used by mentors and students for the transfer of declarative, tacit and procedural knowledge about design situations and the application of heuristic design strategies for resolving emergent problems. For example, Student 16 said that she acquired most of her design ideas and design strategies for applying them from her mentors who used sketching and articulation to show and explain how and why particular aspects of the design could be resolved using various methods. Student 16 said:

> He sketched and talked all the time, in fact he sketched everything rather than describing what he meant, that's where I got a lot of my ideas from that I incorporated into my design. They kept talking to me about the design and usually suggested little changes or adding in things like verandahs and so on. They would sketch over the top of my drawings and say have you tried out this or thought of doing this another way and then sketch little ideas all around the sides of my drawings.

Working in this way facilitated knowledge transfer between mentors and students. The mentors reified their tacit knowledge and design methods by introducing new design elements and procedures for resolving problems that emerged throughout the design development, as shown earlier in Figure 9 (p. 157).

During work sessions, the mentors and the students used fast freehand sketches on translucent "butter paper" (a low cost translucent paper) to develop and explore ideas or design concepts. Most of the students and mentors when sketching also used discussions to involve others in the ideas being developed and articulation to express personal points of view or tacit knowledge based on experience of similar situations to that being explored. This combination of sketching and articulation usually led to multiple layers of drawings being combined into one design concept from which many variations were then explored as the designs were progressively refined. Mentor 4 encouraged students to use very "loose" freehand sketches to explore variations for each of their design ideas to determine their suitability for inclusion in the final solution. An example of one such sketch that shows how three different roof forms were explored in the one simple sketch is shown below in Figure 11.

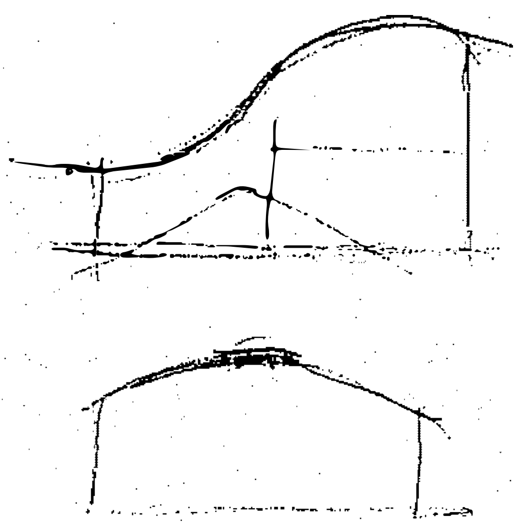


Figure 11. Typical quick sketch showing exploration of three roof forms.

In contrast to this very open sketching approach used by Mentor 4, Mentor 3 used sketching, backed up with discussion and articulation, in a more structured and deliberate fashion. Using this approach facilitated rapid exploration of design forms that were then progressively refined as part of multiple solutions or design variations. Mentor 6 used a similar approach when working with Student 24 by applying freehand sketching over hard lined drawings created using CAD techniques (see Figure 12, p. 173). Mentor 6 sketched with Student 24 over the top of his simple CAD drawings that were progressively refined as ideas were explored, then tested and accepted or rejected for inclusion in the final design. Working in a similar manner, but with a more traditional hand drawing approach, Mentor 1 and Mentor 1a sketched over Student 25's

CAD drawings to develop design ideas. An example of freehand sketching over a CAD base drawing is shown below in Figure 12 which shows room layout and elevation concepts hand sketched over a CAD print.

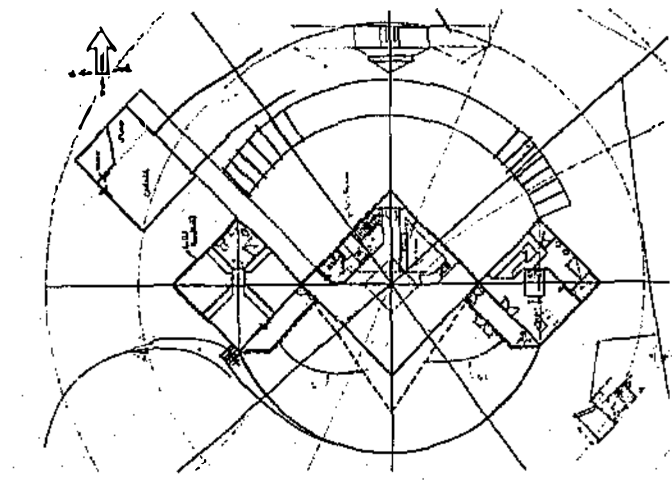


Figure 12 Freehand sketching over a CAD based drawing

In each of the design office situations studied in Phase Three, the mentors encouraged the students to sketch ideas while articulating their thoughts on how the spaces they were drawing might be used and detailed for construction. The mentors said that using this approach encouraged visualisation of the building form on a three-dimensional level. I regard the use of this approach assisted students to develop metacognitive tools for resolving and communicating design concepts. For example, Student 18 found that Mentor 26 could readily use his roughly sketched ideas to visualise design concepts he had developed, then analyse and comment on their suitability. By then analysing and evaluating the design decisions he had made in order to refine the design solutions, Student 18 demonstrated his development of metacognitive ways for resolving design solutions. By following his mentor's lead, Student 18 was then able to explore further his and the mentor's ideas using the same methods for evaluating what he had seen modelled by the mentor. Commenting on how this approach helped him to learn new design strategies and problem solving procedures, Student 18 said:

> ...I came up with quite a few ideas that she was able to look at and say this will work and that won't. She was able to tell me why, so that helped me to understand why some of my ideas were not going to be practical in

> the situation. She also gave me heaps of other ideas to consider and alternative ways of sorting out the design problems. Mostly she just talked me through by getting me to imagine different situations and all the time she was sketching little part of the building and making me do the same with ideas that I chipped in with. She kept asking me to decide what was going to be the best way to solve problems that came out of my design. I had to think it through on the spot and come up with solutions.

When interpreting these comments, I concluded that the mentor had expressed her tacit knowledge of different design situations while articulating reasons for accepting or rejecting the student's ideas. At the same time she had also encouraged and supported the student's creative thinking by stimulating his imagination with sketches and verbal pictures. In this way, the mentor facilitated student learning about design in ways that encouraged visualisation of ideas and multiple solutions. By encouraging the student to visualise and to evaluate his own ideas, the mentor supported the student in his development of metacognitive ways for refining design solutions.

Most of the mentors defined their design and drawing standards by using "office set" exemplar drawings and sketches of their own designs to show and discuss the methods they use. These "office set" drawings were also used by the mentors to establish for the students benchmark standards used by the wider community of design practice for the documentation of authentic projects. Most of the mentors indicated that they used sketches and drawings from multiple design projects to scaffold student learning. Mentor 3 said that he used this approach so as to lead by example. He said:

> I talked about every aspect of the design and sketched out ideas with him when we wanted something done in a particular way.

By sequencing design tasks to progressively introduce information and strategies necessary to resolve a design, the mentors assisted students to transfer learning about one situation or aspect of design, to a different one. For example, Mentor 3 said that he used sketching to do this as follows:

> We used little sketches to make sure that he got the basic stuff right like the orientation and the entry etc. When we got all of that sketched out right for the Bridgetown one, we then used the same plan and strategies as a basis for designing the one for the Kimberley.

The sketch used for this purpose (as well as for commencing the next step in the design process using overlaid bubble forms for room positions) by Mentor 3 is shown Figure 20 (p. 209). Analysis of data coded in this category led me to conclude that mentors and students used sketching along with discussion and articulation to develop, refine and present design ideas and solutions. As a learning tool in the design office situation, sketching provided a means for fast representation of design concepts and ideas, as well as demonstrating methods used by expert building designers to resolve problems that emerge during development of design solutions.

As the students developed their skills to visualise and communicate design concepts, they also developed cognitive skills like the evaluation of different possible solutions for exploring and refining designs, which developed their problem solving ability.

Category 3.1.6 CAD overlay sketching.

In all but one of the design office situations studied, CAD based design and drawing methods were used as part of the mentors' everyday practices. In Phase Three, Mentor 3 used sketching together with articulation during 21% of the work session times to model his approach to design and to coach Student 22 in the use of his methods. Then, the freehand sketches produced during the work sessions were interpreted by Student 22 into CAD drawing files that were printed off in preparation for the next work session. In the next work session, "butter paper" was placed over the CAD drawings and further freehand sketching took place as design ideas were explored and refined. An essential part of the sketched overlay drawings was the use of notes made on the sketches by the student and the mentor to explain design decisions. These provided reasons for particular elements being included or excluded following exploration and evaluation and were used for reference later when construction drawings were produced. Commenting on how Mentor 3 encouraged him to use sketching as part of the exploration and development of multiple design solutions he had visualised during work sessions, Student 13 said:

> I did heaps of sketching to develop the designs. When we worked together we mostly talked about the sketched ideas and worked over the top of them trying out new solutions. We made a lot of notes while we talked and sketched and I used these later to sketch out other ideas that we discussed.

An example of the type of sketches produced by the students and the mentors in these work sessions is shown below in Figure 13 (p. 176). This sketch has a CAD base that consists mostly of circles with radiating lines used to define zones. Most of what can be seen though is heavy pencil overlay sketching which shows multiple ideas being explored by the student and the mentor as they developed various parts of the design.

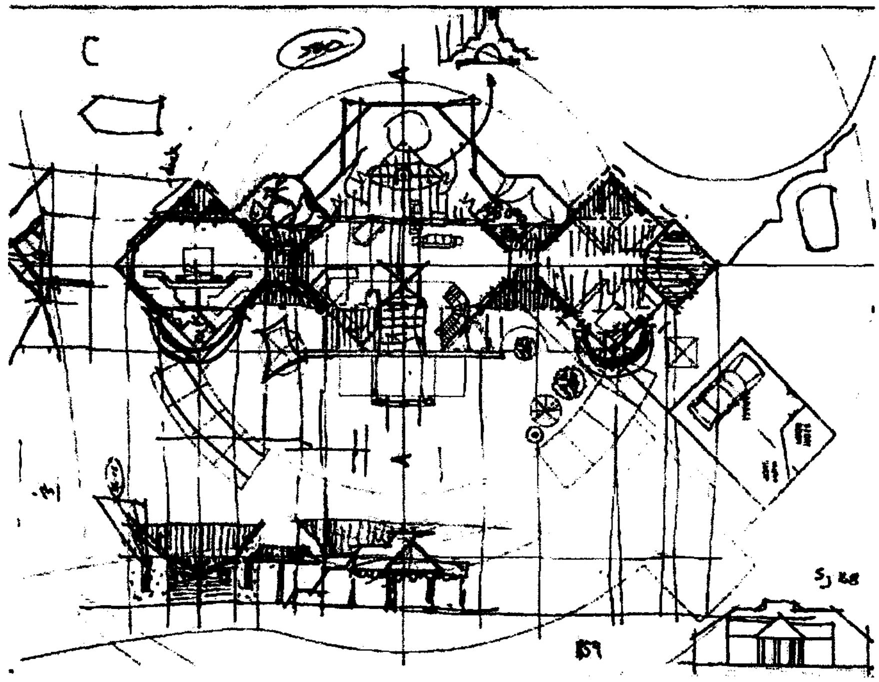


Figure 13. Overlay sketching of CAD drawing showing exploration of ideas

Working with CAD based design and drawing methods provided the students with tools to explore greater numbers of design variations based on their own works. CAD methods assisted the students to incorporate design elements or even whole plan forms in electronic format from the mentors' exemplars into their own design solutions.

Analysis of Phase Two data indicated that this approach was said by the mentors and the students to enhance their creative development by making it easier to quickly explore ideas that might include complex shapes and technical detailing. In Phase Three, Mentor 3 used CAD based "office set" drawings in this way during 54% of the work session times and Mentor 6 did likewise during 68% of the work session times.

Commenting on his use of CAD based design and sketching methods for brainstorming ideas and rapidly producing drawings, Mentor 6 said:

> We work on a print and scribble system, just throw the ideas down, doesn't matter if it's wrong just throw it down, print it out then hack it up with a pen, manipulate it a bit then print it out again. We chew through a lot of paper but that is how we do it. We don't actually take something away and sketch it, we resolve it on the machine and by the time we get to print it out for sketching on we already have the guts of the job.

Mentor use of this approach provided ways for transfer of procedural knowledge about design methods, as well as transfer of their tacit knowledge of successful design practices and failures. Student 8 was encouraged by his mentor to use this technique to explore every aspect of ideas he had sketched, to determine their suitability for inclusion in the final design. Of this approach Student 8 said:

> He (the mentor) would say to me "take a big bundle (of butter paper) I use heaps (the mentor) why don't you?" Then he told me to just get into it and sketch ideas as fast as I could think of them without worrying about the details, you know, if they are practical or not. The idea of this was to get some concepts happening, then sort out the problems later.

The use of CAD based "office set" drawings and quick freehand sketching techniques emerged as key elements which enabled students to learn ways for exploring design ideas, problem solving methods and for developing design solutions. The use of over-sketching on drawings was common to most of the study design office situations. It provided a means for progressively building up a design solution, while having a visual record of the ideas explored available to reflect upon when branching to the design process to investigate other ideas or potential new design solutions.

Findings from analysis of data coded in this category led me to conclude that the students acquired skills in the use of sketching and with CAD based drawings by replicating methods modelled by mentors during work sessions. When applying sketching and CAD drawing to the development of design solutions, students also utilised discussion and articulation to explain the reasons behind their design decisions and in so doing defended their design ideas and communicated their solutions. As the students acquired ways for creating and documenting design ideas as modelled by the mentors, they made greater use of cognitive tools to explore, evaluate and refine design ideas. Student development of ways to visualise complex design problems situations and possible solutions was assisted by their use of CAD and hand sketching methods for rapidly exploring multiple solutions. Reflection on possible solutions and evaluation of these led to student use of metacognitive design practices in ways similar to that modelled by the mentors during work session with the students.

Category 3.1.7 Explanatory notes and drawing annotations:

Most of the mentors required the students to use report styled information sheets and notes on drawings as a means for describing design features or construction details when defending their design solutions. Student use of notes and annotations is in this way I regarded as part of their articulation of the reasons for using design methods and reasons for having taken particular design decisions. Mentor 10 said that he made extensive use of reports and notes in his own works as a usual office practice and had insisted that Student 14 employ the same methods for the authentic design project on which they collaborated. On this point Mentor 10 said:

> After we had worked through the design ideas I got him to sit down and write a report explaining what the design was all about and why certain decisions had been made. It was pretty much a summary of the whole design process and how it related to the brief and the practicalities of transporting and building it.
> On each sheet of his final drawings he had a summary of what he had done and why. This made him think about how he had got to that point and encouraged him to keep thinking back to the original assignment, the brief, to keep him focussed.

The use of this approach by Mentor 10 to encourage Student 14 to reflect on how he had arrived at his design decisions and to evaluate them as part of the emerging design solutions I regarded as a teaching practice that helped to facilitate the development of metacognitive design practices. Student use of notes and drawing annotations assisted learning by providing a structure for reflecting on the processes and decisions that they made throughout the design process. This made visible their tacit knowledge of the design situation as well as demonstrating their procedural knowledge and the methods that they had used to create, refine and defend their design solutions. Reflection used in this way assisted student learning.

Student 13 confirmed that his mentor encouraged him to use notes to record design decisions and strategies suggested or explored during work sessions. These, he later used when reflecting on the pathways followed through the design process as part of refining the design solutions. Commenting on this, Student 13 said:

> He (the mentor) also made me take a lot of notes of what we discussed because he said that he found notes to be a useful to look back on after a meeting or work session where a lot had taken place and you might not remember it all, or how it all fitted into the design later He suggested that I keep notes about how I had developed each part of the design and why I had done it that way. This was really useful when it came to presenting the design to him because I was able to defend my ideas by showing him what I had tried and why I kept the bits that I did.

Most of the students and the mentors made comments similar to these during Phase Two. Analysis of Phase Three data indicated that notes were used during 10% of the work session times to record ideas explored, strategies employed to resolve emergent problems and ways for dealing with the presentation of solutions being developed. I concluded that the use of notes by students and mentors in work sessions and in "office set" or presentation drawings assisted student learning by providing a means of reflection that assisted metacognition. It also provided reference information that was used for reflecting on design procedures applied in developing design solutions.

Evidence of this can be seen in the presentation drawings submitted for evaluation at the end of the project by all of the students. Most of the drawings contained detailed information aimed at clarifying the reasons for many aspects of the design that may otherwise have been unclear. For example, Figure 14 (p. 179) shows the final design presentation drawing produced by Student 22 in which he has included a block of explanatory notes in the bottom right side.

Figure 14. Final presentation drawing showing block notes

The drawing shown in Figure 14 has been reduced from A1 size and therefore the notes are not clear to read. For this reason, the notes have been transcribed as shown in Figure 15 (p. 180) below.

> The main emphasis on the design of this house was to create the feeling of casual living in a family lifestyle kind of way. My perception of living in the new millennium is one of easy living and so the design of the house was aimed at creating that feeling. The family can enjoy the magnificent feeling of living in an outdoor setting but with all the protection of a climate oriented house. The wide verandah invites the family to sit and enjoy the views down the valley and to feel at peace with the water moving across the rocks below. Having the kitchen and family room facing into the valley view presents the best outlook and takes advantage of the prevailing breezes for cooling in the summer. The bedrooms have been placed on the east-side to allow morning sunshine to greet the family when they wake. The large open areas for family living have movable screens that assist in restricting heat to smaller more personal areas during winter.

Figure 15. Notes from drawing by Student 22 (see Figure 14)

The use of notes and annotations on design development sketches and drawings emerged as a common practice used by all of the student/mentor working teams. It provided students with a means for defending design decisions and assisted in showing an audit trail that demonstrated the procedures and factors that shaped the final design presentation. Student 14 said that his mentor used notes to explain the reasons for design decisions he had made so that when the drawings were viewed by the client they understood why the design had been developed in particular ways. Of this approach, Student 14 said:

> He always went through why things needed to be done a certain way and he made me put notes on the sketches to explain why the design was how it was.

Mentor modelling of the use of notes on drawings led students to acquire similar methods for creating their own design works and for defending them by referring to the design audit trail documented by those notes. This process led students to reflect on their design methods and decisions and in so doing develop metacognitive ways for evaluating and refining their potential design solutions. Student 16 said that she used notes in the same manner she had seen her mentor using. She said:

> I would go back on to the computer and draw their ideas up with mine and also put in a lot of notes to explain why I thought it should be done that way. They always sketched it out first and then put it on the computer; they used notes all the time on the drawings to explain how they got to that design and why it was going to be used. So I did the same and that made it easy for us to work through my designs together. Using the notes as reminders I was able to think back over what I had done and why I had done it that way. This made it easy to try other ideas in my head before spending time drawing them out.

Data such as these led me to conclude that student learning about design strategies used by mentors and the reasons for design decisions they made was assisted by their use of notes to record and review design activities and outcomes. Mentor 6 modelled his use of notes for Student 16 and coached her in ways for applying his techniques to her own design project. Working in this way, the mentor made use of a common design office practice, notes on drawings, as a coaching tool that could then be used as a post organiser when reflecting on pathways followed during the development of design solutions. In Phase Three, I observed Student 16 using design methods that I had observed earlier being modelled for her by Mentor 6. Her approach to design reflected the methods used by Mentor 6. She used notes on drawings, as part of her application of heuristic design strategies and cognitive design tools, to reflect on each of her design decisions in order to evaluate them before their acceptance as part of the emerging design solution. Student 9 followed much the same pathway when working with his mentor, who also advocated the use of notes as tools for the review, development and defence of design solutions. When commenting on his use of this approach Student 9 said:

> I wrote down notes on his sketches and the drawings we worked on together, you know just little things that he came up with that I wouldn't remember but needed to use later on.

In my own field notes journal in which I recorded my observations of work sessions involving Mentor 26 and Student 18, I made note of the emphasis that the mentor put on the use of notes as a learning tool. In particular, the mentor encouraged the student to keep detailed notes supporting all design decisions and to include these on drawings for submission to the client and to council so that any discussion of these drawings could be linked to the influencing factors stated. From this I concluded that the use of notes on sketches and drawings was an important aspect of student learning because it provided tools for mentors to model their usual practices and the reasons for working in the manner that they do. In addition, notes and sketches were used by students to reflect on the pathways followed in their decision making processes in design and to present in written form a record of their reasons for using the solutions they had arrived at when defending their work to the mentors.

Category 3.1.8 Multiple perspectives from consultants and others.

In most of the design office situations studied in Phase Two and all of the design offices in Phase Three, the students had contact with other design staff working in those offices. Findings from data coded about student interaction with others in the design office situations suggested that these contacts helped students to acquire multiple points of view about design, as well as alternative design methods. I regard this to have assisted students to learn metacognitive ways for dealing with design. Most of the mentors encouraged the students to learn from others in the design office situation so as to benefit from their experience and to gain multiple perspectives of design practice. This approach supported student social construction of knowledge through formal and informal work sessions. In some of the design office settings, the students were encouraged by the mentors to participate in discussions with other design staff engaged in authentic commissions. In some instances the students were encouraged to contribute to the design and documentation of current projects. This provided the students with authentic design experiences and assisted them to acquire tacit knowledge about real building design methods applied in the context and culture of the mentor's usual practice.

Student learning through interaction with others in the design office was encouraged by the mentors. Most of the mentors highlighted the importance of exploring multiple solutions to design problems with the help of others who often provided opinions, advice or assistance of value to the students to assist them with the development of the final design solutions. In some instances that assistance came from individuals with expert knowledge on some aspect of the work at hand as commented on by Student 16, who said:

> There was a guy there who worked for them who helped me a lot with the computer work and he was more skilled than they were in using the computer. I talked to a couple of the guys who were doing all the design work and they gave me some pointers on what to do with transportables and they asked me quite a lot about using computers which I am pretty good at. So we helped each other.

All of the students in Phase Three said that they learned new design methods and problem solving strategies by working with a mentor and other design office personnel or consultants. Most of the students said that they learned much from others in the design office when they discussed and sketched different aspects of current design office commissions as a means of providing examples of ways to resolve the students' design project. In this way the students acquired information, design processes and problem solving procedures modelled by others. Similarly, the mentors provided information and procedures based on their experience-based tacit knowledge for the students to use in resolving emergent problems in their design works.

For example, when commenting on his mentor's approach Student 13 said:

> He had some good schematic design ideas and we sort of combined his ideas and mine in the final design. He had a lot of different ideas and diffierent ways of putting it across. That was the great thing about it, he has had such a lot of experience he is able to say look I've tried it this way or that way and he gave me examples of where it worked or failed. That really put me at ease because I felt it was no shame to have something not work. I realised that you just had to try it out to know That made me explore more ideas even if they were a bit off the planet.

Most of the students who had contact with other design office staff or consultants in the study settings said that their experiences had provided them with alternative points of view, multiple design strategies and multiple design solutions to explore. From this type of interaction with others, the students developed tacit knowledge of design methods and procedural knowledge of ways to implement heuristic design strategies including the reasons for applying particular methods to commonly occurring design situations. For example, Mentor 4 explained his reasons for encouraging students to seek out the views of others in the design office in order to assist learning by commenting:

> You need the interaction with others to bounce ideas around and sometimes it is better that students go into a large work environment where they can get ideas from many people rather than just one. That apprenticeship style of learning needs to be in a sharing environment.

Some mentors arranged for students to have contact with an extended network of design experts and consultants. The mentors who worked in this manner contended that contact with other professionals created opportunities for students to expand their design perspectives and provided models for multiple design methods as shaped by the strategies used by others to resolve problems in discipline areas that support building design.

As well as working on their authentic design project with a mentor, six of the students also participated in other projects that were the mentors' current design office commissions. This provided the students with authentic experience of design development and problem solving in the context and culture of the mentor's everyday design office work practices, outside of the student project they had undertaken. In four such situations, the students worked with more than one mentor, opening the way for multiple viewpoints or perspectives to be explored. This approach was said by the mentors to encourage the students to develop their own ideas from multiple viewpoints, with the possibility of the students coming up with something special that was still essentially theirs, but having well proved design elements from recognised experts at its foundations.

Some mentors said that contact with multiple designers, other design office staff, or consultants from other disciplines, provided opportunities to enhance student learning by introducing them to the broad spectrum of their everyday culture of practice activities. Student 13 said that he was greatly assisted in his learning by having a "back up" mentor assigned to him by Mentor 3 so that there was always someone available to him, or another opinion or point of view to consider. Of this, Student 13 said:

> Barry brought in another designer (Jack) from the office to sit in on meetings so that if I needed help when Barry was not around Jack would be up to speed on the design and be able to help out and that was really good because he gave me a few pointers on how things were done there and where I get could information on some parts of the work.

In another office setting, Student 23 worked one-on-one with Mentor 4, but with no other in-office staff. In order to introduce the student to experts from other disciplines that were to be part of the design project at hand, Mentor 4 involved Student 23 in discussions with consultant engineers and builders visiting his office as part of his own current commissions. In Phase Three, Student 23 was included in activities involving Mentor 4 and three other design experts during 11% of the work session times. This contact with other experts assisted student learning by contributing alternative perspectives as well as information and solutions that were later explored and applied by Student 23 and Mentor 4 as they worked through the project. Commenting on this following one work session, Student 23 said:

> It really helped me seeing him (Mentor 4) having to explain to the engineer what he wanted out of the roof form and hearing the reasons that he gave for insisting on not having a box gutter and highlight window. I had a similar problem in my design and that got sorted out just by my being there at the right time to see how he did it in his own job.

As noted earlier for Student 13, Mentor 3 also arranged for a back-up mentor to be available throughout the project to provide alternative points of view, problem solving strategies and logistical assistance to Student 22 at times when he was unavailable. Mentor 6 also used his other in-house staff to support Student 24 throughout the design project, but did so by arranging for the student to have his own CAD work station in the design office. This approach allowed Student 24 to work alongside other designers where he could see and hear their everyday practices in action, as well as call on them for assistance when needed. Working as he did in the design office of his mentor gave Student 24 first hand experience of the authentic design office culture of practice and facilitated his use of the office services and resources in ways typical of the culture of practice there.

Working in this situation also meant that interaction between Student 24 and Mentor 6 took place frequently and on an as-needed basis, reducing the need for extended work sessions. Mentor 6 said that he arranged for student 24 to be located in the open office space used by the mentor and all of the other office staff to ensure that he experienced the same working situation as any other designer there. Being located in the general work area meant that Student 24 could hear and see all that took place in the design office and was able to participate in exchanges between staff members or seek their assistance whenever needed. In this way, Student 24 experienced the authentic culture of practice and worked with his mentor in the context of the commercial operations of the discipline domain. He was able to exchange ideas with others and in so doing acquired new ways of designing and developed multiple perspectives of design practice which he applied to the authentic projects he was undertaking with his mentor.

Mentor 1 and Mentor 1a arranged for one of their design office staff to sit in on all work sessions with Student 25 so as to provide alternative viewpoints and back-up services. The person they chose for this task had recent experience as a mentee and as a TAFE student. Having this background, plus experience of working for a year in the mentors' culture of practice situated them well to advise Student 25 on many aspects of working with a mentor and of design office practices. On 15 occasions throughout the Phase Three work sessions, Student 25 was given support or input to her design effort by staff or consultants operating in the design office of Mentor 1. Assistance provided by others in this way included their tacit knowledge about various design situations that had similarities or relevance to the problems that emerged during development of her project and procedural knowledge of ways they had used to resolve problems in their own commissions. Although these activities took place in just 12% of the work session times, they are design office practices that assisted learning for Student 25 by providing expert knowledge at those times when it was most needed.

Commenting on this in a post work session interview, Mentor 1a said that having others participate in activities involving students in the design was a common practice that stemmed from usual office teamwork methods. He said that such contacts with consultant staff assisted student learning by providing information about office practices, problem solving methods, resources, expertise and alternative points of view.

Student 25 said that her contact with others in the design office had helped her to develop a broad view of the design industry and to better understand the relationships that existed with associated disciplines. This, she said had led to her having alternative perspectives on environmental and structural problems in her own work and that these had shaped aspects of her final design solutions.

Findings from data coded in this category led me to conclude that student learning was enhanced by having multiple views of problems. Contact with others in the design office setting also provided opportunities for students to acquire tacit knowledge of design from various experts experienced in many different aspects of building design practice.

Participation in site visits.

Some of the mentors arranged for students to accompany them on visits to building projects under construction where they were able to show outcomes from their own design decisions with commercial design commissions. When showing students design and construction details on site, the mentors also articulated their reasons for resolving design problems in the manner that they did and demonstrated with sketches the processes they had used to explore and refine their final solutions. When working in this way, the mentors were regarded by me to use their tacit knowledge to provide students with a detailed picture of the design process from sketch to construction. In so doing the mentors also demonstrated links between their design procedures and design outcomes. Working in this way, the mentors provided students with procedural knowledge of their usual design methods, in the context of authentic practice as demonstrated by the solutions under construction. Student 18 said, when commented on this aspect of his learning with Mentor 26:

> The first day that I was there working with her she had some appointments on site so I went along with her to some of the jobs that she had designed. She explained to me a lot of things about the way she

> designs and showed me them in those houses. She also kept asking me questions about what I thought or how I would have designed some of the details.

Interaction with others on building sites or when discussing aspects of a design with consultants or industry experts was said by some of the participants to be of great value in helping them to understand the links between design office practices and actual construction techniques. This aspect of learning design was noted by five students in their project journals as important for understanding the reasons behind the mentor's design decisions and in understanding construction details that were otherwise difficult to explain. I have concluded that mentor use of articulation to explain their reasons for using particular design elements or construction details during site visits facilitated transfer of their tacit knowledge about design to students. This assisted the students to link procedural knowledge necessary for using heuristic design strategies to problem solving methods appropriate to the tasks that emerged from their authentic design project. When interviewed at the end of Phase Two, Student 18 made the following comment about this aspect of his participation in site visits with his mentor:

> I learnt heaps from seeing her (the mentor) projects as they were being built and having her talk about why she designed the way that she did.

Other data transcribed from the journal kept by Student 18 confirmed these comments as follows:

> Went on site today with Susanne to check out a couple of her jobs. She talked all the time about why she had put in the features that she said made it work and showed me how the details were worked to brick course heights and plastering panel sizes. I asked heaps of questions; she liked it when I got into it a bit and she kept questioning me about what I thought and how or why I might have done it differently. Got some good ideas from this. (Student 18, personal journal entry)

Analysis of data such as these led me to conclude that student learning about design was assisted by their participation in visits to construction sites where mentors showed actual examples of their design work and verbalised their reasons for developing the designs in the manner they did. Working in this way provided opportunities for students to acquire tacit knowledge of the mentor's usual design practices, declarative knowledge of site construction techniques necessary for detailing design elements and procedural knowledge necessary for implementing design methods modelled by the mentors. Site visits with mentors provided students with important learning opportunities in which the connections between design theory and practice was readily established.

Summary Of Findings For Category 3.1

The following practices emerged as effective means for transfer of declarative and tacit knowledge in the application of design processes and procedures modelled by mentors as typical of their usual design office practice methods:

- examination of the design brief and all influencing factors in preparation for a design development;
- extensive use of questioning and thinking aloud to:
    - introduce, explore and defend design ideas;
    - explain the processes used to develop design solutions; and
    - for evaluation and testing of design elements.
- the use of extensive and diverse non-context specific resource materials;
- extensive use of reflection on past and current design projects as design resources;
- matching of proved design and construction practices to design concepts being explored in the student/mentor collaboration;
- use of the "office set" approach to provide visual representation of ideas explored, information researched, variations on design concepts or details, branching of lines of inquiry, evaluation of design elements and influencing factors;
- extensive use of visualisation to explore multiple perspectives and solutions;
- the use of CAD design and drawing methods to quickly explore new ideas or concepts;
- mentor availability and the extended support offered by contact with others in the work place or associated discipline consultants; and
- student participation site visits and current office projects in which the mentors link actual practices with theory or concepts.

Learning methods using Modelling, Coaching and Scaffolding

This section reports findings that emerged from analysis of data about how student learning was assisted by mentor use of the specific cognitive apprenticeship teaching strategies of modelling, coaching and scaffolding. Many of the elements discussed here have already been mentioned as occurring in other activities or practices regarded as affecting student learning in the study situation. Here, they have been specifically addressed because of their particular relevance to these three key cognitive apprenticeship teaching strategies. Findings that emerged from data coded in categories used to represent the modelling, coaching and scaffolding teaching strategies are reported here, along with data from Phase Two interviews and the video record of Phase Three work sessions.

Earlier in this thesis, it was reported that mentor use of modelling and coaching was characterised by a constant shifting between the two during student work sessions.

Similarly, mentor use of various materials to scaffold student learning has already been mentioned in the context of coaching students in the application of heuristic design strategies and problem solving methods typical of the design office culture of practice. During analysis of data coded using categories based on these teaching strategies, one hypothesis to emerge suggested that these three teaching strategies together form the core practices used by mentors to communicate their tacit knowledge and design methods to students. This hypothesis is now expanded.

Category 3.2 Learning methods using Modelling

In this study, modelling is thought to include activities used to support learning through personal demonstration of processes or procedures used to create building designs and to resolve problems emerging from the exploration, development and assessment of possible solutions. Of particular interest was the manner in which building designers, when working one-on-one with a student, conveyed their knowledge and skills by modelling their approach to identifying and solving design problems. Here, modelling also included the demonstration of design strategies that affected personal style in building design. Personal style in design is regarded as the use of design characteristics or elements in ways that typify that design as having been created by a particular individual designer or in the manner of a recognised genre.

Findings from analysis of data coded in this category indicated that the mentors reified their knowledge and design processes by modelling their ways of using design strategies and problem solving procedures. They mostly did this by working one-on-one with students using sketching and discussion to link their interpretation of the design brief to design and problem-solving strategies typically used in their practice. As part of this process, the mentors used procedures typical of what they said were their usual practices to schedule tasks as an advance organiser for addressing the students' design project. The main tool used for this purpose took the form of a set of overlaid drawings, known as the "office set" (see *Category 3.1.4*, p. 166) that provided job planning schedules, as well as an audit trail of problems faced, solutions explored and ideas reviewed over the life of the project. The use of this approach emerged as a practice common to most of the mentors in the study and was observed to occur during 23% of the Phase Three work session times.

Most of the mentors used examples of their own design commissions to model their approach to design and problem solving. Five of the mentors made extensive use of their own works as a modelling tool when articulating their personal views on design and constructiondetailing. Throughout the work sessions, the mentors shifted between *modelling* and *coaching* as they moved from a leading role to an assisting, consultant role when working with the students on their design project. Analysis of Phase Three data indicated that activities in which the mentors were modelling their ways for using heuristic design strategies and problem solving methods and coaching students in the application of those methods, took place on average during 38% of the work session times.

Analysis of data about how the students used methods modelled by the mentors to develop their own design approach suggested that the students adopted the mentors' design practices. When commenting on how he initiated what he described as his structured approach to teaching design to students, Mentor 7 said:

> If you don't give someone a start point, as a young person or an inexperienced person they'll sit there for three hours and say "what the hell am I going to do?" They will think "I don't know where to start, do I start in the kitchen, do I start from here or there", you know, they're lost.

One way in which Mentor 7 and some of the other mentors modelled their design methods was to introduce students to their design practices by including them in the day-to-day events taking place in the design office. In some instances, this involved the mentors allocating the students simple tasks that formed part of the authentic commissions being undertaken in the design office. The mentors then modelled ways for resolving those tasks by working with the student and others in the design office as per their usual work practices. The following comments made by Student 16 confirmed how this approach helped her to acquire tacit knowledge of common design office work practices and procedural knowledge needed in order to apply the mentor's design methods.

> When I first went in there I got a good idea of what their work involved by watching and talking to Steve and some of the others as they worked on a project that they were trying to get finished. That helped me get into their way of doing things. What was really great was they let me work on some of the drawings with them and showed me some new design and rendering tricks.

Data such as these led me to conclude that through these processes students acquired declarative knowledge about the kinds of activities undertaken in the design office setting using these processes. The students also acquired procedural knowledge necessary for implementing the design methods used by the mentors and others in the design office. Student learning in the design office situation was assisted by their observation of mentors and of others undertaking their everyday design activities and during work sessions in which the mentors modelled design methods.

Some students also reported that they had learned much by observing the mentors dealing with problems emerging from their own design commissions and office practices, like problems with computer technology. Commenting on this, Student 16 said:

> ... sometimes I saw Doug and Steve (the mentors) getting frustrated and swearing at the computer because they could not get it to do what they wanted and I thought that was good because they were not perfect either and it made me feel OK when I had similar troubles.

Most of the mentors took a structured approach to modelling their design methods for students and in so doing created and controlled learning opportunities rather than leaving them to chance. Most of the mentors sequenced design activities by introducing new design concepts or procedures using tasks that increased in complexity as needed to address problems that emerged from the student's authentic design project. The following comments made by Mentor I about his use of this approach as regarded by me to typify the approach taken by most of the mentors when working with students:

> ... we work with the students mostly by showing them the way at first. We work through small design tasks with them to show them how we resolve the sorts of problems that always come up in design work. From there we break the job down into easy stages and then let them have a go at it themselves and have time to think it over before we get back to working through their ideas with them.

In some cases the mentors engaged others in the design office to model for students aspects of their design office practices. Mentor In, when commenting on how in his office a staff member with recent TAFE experience was assigned to assist Student 31, said:

> ... we were lucky in that in the initial contact with Dennis we were able to show him our way of doing things, but we also had Brian here who is an ex TAFE student and already knows the ropes in this office. Brian did a lot of the spade-work in helping Dennis to settle in with the other designers in the office and to get started. He showed him our set-up and the general approach that we take with all of our design and documentation.

Comments such as these confirmed the importance of the support offered by having multiple mentors in design office learning situations and in providing multiple models of design practice with which the students developed their own methods. Findings from analysis of the study data suggested that most of the mentors used a similar approach when modelling their design practices. Typically, they began by sketching common design situations and the methods they used to resolve problems that emerged from them, while also articulating their reasons for using heuristic design strategies or for decisions taken when dealing with them. Commenting on how he used this method to provide Student 13 with the information needed to commence the authentic design project used in Phase Two, Mentor 3 said:

> I did these (sketches) in front of him while we were talking to get him to think through the basic construction information and key elements that he needed to know.

One of the sketches referred to here by Mentor 3 is shown below in Figure 16 (p. 193). Simple freehand sketching of this type was used by most of the mentors to demonstrate to students how to resolve design elements by having a structured approach to design based on replicable procedures including sketching, schedules, lists and notes. Mentor modelling of methods such as these demonstrated for the students the mentors' design tools, defined directions and set time lines for completion of tasks as per the usual practices of the design office culture of practice.

Findings from data coded about mentor modelling of their design practices suggested that they used discussion and sketching as tools to introduce their ways for developing design solutions, while also articulating the reasons behind design practices and decisions to confirm their working practices. The sketch shown below in Figure 16 (p. 193) was produced by Mentor 3 in a work session attended by me and video-recorded for analysis along with other data collected. As Mentor 3 sketched the construction details shown, he articulated reasons why the pitching height of the verandah had to be at 2100 mm and why the minimum pitch of the roof was set to 5 degrees. To reinforce the need for setting these figures, he described in detail several instances in which he had experienced difficulties with similar situations with clients and builders who sought to detail the design differently. Working in this manner, the mentor provided tacit knowledge of his design experiences, as well declarative knowledge of different design situations the involve similar detailing and procedural knowledge of ways used by him to resolve the problems identified using the sketched example.

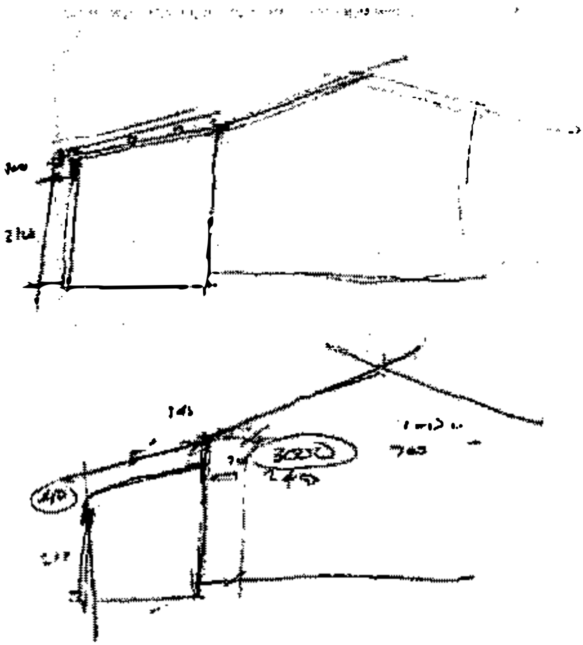


Figure 16 Sketch showing construction details

The following comments made by Student 13 indicate how Mentor 3 began by modelling his design approach using sketching and discussion then transferred ownership of the design development to the student when the basic information and design approach had been established. Student 13 said:

> He sketched and explained things all the time. When I first went there he already had a few schematics drawn, but he wanted me to tulk about it before he pulled them out. He went though some sketches that we did together before the end of the meeting and basically said to me OK go home with this information and build on it with your own ideas.

This method of showing an approach to design, backed up with information for students to initiate their use of the methods modelled, was typical of that used by most of the mentors. Student 9 described as follows how he and Mentor 2 similarly worked by building up layer of translucent "butter paper" drawings to progressively develop a design solution:

> We sketched all over my drawings together and he worked in pencil using tracing paper over the top so that he could use layer over layer of drawings as he built up different ideas. We could flick back over what we had done and see how the design had developed.

Mentor modelling of their work practices in this manner provided a means for transfer to the students their tacit knowledge, gained from experience of many different design situations, when dealing with the specific problems that emerged from the authentic design projects undertaken by the students. Most of the mentors modelled their design methods by demonstrating ways for exploring multiple design solutions or variations of an idea by using overlaid sketches on translucent "butter paper" so that the underlying sketches were visible as part of the new geometry being developed. When commenting on how Mentor 1a had demonstrated design procedures using this method, Student 8 said:

> Just watching him doing the butter paper sketches was great, seeing him do different bathroom configurations that I had never seen before like the one he did with the 45 degree walls. Each new sketch was on a different layer of paper so that you could see the design changing and by overlaying them in different [illegible]vs he showed me how to test different layouts or variations on the [illegible] design.

The mentors encouraged the students to use heuristic design strategies and office practices they had found to be successful in their own commissions. They mostly did this by demonstrating and explaining their application using "office set" drawings, sketching and the students own project drawings. Working in this way the mentors were able to sketch typical problem situations and the solutions they had used to resolve them, while articulating the reasons for decisions made and methods applied throughout that process.

Having begun by modelling their usual design approach, the mentors then shifted their approach to focus on coaching students in the application of heuristic design strategies based on their everyday practices. Some mentors saw modelling of their approach to design as the key to motivating students to achieve beyond their previous best performance. Data collected in member check interviews at the end of Phase Three confirmed that the following comments by Student 14 typify what most of the students said about their experiences when working with a mentor in a design office.

> ... this was a great working experience and I learnt heaps in a short time about design and how the industry goes about getting projects done in an office. Just having him show me how to use his methods to sort out my design problems helped me to understand more about design and how to come up with the best design I've ever done.

Comments such as these and other similar data suggested that mentor modelling of how their usual design practices could be used to resolve problems in the tasks faced by students in their design project helped the students to acquire new design knowledge and skills. The mentors also provided the students with insights into the wider community of practice by introducing design elements that involved contributions from other associated consultant discipline experts. For example, Mentor 6 said that he demonstrated the overall design process for students so as to give them the "big picture" of how what they produced related to other associated disciplines. Of this approach Mentor 6 said:

> It's really important for a student to see the process by which a design is brought up. Not just in plan form but through all of the related drawings so that at any one time the overall concept is evident for the engineer to see, or the estimator or any other consultant who might be a part of the design process along the way.

Using this approach to modelling design working practices was said by some mentors to "keep the energy going" for students by presenting a global view of design development while working on individual elements of a design using small tasks that collectively produced a final design solution. Mentor 2 said that he regarded this to be an important element in his modelling of design methods because it stopped students from getting "bogged down" with details when larger issues needed to be addressed first. Mentor 2 said he motivated students to explore design variations before resolving the fine details of a design by giving them a quick demonstration of how the design might be viewed differently by reworking earlier sketched ideas. Mentor 2 said of his use of this technique:

> In the last time (working session) I saw him I grabbed a piece of paper and I actually went shush shush shush (demonstrated rapid sketching technique). I just had to get at it and throw lines everywhere. Just to say to him get some energy into it. He had some good ideas there but he needed to work them over to explore other possible solutions.

This approach was picked up and used by Student 9 who worked with Mentor 2. When discussing what he had learnt from working with Mentor 2, Student 9 said:

> He just sort of came up with heaps of ideas. I don't know how he did it, but it was all fast sketching. He just created more ideas each time on top of the other ideas using sketches. He kept sketching everything. He gave me some basic ideas of how things were going to go using sketches and then I took that home and worked on it and fixed it up by drawing outlines to rooms and getting distances correct and made it work. That's how I got started with the design.

Mentor modelling of processes, procedures and design strategies was never simply a demonstration of their practices. It also mostly included elements of coaching and usually also scaffolding using resource materials to boost students past barriers to their progress. Having mentors apply and articulate their usual practices made visible to students the mentor's tacit knowledge, like how to deal with verandah roof details as mentioned earlier and many other design situations, as well as the procedures they used to deal with them.

As their designs developed, the students usually took a more active role in their collaborative work sessions and the mentors moved more to coaching than modelling, while also taking less of a leading role in decision making in the design. Evidence of this shift can be seen in comments reported earlier by Student 16 who said:

> When I went there I didn't feel confident to talk about my ideas and wasn't sure about how they did things there. That changed pretty quickly because although they took the time to explain a lot to me about their design methods, they also made me talk about mine and got me to explain every part of my design as it developed. That really helped me to be more relaxed about talking to them and by the end I think I was doing most of the talking and they just helped when I needed it.

During Phase Three work sessions, activities in which the mentors were considered to be coaching students took place during 61% of the work session time. The fluid nature of the balance between modelling and coaching in mentor supported design office activities involving Mentor 6 and Student 24 is regarded by me to be typical of what took place in most of the student/mentor collaborative work sessions. For that reason, a description of how Mentor 6 worked with Student 24 is provided here.

When interviewed prior to the first work session, Mentor 6 said that when mentoring students he always used examples of real design situations and solutions to model his usual approach to design. This he said provided visual evidence of design ideas and concepts that he had applied in his own commissions and about which he could articulate detailed informed description of the reasons underlying decisions taken and alternatives explored in resolving the design problems. I observed that during the first work session with Student 24, Mentor 6 spent 13% of the work session time modelling his approach by sketching forms that evolved from the design decisions taken leading up to the completion of an exemplar project being discussed. The exemplar project used was presented by Mentor 6 as an "office set" of drawings generated as part of his usual design office practice.

Analysis of Phase Two data suggested that the use of the "office set" approach was a key element in modelling design ideas and strategies for dealing with problems that emerge during the design process. Findings that emerged from analysis of Phase

Three data showed that the mentors used "office set" drawings when modelling their design approach, during 40% of the work session times.

During analysis of the video recordings of the Phase Three work sessions, I observed that the balance between modelling and coaching constantly shifted in a cycle of detailed explanation building and demonstration to facilitate the student's use of the design procedures being applied. Figure 17 represents that cycle of modelling, demonstration, coaching and explanation building.

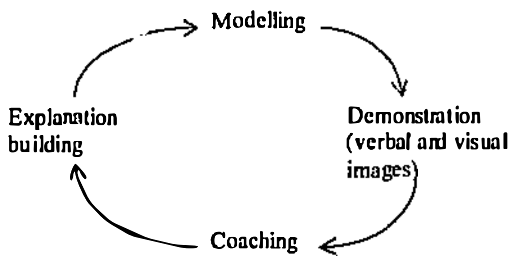


Figure 17 Cycle of modelling, coaching, demonstrating and explanation building

Mentor 6 used a multi-faceted approach to progressively build a verbal and a visual picture of the design problems and their possible solutions using the "office set" design tool, sketching and discussion. In this way he reified his tacit knowledge and procedures for dealing with problems emerging during the design process. Findings that emerged from analysis of data about other student/mentor design office collaborations showed that mentor modelling of their design methods helped the students to acquire declarative knowledge including regulations and standards that govern construction practices and information about how these influence design and structural detailing. It also facilitated student acquisition of procedures used by experts to deal with problems that emerged from tasks embedded in the authentic design projects on which they worked. This was evident in the work produced by Student 24 (who worked with Mentor 6) when his design drawings were assessed by a panel of building design experts (see judging of student designs on page 269). Although this assessment did not form part of the main data gathering methods, it was regarded as providing data about student learning outcomes that were confirmed in member check interviews with TAFE lecturers at the end of the design project. Findings from analysis of these data confirmed other findings that emerged from this study and supported my contention that new learning had occurred.

When discussing how each of the students had performed according to the assessment of their final design commissions, Lecturer I said:

> They all did really well in the project and I can see a great difference in the standard of their work when I compare it to what they usually produce in classroom based design exercises that we do with them. Colin (Student 24) came through with the best design. The panel (group of building design experts who assessed the student designs) thought that his work was of a professional standard and that he had really made the best of working with Mentor 6.

In addition to the structured work sessions in which the mentors modelled their working methods for the students, other unstructured activities took place in the design office from which the students acquired knowledge by observing and sometimes participating in exchanges with others. Most of the students reported that hearing and seeing others working with clients and consultants on real design projects had enhanced their learning experiences in the design office. When commenting on how this aspect of working in a design office had assisted his learning, Student 13 said:

> I learnt heaps just by being in the office and listening to all the conversations going on around me. Sometimes they got pretty heated and that was great because they had to defend their ideas if they wanted to get them through.

Working with a mentor in a design office and being witness to all that takes place was said by many students to add new dimensions to their learning. Student 16 said:

> It gave me a different point of view about looking at design, you know, you are not so limited to what you can use. I've got a much broader view of design now and know about alternative ways of doing things that you just don't get to see at TAFE.

Findings that emerged from analysis of data about practices used by the mentors to model their design methods and problem solving strategies suggested that modelling was used by the mentors to:

- demonstrate their usual design methods, problem solving strategies and a structured approach to design through the use of authentic "office set" drawings, sketching, over-sketching of CAD drawings, schedules, lists and notes;
- demonstrate to the students design tools, heuristic design strategies, defined directions and set time lines for completion of tasks;
- provide declarative knowledge of design situations, regulations, codes and standards as well as procedural knowledge for applying design methods; and
- structure design activities to replicate the sequencing of design production in authentic practices.

Category 3.3 Learning methods using Coaching

Carver, (1995, p. 206) contends that coaching occurs when "the teacher observes and facilitates while students perform a task". This study supports that view with coaching also including activities or situations where a mentor assisted students by working collaboratively with them to resolve design problems. The use of coaching is considered here to include mentors guiding students in their use of heuristic design strategies and problem solving methods by articulating the reasons behind design decisions, procedures and individual style elements regarded by them as being typical of their usual design office culture of practice methods.

Analysis of the video recordings of student/mentor work sessions showed that all of the Phase Three mentors moved constantly between coaching and modelling as they worked with the students on the real work design project. Activities in which the mentors were considered to be modelling took place during 23% of the work session times and activities in which the mentors were considered to be coaching took place during 61% of the work session times. These figures being taken only as a guide to the balance of activities given the overlap of modelling with coaching that was almost always present.

Mentor use of detailed explanations and sketching when coaching students in the use of heuristic design strategies and problem solving methods was common to all of the Phase Three design office situations. Much of what the mentors presented consisted of guidance and explanations for addressing problems emerging from the authentic tasks embedded in the student project using articulation and sketching. For example, Mentor 6 created the sketch shown below in Figure 18 (p. 200) to assist with his explanation of how to design on a hillside site with clay soils, when coaching Student 24. The following excerpt has been transcribed from the work session in which Mentor 6 coached Student 24 in dealing with problems about the building site:

Mentor 6:

This design situation is like one I did recently on a steeply sloping site with wet clay soil and large ironstone rocks. I went for a framed design similar to what you have suggested in your proposal. This is a good way to deal with a site like this because it's best to avoid cutting into the site and risking mud slippage.

Student 24:

I thought that I could also use a flat slab and retaining wall to get a level area at the bottom for the cars.

Mentor 6:

Let's have a look at that. If we cut a section through your design this is how it might look. (quick sketch as shown below). If you cut into the site you will get slippage and water run-off through the footings and that might cause movement for any mass walls. Also, you will need to form drains behind any retailing wall or they will act like a dam and eventually crack and fail. Have you thought about using a fully framed construction to avoid the use of retaining walls?

Student 24:

Not really, I thought that I needed to have brickwork for some of it for thermal insulation reasons.

Mentor 6:

There are many other ways, for instance we can use multi-layer insulation, roof overhangs and verandahs for shade like this (see verandahs in Figure 18) and get the orientation working for us to let the sun in during winter through highlight windows like this (see arrow to window in top of Figure 18).

Mentor 6 went on further to discuss reasons for refining different parts the design that Student 24 had presented. Working in this way, Mentor 6 coached Student 24 through several aspects of the design by discussing reasons for using different design details and by sketching multiple solutions that he called on the student to develop as they worked together in refining the overall design form.

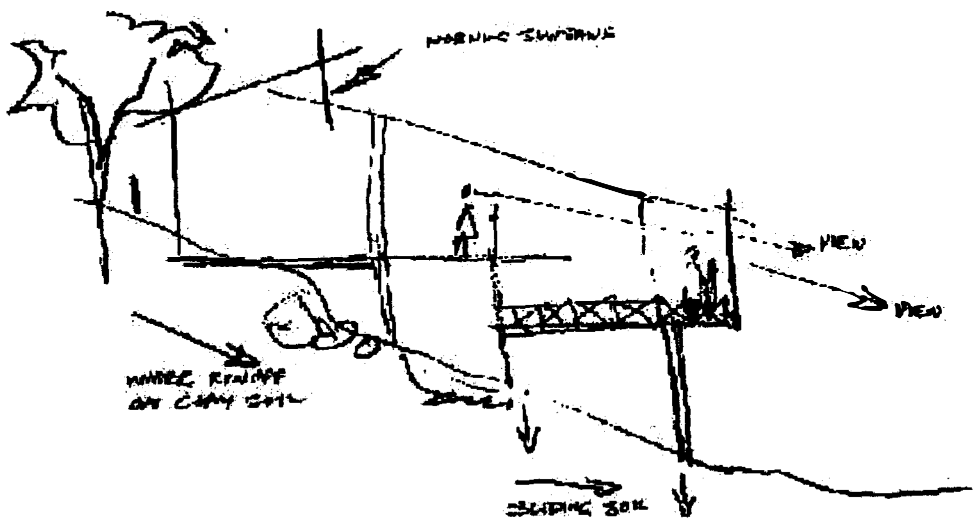


Figure 18. Sketch used during Coaching about sloping site conditions.

Coaching used in this way by the mentors facilitated transfer of tacit knowledge of different design situations or methods to students. Typically the mentors also gave detailed reasons for decisions they had taken when resolving particular design problems in authentic commissions used by them as exemplars on which students could base their own design practices.

Most of the mentors said that when coaching students they expressed their thoughts aloud while sketching design ideas or solutions. This, they said, provided immediate feedback to the students about how and why they resolved design problems in the manner that they did. During Phase Two, Mentor 1 said that he sketched and talked about his decision-making processes when coaching students in the use of his design methods. Of this approach Mentor 1 said:

> We sketch in front of them and we think out loud and say look you do this and don't do that and we rub bits out and develop it on the fly with them.

Student 18 similarly described the approach used by Mentor 26 to coach him by using sketching and articulation. Student 18 said:

> She sketched straight on top of my drawings and sketches as well as doing her own butter paper sketches and overlays. She talked about why she liked doing things her own way in design and all the time explaining why some things worked and other didn't.

In all of the Phase Three work sessions, mentor use of coaching by the over-sketching of drawings was observed to occur in conjunction with detailed descriptions of why and how particular procedures might be used to resolve emergent problems in the design. This aspect of the use of sketching is described in more detail later as part of *Category 3.4 Learning Methods Using Scaffolding* (p. 206) but is mentioned here because it also emerged as an important element in coaching. Some mentors sketched over the top of drawings when coaching them in the use of design procedures. The purpose of working in this way was said by some mentors to provide immediate feedback to the student on the effect that ideas being explored might have on the design form and to show a record of the design variations considered throughout the work session. Commenting on how his mentor used this approach Student 9 said:

> We sketched all over my drawings together. He worked in pencil using tracing paper over the top so that he could use layer over layer of drawings as he built up different ideas and we could flick back over what we has done and see how the design had developed.

Most of the students made comments similar to this when discussing how the mentors over-sketched their drawings to guide them through the design project. From these data I concluded that over-sketching of drawings was an important tool used by mentors when coaching students. Its use was slightly different from freehand sketching to present new ideas or for explanation purposes in that it utilised and built upon existing geometry and thereby presented an evolving form upon which students could reflect and explore new pathways. Drawings produced in this manner during work sessions were added to the students' own "office set" documents that formed the basis for further development of their design solutions. They were also used in coaching sessions to explore multiple design solutions. In addition to these "office set" drawings, the mentors used their own "office set" documents of authentic commissions as exemplars when coaching students in the application of heuristic design strategies and problem solving methods. When using these "office set" drawings for coaching purposes, the mentors were able to provide examples of completed design solutions that addressed similar design situations to those of the students' authentic project. Using these, the mentors then demonstrated their design methods and conveyed their tacit knowledge of various situations and design solutions for students to adapt to their own works.

Student 16 said that her mentors encouraged her to develop an "office set" using the overlaid drawings they had developed together when coaching her through the use of their design procedures. The "office set" drawings she created were also used in later work sessions with the mentors to explore and refine other design solutions. Of this approach, Student 16 said:

> ... it meant that I had layers of sketches in what they called their "office set" and from that I could see the design progressing and also see where we had tried things out and then gone another way.

During Phase Two, Mentor I said that his approach to working with students was based on "sketch and talk" so that every aspect of the design process and every design idea explored was documented using sketches and notes that formed the "office set" drawings for the design project. These drawings were then used during work sessions to further explore and refine design solutions. Other "office set" drawings created for authentic commissions were used during coaching sessions along with the student's drawings to introduce design strategies and for explaining how problems similar to those that emerged from the student's projects had been resolved in other projects. Findings for this category suggested that most of the mentors used "office set" drawings as tools to assist their coaching of students in the application of their usual design practices. The following comments made by Mentor 17 are typical of many similar data coded about coaching using drawing sets to show different aspects of design practice:

> ... I stress to the students that it is vital to be confident that you have explored every aspect of a design before trying to create formal drawings that the client might accept and therefore close off on development that may still be needed. That's why I get students to develop their own "office set" drawings, so that they can see the gradual development of their ideas and to explore every one of them before committing to a design. The whole time I am working with them I also get them to use my own "office set" drawings as a source of information. By using them, they can see and I can explain how and why certain design situations are best resolved. It's a great way to guide someone else by having real examples that have been built and being able to tell them about the successes and failures that came out of them.

I have concluded that students acquired ways for developing design solutions through mentors coaching them in the application of their design strategies and in ways for resolving problems that emerged during the design process. A key part of students learning to apply their mentor's design methods involved the mentors explaining the reasons for their design decisions by using exemplar works documented in "office set" drawings of their authentic commissions. I regard coaching assisted student entry to the design office culture of practice because it revealed how and why mentors use particular strategies to address design problems in the context and culture of their usual practice. Coaching using these methods also showed how the mentors applied the heuristic design strategies and procedures they advocated to their own commissions and thereby demonstrated the success or failure of those methods along with the reasons why.

The manner in which Mentor I and Mentor Ia used coaching methods was representative of the way most of the mentors used coaching. For this reason, the following description of how Mentor I and Mentor Ia worked with Student 25 during Phase Three is included here to illustrate the how coaching was used in the design office work sessions by the mentors to assist student learning in building design.

Mentor Coaching in design office work sessions.

I observed Mentor I and Mentor Ia coaching Student 25 in the use of design strategies they described at the time as their everyday practices. Mentor I and Mentor Ia started out in a similar fashion to that used by most of the other mentors studied, by taking a very open view of the design at hand so as to "leave it open to multiple ideas" for the student to explore. During 51% of the work session times the mentors encouraged Student 25 to visualise as many alternative design concepts as possible by placing herself mentally on site, experiencing the location. During 30% of the work session time, each of these ideas or concepts was then explored by sketching and discussing them to the point where they could be evaluated, then accepted or rejected for further development. Coaching activities in which the mentors sought to inspire new thought by reviewing the student's work took place during 32% of the work session time. With each new design explored by Student 25, the mentors introduced new approaches for resolving the problems emerging from the situation. These activities occurred during 41% of the work session time. Much of what the mentors provided during these sessions involved the introduction of multiple perspectives of the design project being discussed, along with tips and techniques for resolving the difficulties that they identified as likely to emerge from the situation presented. For 61% of the work session time, the mentors explained their use of information based on their tacit knowledge of similar situations they had faced in their everyday activities and the procedures that they had employed to resolve them.

As the design being developed by Student 25 began to emerge from the many forms she had explored, the mentors coached her along a pathway aimed at refining her preferred design solution. Following the third work session, Student 25 commented that she had arrived at the basic form of what was to become her final design by applying the "process of elimination" that Mentor I had introduced during the first work session. She explained that she had considered several other possible plan-forms for her design, but had rejected them after exploring their attributes and finding them unsuitable. Throughout the six observed work sessions involving Student 25 some aspects of this early process of exploring multiple perspectives on global scale in the design took place with the mentors. Much of it also occurred for Student 25 at home where, according to her, she used the mentors' advice to make the evaluations by herself by developing and exploring their value within the framework of the procedures in which she had been coached by the mentors during the work sessions.

The most intense work sessions involving Student 25 and her mentors took place when she had established a plan-form that was accepted by the mentors as suitable to be refined for a final solution. At this time, the mentors used sketching and discussion to introduce and explore possible variations to the design at a detailed level within the context of the overall plan layout and elevational treatments. Student 25 said that this stage of development was most enlightening for her because she felt that she had achieved freedom in design through using an open-minded approach to visualising the final form. This she said had led to her creation of multiple design solutions for evaluation and integration into the final design concept.

When Student 25 presented what she regarded as her final design, Mentor I and Mentor Ia encouraged her to evaluate its suitability by discussing at length with her numerous variations for the details of that plan that could be used to refine it. Throughout this process they coached her in ways to explore and to detail the ideas presented in the final design by using multiple layers of translucent "butter paper" to over-sketch new ideas on the existing design geometry. They also used examples from their own "office set" drawings of commissions that had similar design situations but different solutions to those being developed by Student 25.

During 31% of the work session time, the mentors modelled design variations and alternative approaches that were based on exemplars taken from their own works in progress. Each design element or procedure introduced in this manner provided strategies for conceptualising new ideas and resolving emergent problems in the design being developed by Student 25. This, I contend, encouraged Student 25 to use metacognitive ways to explore and to refine her design ideas. When discussing this approach with Mentor 1a during Phase Two, he said:

> If you just keep telling them what to do they never develop their own ideas, if they go it alone they might make mistakes but they also come up with the goods occasionally and when that happens it's pretty easy to see.
> I give then a starting point with some sketches and then let them experiment with the ideas, when they come back with something too outrageous I just slowly pull them back by getting them to show me how they might actually build it. You might say to them what a great idea but get back to the real world.

Some mentors said that they encouraged students to "run off at a tangent" in design because it often resulted in creative, innovative ideas being explored. Other mentors were more focussed on monitoring student exploration of "radical ideas" and used coaching methods to guide exploration and discovery by setting parameters that were based on the requirements of the client brief. For example, Student 13 described how Mentor 3 coached him through the design process, saying:

> He gave me the advantages and disadvantages of things like room sizes or positions. Then he let me decide on how I might use things. He let me do the design but he guided me when I got bogged down or started doing things that he saw as running off line.

Student 16 experienced a similar approach in her collaboration with Mentor 6 and Mentor 6a. She said:

> Most of the time I did it on my own but with them helping out when I got stuck or just looking over my shoulder and making comments when they saw things that they thought could be done differently. I had to keep myself working at it, but they were always there on the sidelines keeping an eye on me and going through my sketches asking me to explain why I

> was doing things in that way. They kept talking to me about the design and usually suggested little changes or adding in things like verandahs and so on.

Most of the mentors used coaching to assist student learning by reifying their tacit knowledge and design procedures when demonstrating and explaining their application to problems the emerged from the students' authentic design project. Through this coaching process, the students acquired the knowledge and skills needed to resolve design problems. Analysis of the study data suggested that coaching occurred by:

- guiding students' application of design, heuristic design strategies for resolving emergent design problems and for refining design solutions;
- explanation building to detail the reasons underlying design processes and decisions, based on personal experiences;
- over-sketching of students drawings to provide immediate feedback on ideas explored or solutions accepted; and
- assisting exploration of new design ideas that stemmed from earlier concepts, as documented in the "office set".

Category 3.4 Learning methods using Scaffolding

Carver (1995, p.206) contends that scaffolding occurs when the "teacher provides support to help the student perform a task". This study supports that view as well as regarding scaffolding to include tips and tricks or resource materials provided by the mentors to assist student learning or problem resolution activities in design. This included techniques, explanations or partial solutions that enable students to progress beyond points of difficulty.

Findings that emerged from analysis of the study data suggested that the mentors used scaffolding to assist students over barriers to their progress by providing timely information and procedures, based on authentic experiences, to resolve problems emerging from the design process.

All of the mentors used a range of different methods including the use of the following materials to scaffold student progress with design:

- exemplar drawings;
- architectural journals and catalogues;
- codes and regulations;
- advertising materials like magazines and travel brochures; and
- hand and CAD drawn sketches.

Scaffolding often also included assistance by consultants and other design office staff who provided specialist knowledge or alternative procedures for solving problems that were preventing student progress. All of these elements have been mentioned already in the discussion of design office practices, modelling and coaching. Their use as scaffolding elements is further discussed here because scaffolding is universally recognised as important to student learning in the design office situations of this study.

Student development of autonomous ways for using information and design methods modelled by mentors took place during their collaboration with the mentors and as part of their independent design activities. The use of scaffolding materials and methods as listed above is discussed in this section with reference to its timely application by mentors and others in situations where students experienced difficulty in progressing because of problems that emerged from the authentic tasks of their design project. Scaffolding used in this way differed from the use of these same materials during explanation building or coaching where new ideas or concepts were introduced along with ways for dealing with them. The essential feature of scaffolding was its timely application to overcome barriers to student progress. Another key aspect of using scaffolding was its gradual withdrawal as students acquired knowledge and skills needed to complete their tasks. The gradual withdrawal of scaffolding, referred to as fading, was examined using the video recordings of Phase Three work sessions.

Four aspects of mentor use of scaffolding that assisted student learning emerged from this study. Each of these, observed in use by mentors during Phase Three work sessions, is now discussed along with emergent findings and examples drawn from the study data. The categories are:

3.4.1 Mentor sketching, over-sketching of CAD drawings and notes;

3.4.2 Resource materials including codes and regulations;

3.4.3 Scaffolding using exemplar "office set" and CAD drawings; and

3.4.4 Consultants and others with special skills

3.4.1 Mentor sketching, over-sketching of CAD drawings.

Throughout this study, the mentors used freehand sketches and over-sketching of CAD drawings to introduce ideas and to explain design situations or methods. Sketching was also used extensively by mentors to provide timely tips and techniques to assist students to overcome design problems. What made the mentors' use of such sketches different from their usual application as tools to assist coaching, was that they were specifically created and used in response to student requests for help, or when the mentors saw that the students had come to a barrier to their progress. The other aspect of sketching used in this way was that as with other aspects of scaffolding it was used only as needed and progressively withdrawn (fading) as the students developed knowledge and skills to resolve emergent problems that had been targeted by mentor scaffolding using sketching.

For example, some mentors made use of sketches to form links for students between room relationship bubble diagrams and concept design layouts. Mentor 3 said that working in this way was typical of his usual design procedures, but was not used by the students he mentored until he introduced it to them after having seen them struggle to move on from basis plan forms. The manner in which Mentor 3 used an overlay sketch to scaffold learning can be seen by comparing Figure 19 (p. 208) which shows a simple plan form (created by Student 22) with no room relationship links, with Figure 20 (p. 209), which shows a plan developed over a bubble diagram, developed by Mentor 3 with the student. Mentor 6 prepared the bubble diagram part of that sketch after examining the student's first design efforts (see Figure 19). The bubble diagram was then developed by Mentor 3 and Student 22 into a plan form. This coaching process utilised sketching as a scaffolding element in that it provided timely information and the basis for a design procedure that overcame a barrier to design development for the student. For this reason, I regarded this use of sketching to be a valuable scaffolding element for student learning.

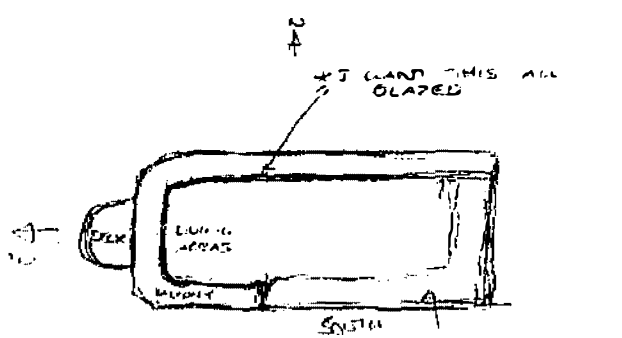


Figure 19. Student design sketch without room relationships.

The sketch used by Mentor 3 to scaffold Student 22 is shown below in Figure 20 (p. 209). In this sketch Mentor 3 has overlaid defined room shapes on a bubble form layout used to initiate the design by first establishing zone relationships in the building.

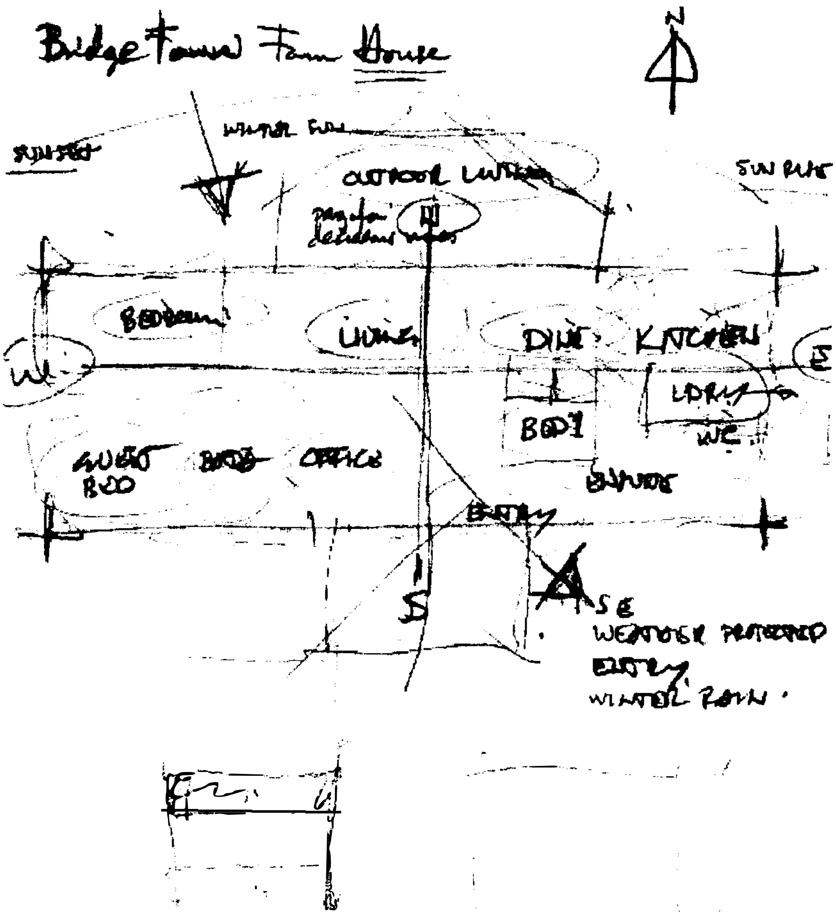


Figure 20. Design sketch showing defined room areas over bubble concept forms.

Such sketches were said by most students and mentors to be valuable tools for overcoming barriers to student progress during the development of design projects. Mostly, these sketches were quickly executed using soft pencil on butter-paper, concept drawings, or roughed out details ready for the student to resolve into their design.

During Phase Three, the mentors used sketches to illustrate, develop and explain concepts and design ideas or details, as part of their modelling and coaching efforts with students during 53% of work session times. An example of this form of sketching as used by Mentor 4 with Student 23, to scaffold learning is shown below in Figure 21 (p. 210).

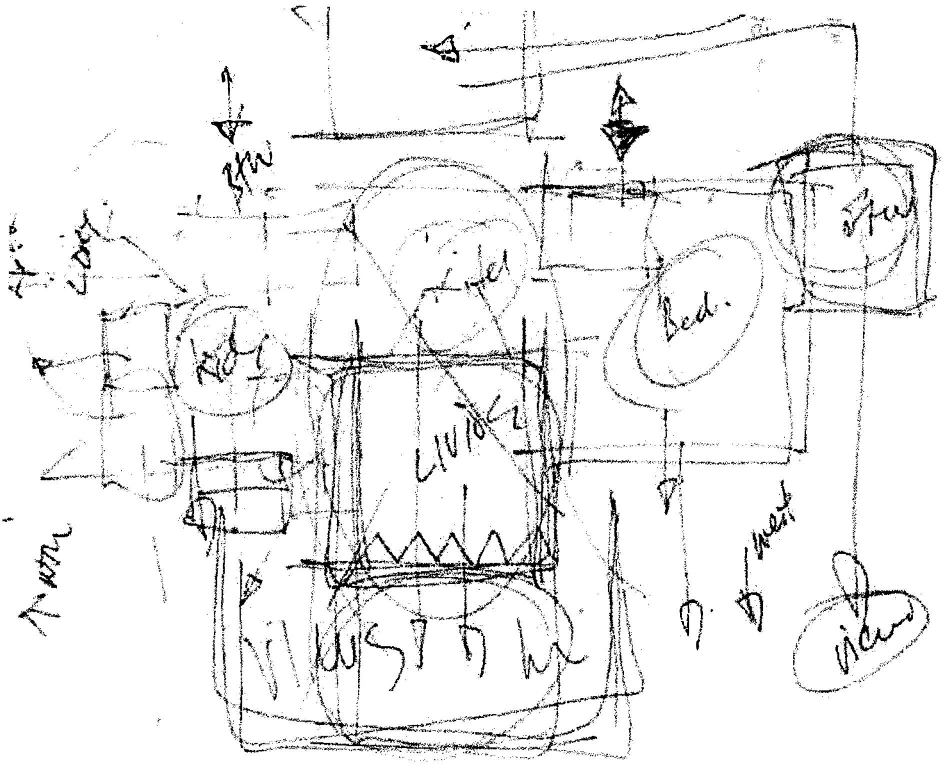


Figure 21. Sketch used for scaffolding Student 23.

Hand sketching over the top of CAD drawings was similarly used to scaffold student learning. For example, Mentor 6 helped Student 24 to position his design by showing him how to create focus lines, using over-sketching. The sketch produced by Mentor 6 for this purpose is shown here in Figure 22 (p. 211). The focus lines drawn by Mentor 6 run from the two left side corners to meet with a line from the centre of the right side site boundary. Secondary focus lines are shown as broken lines that were added when Mentor 6 coached Student 24 in his ways for developing alternative building positioning axes.

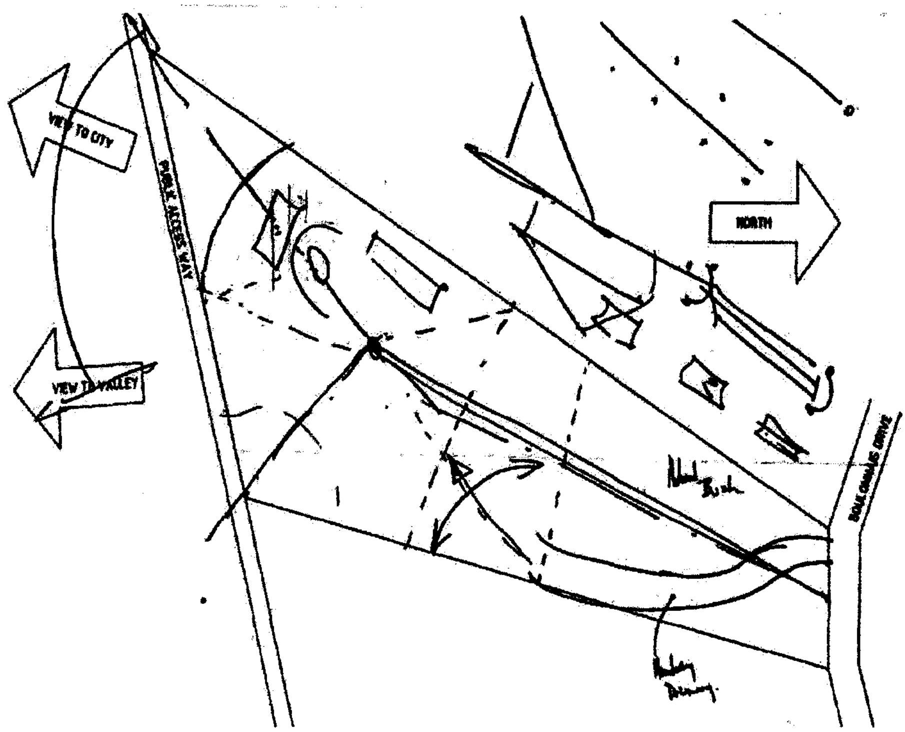


Figure 22. Over-sketching of CAD drawing showing focus lines.

Throughout this study, I observed that most of the mentors scaffolded learning by using sketching and over-sketching of CAD drawings which sometimes included elements taken from their current works or office archives that were similar to the students' designs. Used in this manner, sketches enhanced and scaffolded learning by providing sources of exemplar materials that incorporated similar situations (and the solutions used by the mentors to resolve them) to those faced by the students in their own works. Sketching used in this manner also provided transfer of the mentor's tacit knowledge of different design situations and the information needed to address them in order to meet regulatory requirements and industry standards for drawing documentation and construction. Having such materials as the basis for work session discussions allowed the mentors to use over-sketching of exemplar drawings or the student's own drawings, along with articulation, to assist students to resolve problems in their own works. Sketches produced in this way were also used to explain how other design strategies might be applied to problems that emerge from the student's designs. Student learning outcomes from mentor use of sketching to scaffold learning included:

- acquisition of declarative knowledge about multiple design situations as seen in exemplar "office set" drawings of authentic commissions;
- acquisition of tacit knowledge based on experience of using design methods reified by the mentors through use of sketching of similar problem design situations and the methods they had used to develop solutions for them;

- procedural knowledge of ways to apply alternative design practices as shown by the mentors in their use of overlay sketching of exemplar drawings to reify their methods for applying design procedures with reference to the student's own project; and
- design methods and multiple solutions to problems typically addressed in everyday design situations that emerged from authentic projects as demonstrated by the mentors when sketching design elements from their own works to illustrate potential ways for resolving problems that emerged from the student's design project.

When commenting on how Mentor 28 used this technique, Student 8 said:

> It was only when we started getting stuck for ideas or close to the deadline, he would come back to me with an idea sketched out and say here is something I have thought about and we would discuss and sketch that through. When I got stuck, I kept going back to those sketches, because I kept them in my own "office set" drawings and I would use them to sort the problems.

Mentor2 said that some students were unable to proceed with design because they did not have the necessary knowledge of building codes and regulations, or industry standards for construction detailing and the like. To assist them to overcome such barriers to their progress, he sketched for them key elements from exemplar works to specifically address problem parts of their designs. This use of sketching to scaffold learning helped students to acquire declarative knowledge of different design situations and to develop tacit knowledge of ways others had dealt with problems similar to those encountered in their project. It also facilitated their use of procedural knowledge necessary to apply design methods, acquired from the mentor, to resolve their own design problem situations.

Mentor use of sketching to scaffold student learning helped students to acquire tacit knowledge about design and drawing standards, as defined by the mentors, through their use of exemplars, drawings and sketches, from which the students could develop their own designs. Using solutions from other works to scaffold the students' designs facilitated the introduction of industry and design office standards to those designs. Mentor 3 said that he used this approach so as to lead by example. He said:

> I talked about every aspect of the design and sketched out ideas with him when we wanted something done in a particular way, or if it had to conform to particular codes or regulations.

I determined that student learning was enhanced by mentor use of sketching to demonstrate and explain their design methods and by the use of sketches by students to present and defend their design methods and solutions. For example, the student design shown in Figure 23 (p. 213) was developed using the method provided by Mentor 3 (see Figure 20, p. 209) which shows the bubble diagram and over-sketching approach introduced by Mentor 3. Although the layout in Figure 23 is different from the mentor's example, Student 22 has clearly applied the method learned from Mentor 3.

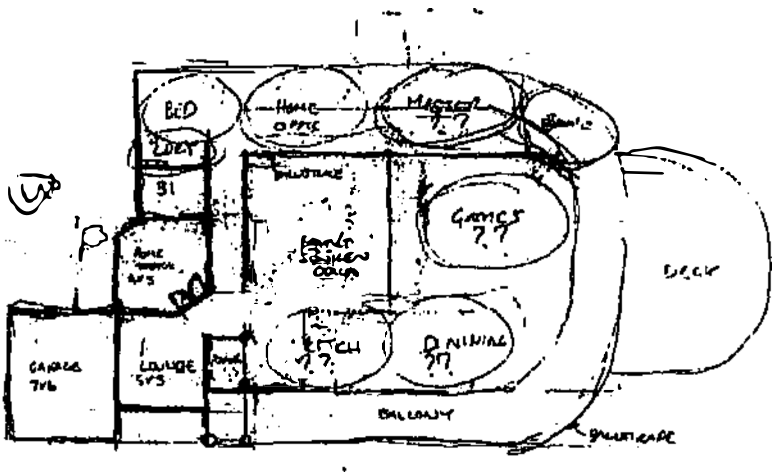


Figure 23. Student design using over-sketching of bubble diagram.

Additional information, in the form of notes, was often provided on sketches used for scaffolding learning. Mentor 3 made extensive use of notes and sketches as scaffolding tools when working with Student 13. On this point Student 13 said:

> I did heaps of sketching to develop the designs and when we worked together we mostly talked and sketched ideas and worked over the top of them trying out new solutions. We made a lot of notes while we talked and sketched and I used these later to sketch out other ideas that we discussed.

An example of the notes produced by Mentor 3 to scaffold Student 13 is shown here in Figure 24 (p. 214).

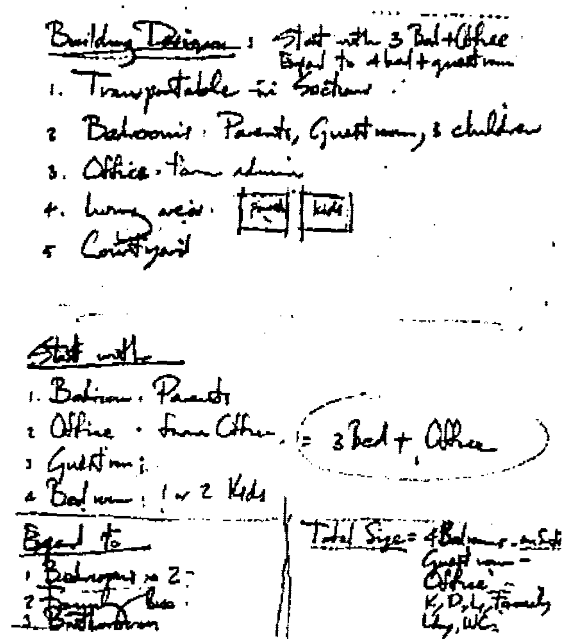


Figure 24. Notes used to Scaffold student learning.

Notes used on sketches in this way assisted student learning by providing an advance organiser for each new stage of the design development. Their use was also important for student reflection on the design process and also important when defending design decisions to the mentor or others.

Where CAD technology was used in design and drawing production, most of the mentors used a print-out of the semi-completed student design to sketch over the drawing to scaffold students' progress by exploring new ideas or to assist in developing existing ones. An example of how Mentor 6 used over-sketching of CAD drawings to scaffold Student 24 through parts of his design is shown here as Figure 25 (p. 216). In this drawing, freehand over-sketching can be seen in almost every part of the CAD base drawing. This demonstrates how CAD drawings were used as a means of formalising the emerging design geometry, which was then explored and developed using freehand sketching methods. The use of over-sketching of CAD drawings to scaffold student development of design elements often occurred as part of coaching, but with the focus being on overcoming design problems that had presented barriers to the student's progress.

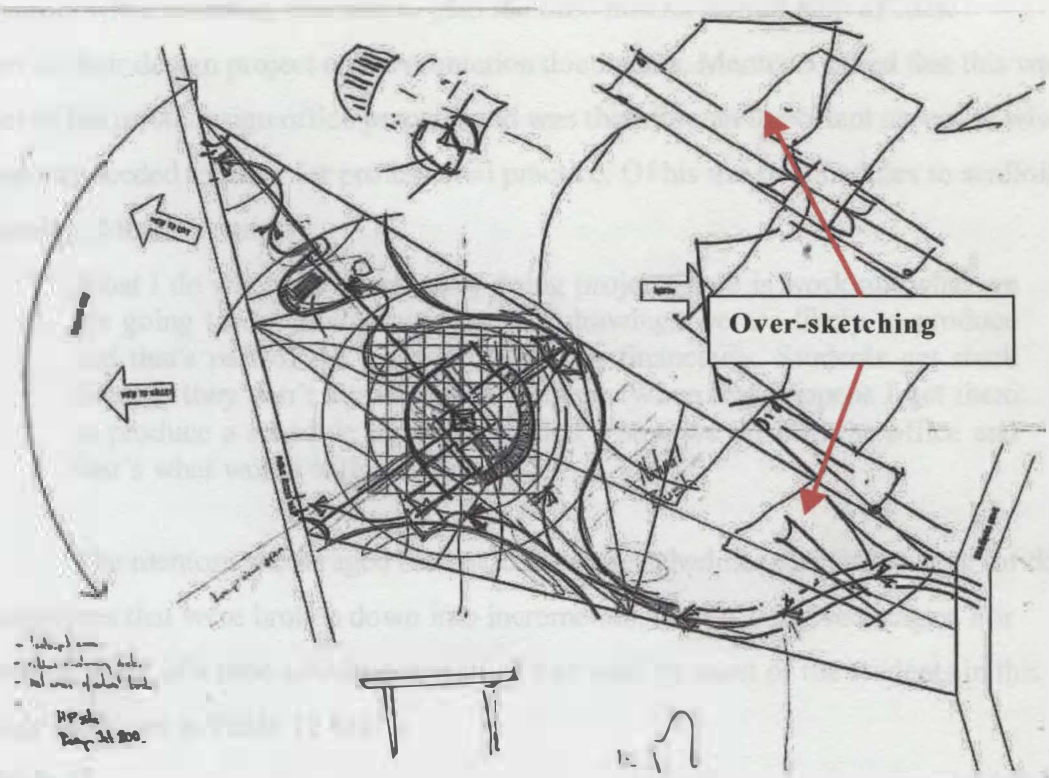


Figure 25. CAD Drawing over-sketched by Mentor 6 and Student 24.

During 28% of the work session times, Mentor 6 encouraged Student 24 to over-sketch his own CAD drawings in the manner modelled by the mentor. This, he said, assisted learning by providing a scaled (and therefore realistic) base upon which to explore other ideas or variations on the design. The visual record of all ideas explored using true to scale over-sketching gave the student an audit trail that showed the branching of ideas and explanatory elements concerning why certain parts of the design had been accepted or rejected as part of the final solution. Analysis of Phase Three data about over-sketching and notes on drawings suggested that they were used by the students as reminders of why particular decisions had been made, and this assisted them to make other design decisions, as informed by their earlier explorations, when not assisted by the mentor. The key element was the record of the design decisions explored, as seen through the sketched ideas and notes made by the students during the work session. Notes on sketches used by mentors to scaffold student learning helped the students to reflect on the purpose of those sketches when revising their designs and to utilise the information shown when implementing design methods acquired from the mentor.

Another aspect of using progressive over-sketching of design ideas to scaffold learning was that of scheduling the sketches, drawings and models produced to give order and structure to the design process. Schedules were also used by many of the mentors when assisting students to plan the time line for completion of each part of their design project and presentation documents. Mentor 3 noted that this was a part of his usual design office practice and was therefore an important aspect of what students needed to learn for professional practice. Of his use of schedules to scaffold learning, Mentor 3 said:

> What I do when we are actually doing projects here is work out what we are going to do, how many sheets of drawings we are likely to produce and that's part of the process of quoting financially. Students get stuck because they don't know what to do next. When that happens I get them to produce a schedule to work to. That's how we do it in the office and that's what works with students.

The mentors encouraged the students to use schedules as a framework for design procedures that were broken down into incremental, readily achieved stages. For example, part of a time schedule typical of that used by most of the students in this study is shown in Table 12 below.

Table 12
Sample part of student design project schedule

Day	Design Element	Drawings required	Resources	Time taken	Time allocated – Time left
Thus 5th	Brief breakdown	Schedule of criteria	Example of client brief from Brian	4 hours	1 day 28 days
Friday 6th	Site requirements	CAD layout with levels and features	Drawings of Winthrop job, council regulations	7 hours	1 day 27 days
Saturday 7th	Contour lines on site, geological survey drawing	Plan of site plus sections through n/s and e/w	DOPLA plans (get on NET) Client brief title drawings	4 hours (incomplete at this time)	0.5 days 26 days
Sunday 8th	Design zone relationships	Sketch layouts (keep it simple)	Example drawings, Building Code	Allow 3 days	0.5 days 25 days
Monday 9th	Start bubble diagrams	Butter paper sketches	Criteria from brief	Allow 1 day	2 days 24 days

Most of the mentors used schedules similar to this to assist students to organise their time to complete various tasks. They were used by all of the mentors in Phase Three to keep track of the students' progress in the same way in which they monitored real work projects in their normal office practices. This helped the mentors to identify problem aspects of student completion of design tasks within the overall time available for the authentic project and helped them to provide additional assistance quickly when barriers to progress were encountered by the students. For this reason I regarded mentor use of schedules to support student learning to be another aspect of scaffolding.

I have concluded that student use of design project scheduling in the manner modelled by mentors assisted learning by providing an advance organiser for tasks leading to design solutions. Its use by students was also important as a tool for reflection on pathways followed during the design process and also important when exploring new perspectives or alternative design elements.

3.4.2 Resource materials used to Scaffold learning.

Scaffolding resources used by the mentors to assist students included books, journals, magazines and photographs covering a great range of topics, not all of which were necessarily architectural design focussed. Anything that included stimulating imagery such as design or fashion elements like those found in magazines, travel brochures and the like was used by some of the mentors to inspire ideas in building design. All of the building design offices situations used here had extensive libraries of diverse and non-context specific materials available for the students to use. In most cases these things were provided informally as coffee table items used for casual reading in the social culture of the office. All of the design offices also made extensive use of "office set" drawing documents of authentic design commissions and CAD based drawings and component libraries as resources for scaffolding student learning. Most of the mentors said that they encouraged the students under their direction to use these materials to stimulate and inspire new and imaginative ways of dealing with design problems. When commenting on his use of such materials, Mentor 1 said:

> We have a really good collection of magazines and books which we all use in the office to get ideas and keep up with what's going on in the big picture overseas and in Australia.

Most of the students said that they had used a diverse range of materials supplied by their mentors as a source of information and inspiration when looking to overcome barriers to the progress of their designs. Mentor 2 used books and other materials to introduce new ideas and to stimulate Student 9 to visualise a design approach for a country setting. Of his use of such materials with students Mentor2 said:

> I said to him go and read some books and look at some pictures, go to a travel agent and pick up some brochures of the places you are designing for. Try to get the images in your mind because some of this country that these houses are going to is beautiful.

When Student 9 was asked about how Mentor 2 helped him progress beyond the initial design sketches he created from the criteria set by the client brief, he said:

> He brought out a couple of books, just landscape and the BCA (*Building Code of Australia*), as well as some trade litera . that showed timber and metal work building products. We pulled ideas out of them on balustrades and details for transportables We also looked at photos and stuff on the climatic zones in a book called "Living With Climate" that was really useful for working out roof overhangs as well as window sizes and positions. He sketched out three or four different ways of using roof shapes to get sun protection for the walls. We also used a cardboard model he had of one of his jobs to talk about how wide the verandah needed to be on the west-side to keep the sun off the kitchen windows in summer. Once I had all that stuff I was able to get on with the design.

This statement shows that Mentor 2 used a number of different resource materials to scaffold Student 9 over the barrier that had put a halt to his progress. They included books for landscape and site development, the *Building Code of Australia* for construction details and safety standards, trade literature for technical information about building materials, a text book on designing for different climate conditions, photographs for inspiring design style and a model for exploring design form.

Bringing resources such as these together was a key part of scaffolding student learning in the design office situation as it facilitated the progress of the student's design work with the immediacy of having the mentor at hand to direct its use. Many comments similar to those made by Student 9 were included in data coded about the use of resources used by mentors to scaffold student learning. For example Mentor 3 used commonly available magazines to assist Student 13 when he was "stuck for ideas". Commenting on this Student 13 said:

> ... he brought along some pamphlets and magazines that had pictures and articles in them showing portable houses and that was really handy because I got ideas from them to get my design under way.

Student 14 said that when he was "stuck" his mentor used his own drawings as exemplars, as well as sketches to scaffold him through difficulties. Of this approach Student 14 said:

> ... he didn't have any similar projects to this one but he showed me a lot of presentation drawings and some details that he had used. He was good like that because when I was stuck he would not try to block out

> my ideas and use his own he would just guide me through and give me little hints and sketches of things to allow me to work it out.

Student 16 said that Mentor 6 and Mentor 6a used a combination of several different materials as scaffolding to assist her in resolving problems that presented barriers to her progress in design. They also facilitated her access to other experts in the design office who provided specialist advice when needed. Of this approach Student 16 said:

> ...when I got stuck they were good at giving me just enough to get on with it. They had a big library of books and pamphlets and drawing sets that I could use for ideas and details or partial solutions; there was heaps of stuff to use. There was also a guy there who worked for them who helped me a lot with the computer work and he was more skilled than they were in using the computer. When I got stuck he helped me out by showing me how to use the computer to experiment with different design combinations using their CAD design components library.

Mentor 26 made use of her own past design commissions to demonstrate design strategies and solutions. She then coached Student 18 in ways to apply those methods to the problem situations that were preventing his progress with his design project. Commenting on this Student 18 said:

> ... she showed me some other designs where she had used the same technique and it had worked well there, it was a practical way of getting it together. She showed me several sets of drawings of other projects that she had done and I got ideas from those on how to set things out and detail them. That got me over the first big hurdle.

Analysis of Phase Three work sessions involving Mentor 1, Mentor 1a and Student 25 showed that they used a broad range of scaffolding materials including exemplar drawings, industry journals, codes and regulations, magazines, photographs and models. Resources such as these were used during 15% of the Phase Three work session times to introduce new concepts or ideas, new design/building materials, different presentation techniques and design elements such as construction forms in steel. During the early part of the design process, the mentors used general materials such as books and photographs to talk about image and form. As the design developed, they made greater use of more specific examples as seen in their own design works in progress to demonstrate and coach the student on the application of the elements provided.

Mentor 1 made extensive use of simple models to scaffold learning when dealing with the visualisation of concepts or three-dimensional design forms. This, he said, was part of their everyday culture of practice when dealing with clients who were not always able to read drawings as building forms. Student 25 adopted the mentor's use of scaled models by making a model of her own project (see Figure 27, p. 221) to communicate and develop her design ideas. Of her use of concept models, Student 25 said:

> The model just helped me to bridge the gap between what I could conceptualise and what I could sketch. We used it quite a lot during the work sessions to discuss the structure and the aesthetics of the building because it gave a real sense of the scale and proportions of the design.

Figure 26 shows a sketch used by Mentor 1 to introduce the idea of a model when discussing the layout proposed for the presentation of the design. The five rectangles at the top of Figure 26 represent the five drawings needed for the presentation and the idea for using a model is shown in the bottom-centre of the sketch. Student 25 picked up on the mentor's suggestion of using a model and implemented it in her final presentation as seen in Figure 27 (p. 221), which shows a photograph of the model that she built.

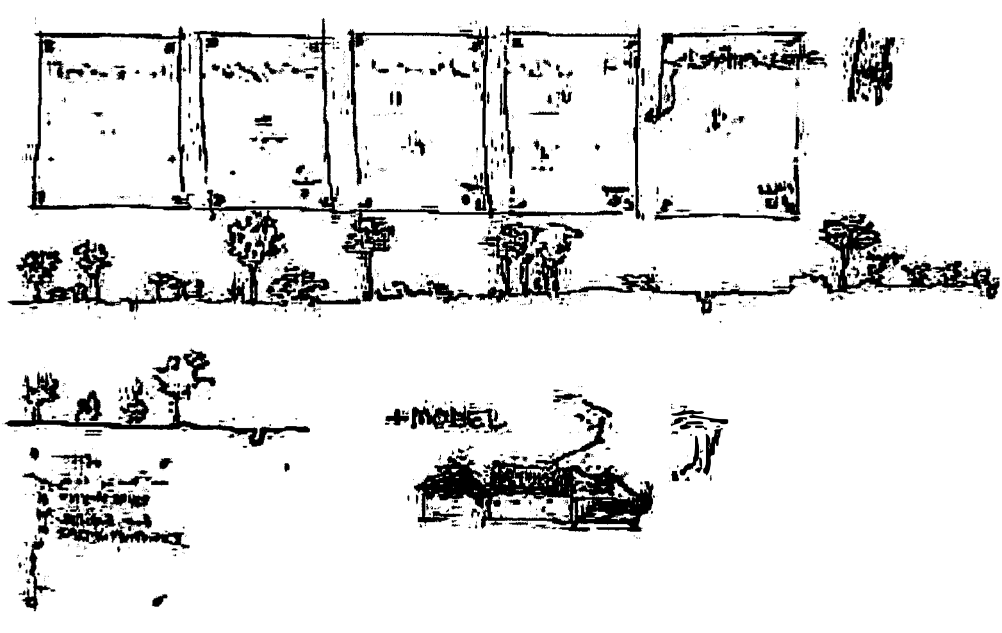


Figure 26. Sketch showing proposed presentation with model.

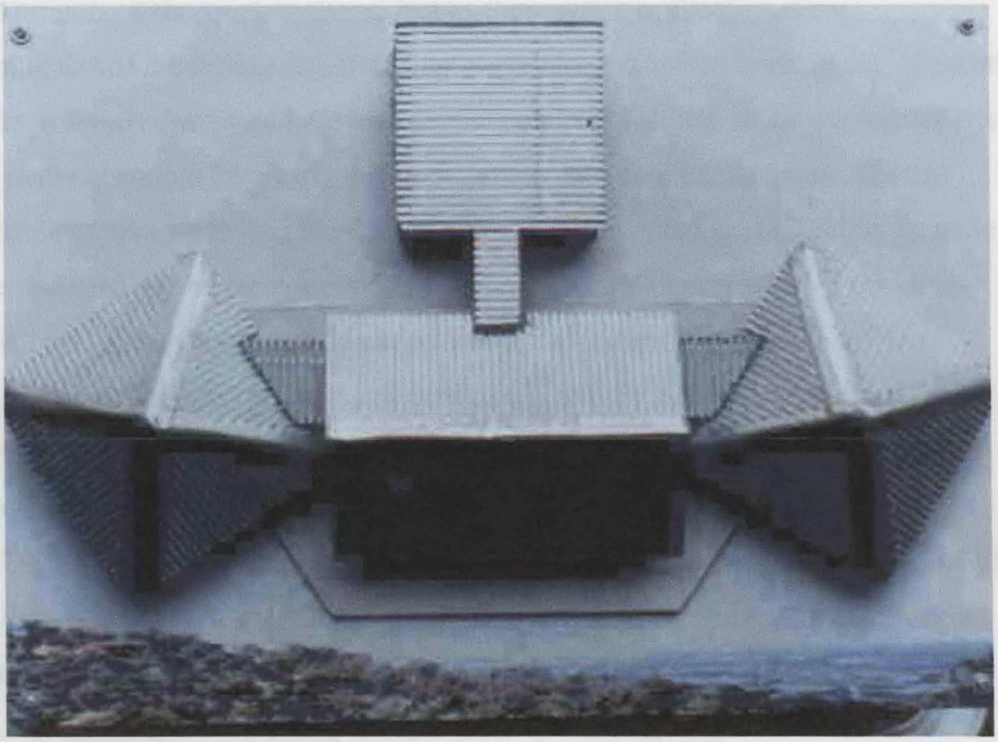


Figure 27. Design presentation model.

This model was used by Mentor 1 and Mentor 1a to scaffold learning for Student 25 when she was having difficultly in resolving the roof forms where the central horizontal section of the building meets the two square sections located at the sides. It was also used to assist Student 25 in her understanding of how building regulations about access to public areas was calculated.

Most of the building design offices had comprehensive sets of codes and regulations, as well as technical documents, both of which were necessary for students to ensure they met legal and regulatory soundness of their designs. Many of the students noted that access to these codes and regulations helped them to resolve problems that emerged during the development of their design project and assisted them to acquire declarative knowledge about building practices. This, they said, greatly enhanced their learning and assisted them in resolving aspects of their designs that they may have ignored or simply guessed at when doing a fictitious classroom based project. This aspect of using resources in this manner was seen by most of the students as the first time that they felt totally accountable for their design decisions. Some students commented that they had been mindful to adhere to regulatory requirements because their mentor had demonstrated the use of regulations in relation to their work and therefore they felt accountable to the mentor in their use of these materials.

Throughout the work sessions, just as there was a cyclical overlapping use of modelling and coaching, there also existed an overlapping of mentor use of the materials discussed here for coaching and scaffolding. At times, mentor use of these materials could be clearly defined as them coaching the students. At other times, the mentors used these materials in ways that I regarded as scaffolding because their use focussed on the provision of assistance to deal with acute design problems, rather than teaching everyday design practices or procedures.

Analysis of the study data suggested that when the students had access to extensive resources, they were more inclined to adopt a meticulous approach to their design by following through many detailed aspects of the work. Mentor use of scaffolding led to students acquiring declarative knowledge of design situations, which helped them to build their tacit knowledge of ways for implementing procedures they had acquired from mentor modelling of their methods and coaching in ways to apply them. Some students said that they did not use this thorough approach when undertaking a classroom based design project where resources were limited. The extensive use of codes and regulations was evident in the notes and sketches produced by most of the students in the drawings presented at the end of the design project.

Findings from analysis of these data led me to conclude that mentor use of a diverse range of resource materials to scaffold student learning helped students to acquire declarative knowledge of many aspects of design practice, as well as knowledge of procedures used by expert building designers to create and develop design solutions. The findings also suggested that timely use of scaffolding led to student development of skills to visualise design problems and ways for them to resolve emergent problems using metacognitive design methods.

3.4.3 Scaffolding using exemplar "office set" and CAD drawings.

The importance of "office set" drawings in design office learning was discussed in *Category 3.1.4* on page 166. This section deals with data coded about the use of "office set" drawings as a tool for scaffolding learning. Specific examples of how different mentors used the "office set" for the purpose of scaffolding student learning are discussed here, along with supporting Phase Two and Phase Three data.

Most of the mentors used sets of drawings from their own design commissions as exemplars to guide and scaffold student learning. The use of these drawing sets occurred during 16% of the Phase Three work session times. Most of mentors made use of CAD technology and geared their design practices around the use of pre-drawn design elements and re-use of entire CAD based drawings. Hand drawn sketches and CAD based drawing elements in "office set" commission documents were extensively used to scaffolding students as they reached various stages in their designs. This form of scaffolding was used by mentors to provide students with pre-drawn partial solutions for a variety of different design concepts and construction details, each showing clearly defined industry standards of documentation that students applied to their own work.

Findings suggested that students were guided by mentors to regard use of CAD based "office set" drawings as resources for developing their own design solutions and to overcome barriers to their progress. The use of "office set" drawings in the full range of design practice mostly took place as part of coaching by mentors, but was also used by them to address specific problems that formed barriers to the students' progress when dealing with the authentic design projects undertaken.

The use of these materials also formed part of a process through which students were required to defend and justify their design development. When discussing how he used exemplar drawings to scaffold Student 30 though difficult parts of her design, Mentor 6 said:

> We would get her going by showing her these simple ones (exemplar drawings) with just plans and elevations and say to her you can do that in your own project and she would apply the techniques herself.

Mentor 2 similarly supported Student 9 when he was having difficulty progressing with his design. When discussing how the drawings used by Mentor 2 had helped him through, Student 9 said:

> He gave me lots of examples of other drawings and other house plans that he had used in those two areas (geographic locations) and used them to explain how he had come up with designs in other similar areas.

Most of the mentors encouraged the students to utilise existing drawings for their developmental works, as these had already been proved by the mentors through authentic commission applications. As a scaffolding element, such drawings facilitated student melding of many different design ideas and provided opportunities for individual approaches to be developed out of existing materials. Authentic commission "office set" documents (drawings and other materials) were used by the mentors as exemplars to explain to students the problem solving strategies they had used to create the design solutions shown. The use of "office set" documents in this way assisted knowledge transfer because it provided a means for the mentors to reify their tacit knowledge and this helped students to acquire ways for resolving their own design solutions. Application by students of design methods acquired in this manner led to students developing their own "office set" documents that show the progress of the project from concept form to construction documentation. Students then used these drawings to reflect on design ideas they had explored and to refine elements deemed suitable for inclusion in their final design solution. Using this approach provided the students with a visual record of the entire design process and strategies used to resolve each element of the final solution.

When discussing his use of "office set" documents as scaffolding tools for student use Mentor 7 said:

> This place is full of examples they can pull out of the drawers and use them to develop their own ideas. That's how we do it in here in all of our commissions.

The use of "office set" drawings also provided students with industry accepted benchmarks against which they could evaluate their own work. This was seen my most of the mentors as a key part of student learning using authentic projects because the "office set" documents provided examples of design and drawings that defined standards of professional practice necessary for the students to achieve in their own works. Mentor I noted that he used exemplar drawings to set standards for student performance. When discussing how he did this with Student 20, Mentor I commented:

> We gave him sample drawings and said this is what we expect yours to look like when it is finished.

Mentor 1 said that he used "office set" drawings to assist students over barriers to their progress with all aspects of design office practice. This he said included student use of design drawings, detail drawings and presentation drawings from a variety of sources such as hand drawn sketches, CAD drawings and other materials produced by consultants outside of the office environment. All of these materials were based on industry standards and provided students with models upon which to base their own works. As scaffolding elements, they assisted students to overcome design problems that formed barriers to their progress, as well as setting standards of excellence that encourage higher levels of achievement in design thinking and drawing production. Making note of this aspect of their use, Mentor 3 said:

> We have these here (showed interviewer presentation drawings of different projects) which we use as a basis for much of our presentation. This is what the student sees. It gets them over the design hurdles and sets the standard that we expect of them.

When commenting on how she was helped through design problems by Mentor 2 who used "office set" drawings as the basis for much of his usual design practice, Student 29 said:

> I had a lot of ideas but just couldn't seem to get started with the design at first because I had never designed anything for a tropical climate before and wasn't sure how to begin. He pulled out three different sets of drawings of Jobs that his office had done up North and used them to show me how they dealt with the air flow through the buildings and the termites, as well as some ideas on cyclone protection without making the place look like "Fort Knox". Once I had those drawings to work from, he just let me loose and I got into it. He was really pleased because I came back with a couple of design layouts which we worked on together to make the final one.

In some of the design offices, whole CAD drawing libraries covering all aspects of design documentation were made available to the students. The students were encouraged to extract from these ideas or component parts for their own designs, just as professional building designers do. Mentor 7 encouraged Student 29 to make use of the office CAD resources to develop her design. The use of materials in this way sometimes blurred the edges between scaffolding and coaching. Commenting on how he had used such materials to scaffold learning for Student 29, Mentor 7 said:

> I gave Karen a lot of CAD files of entourage and presentation stuff that we use so she could just plug those into her presentation. I said to her, you will find this in almost any CAD based office like ours, it's a resource that the industry uses.

In another design office situation, Mentor 3 assisted Student 22 with the graphical presentation of his ideas for the development of the building site by providing the student with "office set" drawings as well as an electronic copy of a full library of CAD details. This allowed Student 22 to rapidly present ideas and explore new ones without having to spend time creating the geometry himself. By having such resources to facilitate drawing production, Student 22 was free to focus his design creativity on a conceptual level, rather than being tied to the restrictions that may have otherwise been presented in the documentation processes of drawing production.

Most of the mentors indicated that as a usual practice they used pre-drawn design elements and CAD based drawings including construction details and commonly used layouts for design elements such as bathroom or kitchen areas, to assist students in their development of design solutions. This approach I regarded as a key aspect of scaffolding that was extensively used by mentors to assist student learning. Most of the mentors used CAD design elements and "office set" drawings to scaffold student learning and to acquire declarative knowledge about:

- commonly used solutions for room layouts in kitchens, bathrooms, bedrooms and technical areas like medical or industrial settings;
- relationships between rooms for traffic flow in various settings;
- regulations and codes as applied to specific design situations;
- construction details such as footings, roof structures, truss and beam fixings and the like;
- colour and texture of surface finishes; and
- the selection of materials and different construction methods as determined by specific design problems or situations.

The following example of how "office set" drawings were used in various ways to scaffold student learning is based on my observation of Mentor 6 working with Student 24 during Phase Three work sessions. I have chosen this particular student/mentor situation because the methods used by them were representative of most of the design office situations studied.

From the outset of their collaboration, the principal tool used by Mentor 6 to scaffold Student 24 through many barriers that emerged during development of his design was the various "office sets" of drawings created with each new project. Using these as a basis for overcoming problems in his own work, Student 24 was able to follow the progress of the exemplar designs by reading through the mentor's notes and drawings that made up the "office set" record of design methods used and decisions taken to resolve the design solutions. Figure 28 (p. 227) shows some over-sketching elements (see the darker line parts) that were introduced by Mentor 6 as successful ways for resolving problem areas in the student's work, but based on parts the mentor's own "office set" drawings being referred to as exemplars during the work session. The particular elements discussed are room layouts and furniture and fittings items shown at the centre of the plan displayed. The manner in which Mentor 6 had used elements such as these in his own works to define spaces in the plan was taken up by Student 24 in his organisation of space in the design shown here. Although a seemingly small design element in itself, at the time it represented a conceptual barrier to Student 24 in his development of a design solution. By using his own works as an exemplar to scaffold learning for Student 24, Mentor 6 assisted Student 24 to overcome that barrier.

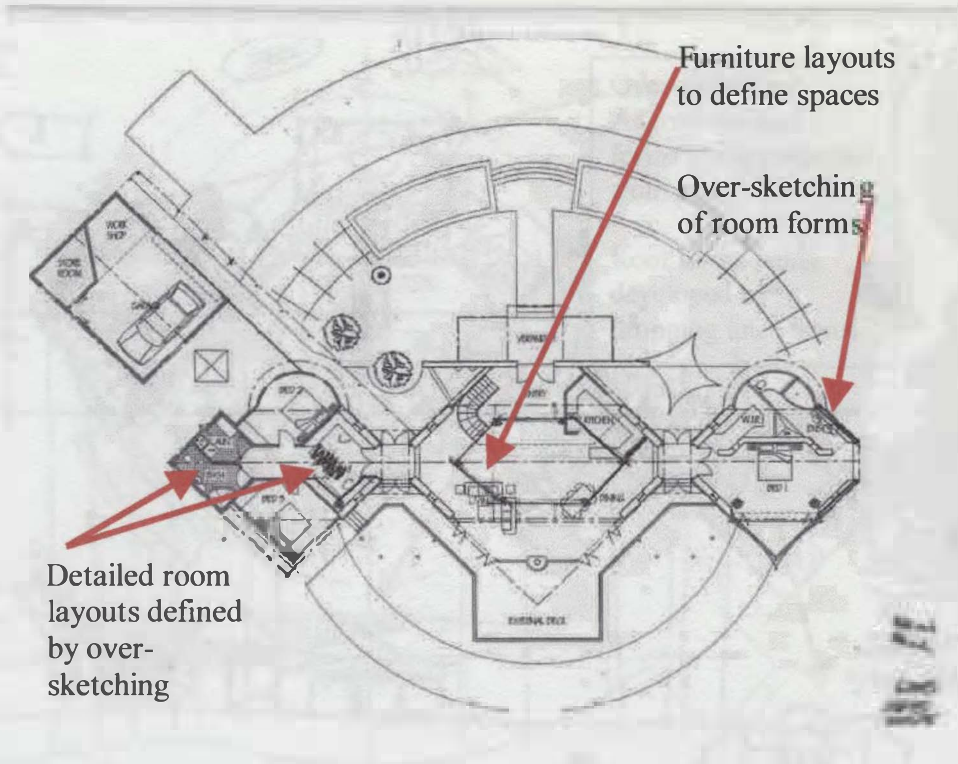


Figure 28. CAD drawing showing sketched development of fine details.

During Phase Three work sessions, I observed Student 24 create and use his own "office set" in much the same manner as modelled for him by Mentor 6. Student 24 adopted the working practices modelled by Mentor 6 and used by him as a tool to scaffold learning when coaching Student 24 through areas of difficulty. Using exemplar "office set" design drawings in this way provided Student 24 with the means to quickly explore multiple design ideas and possible solutions. This I regarded as evidence of development of metacognition. Evidence of the exploration of multiple design ideas in one drawing developed by Student 24 can be seen in Figure 29 (p. 228), which has as its base a CAD drawing, but has been heavily over-sketched by the student when exploring ideas for refining the plan and elevational treatments.

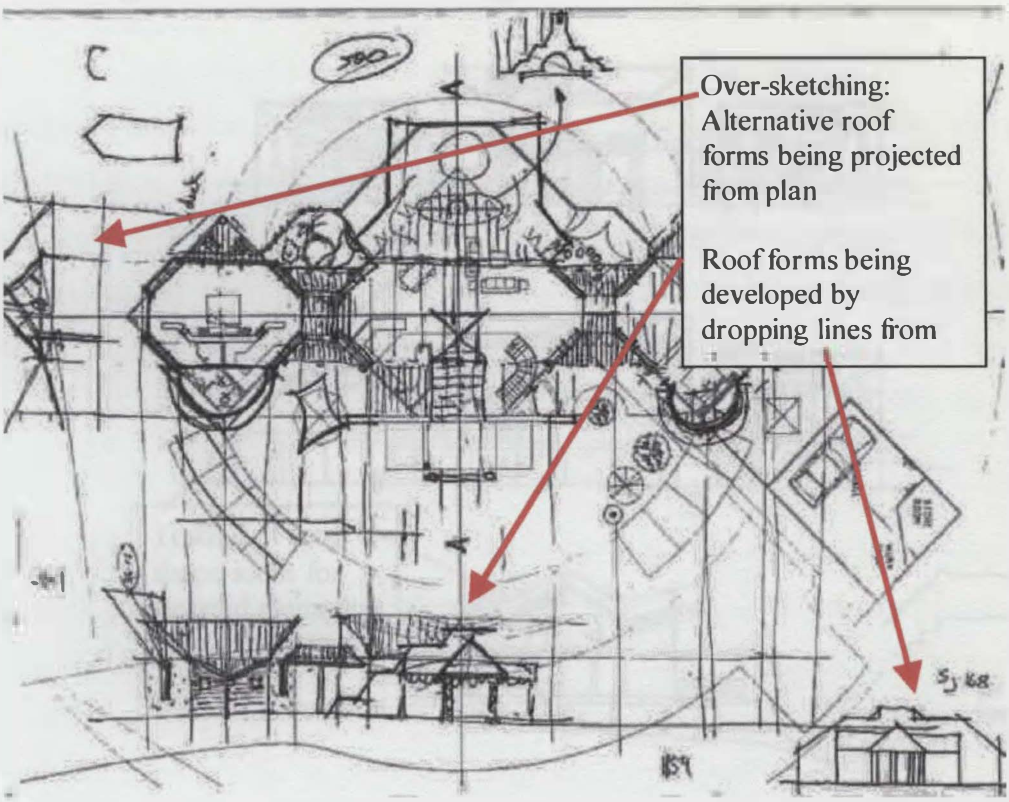


Figure 29. Over-sketched CAD drawing.

Drawings like this were compared by Student 24 to others in design office "office sets" which provided benchmarks against which he could evaluate emergent ideas and synthesise them with new ones developed for the real work design project. This is shown in Student 24's elevational treatment of his design which were developed from ideas first presented to him by Mentor 6 as part of one of his own design office commissions and demonstrates evidence of tacit knowledge transfer about design procedures acquired by Student 24 from Mentor 6. The over-sketching of the roof forms as seen in Figure 30 (p. 229) came about as a result of Mentor 6 and Student 24 working on the design together with reference to the exemplar drawings introduced by Mentor 6.

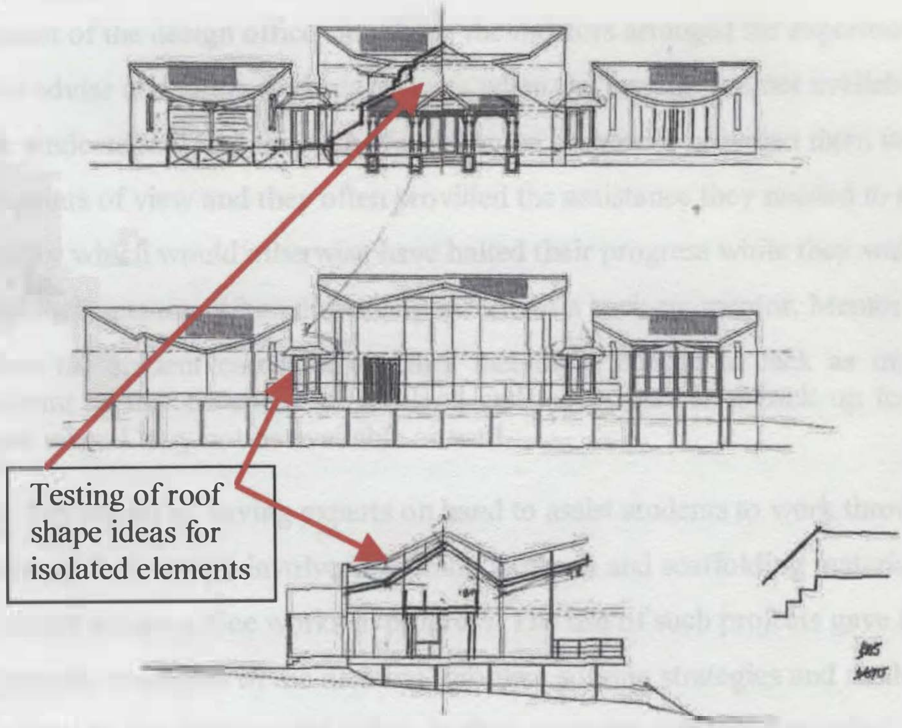


Figure 30. CAD drawing showing roof form development.

Further development of the ground plan seen in Figure 28 (p. 227) also contributed to the formal drawing of the elevations seen in Figure 30. Very little evidence of over-sketching can be seen in these drawings because during coaching, Mentor 6 made use of translucent overlay paper to trace out new ideas over the existing drawings, rather than work directly on the student's most recent work. When questioned on this point, following completion of the project, Mentor 6 commented that he did this deliberately to allow the student to feel some sense of closure coming to the design, but to still keep an open mind on late changes explored as disposable thoughts on paper.

This process was said by Mentor 6 to also allow Student 24 to feel ownership of the final design and that any changes to be made at that stage were for the student to initiate and decide. In so doing, Mentor 6 contended (post project interview) that at this stage of the design, "the student becomes the designer, no longer the apprentice" (Mentor 6) and thus takes responsibility for the design, working in autonomous ways at a higher level of decision making and project management. From these and other data about student transition from being dependent on scaffolding support, to working independently, I determined that most students had at this stage developed autonomous use of metacognitive design methods for exploring and refining design solutions.

3.4.4 Consultants and others with special skills.

In most of the design office situations, the mentors arranged for experienced personnel to advise and guide students at times when the mentor was not available. Most of the students said that this was of great value because it provided them with alternative points of view and they often provided the assistance they needed to resolve some difficulty which would otherwise have halted their progress while they waited for the return of their mentor. When discussing his use of a back-up mentor, Mentor 3 said:

> When the student came for the first meeting I bought in Jack as my assistant so that he could be involved and to be there as a back up for times when I may not be available as well.

One key aspect of having experts on hand to assist students to work through difficult parts of their design involved coaching methods and scaffolding materials linked to current design office works in progress. The use of such projects gave the students authentic examples of the mentors' problem solving strategies and methods of application used by the mentors and others in their everyday culture of practice activities. Student 16 said of this aspect of working with Mentor 6 and his staff:

> When I got stuck they were good at giving me just enough to get on with it. Some of the time when I was working there they got me to work on projects that they were doing in the business and that showed me a lot about how they worked through problems in design and how they ran the business.

Student experience with working on authentic commissions with the mentor and others in the design office assisted them to acquire tacit knowledge of design procedures and declarative knowledge required for their application. This was an important part of student learning in the design office situations of this study.

Most of the students commented that their mentor used examples of their current works to assist them in resolving the design problems of the study project. This they said taught them a great deal because the examples were real and represented actual solutions to authentic problems that the mentor had resolved. Some students said they felt confident when incorporating elements of the mentors' work into their own designs because they valued the mentor's expertise. On this point Student 8 commented:

> He sprung an idea because he said look I am currently working on this and we looked at how we could adapt what he was working on to what we were doing together on the project.

Analysis of Phase Three data showed that during 32% of the work session times Mentor 3 and his assistant mentor used scaffolding materials consisting mostly of sketches, drawings and contract documents that had been produced in the design office as part of real work commissions. By using these materials throughout the work sessions, Mentor 3 was able to scaffold Student 22 over difficulties he had encountered with his own design by applying work practices, design solutions and methods for addressing emergent problems to the student's project. When Mentor 3 was not available, his assistant was able to use the same materials to scaffold student learning, adding his own interpretation of situations and heuristic design strategies in so doing. An important aspect of using design office commission drawings for scaffolding was that when a "back up mentor" or other person in the setting used the same resource materials as the mentor when assisting the students. This often provided the students with another interpretation of the design methods or solutions shown and thereby introduced alternative perspectives, to assist problem solving.

Both Mentor 3 and his assistant also provided scaffolding by using exemplar materials and quick sketches of design ideas or possible solutions. They also included notes on their sketches about design strategies used and the reasons for decisions taken, for later reference by the student when further exploring the ideas thus introduced. For example, during one work session, I observed Mentor 3 and Student 22 create the sketch and notes shown here in Figure 31 (p. 232). Mentor 3 said that this was typical of his work practices and that he used this approach with students to ensure that they documented design decisions and the reasons for using design elements so that they could refer to these later when defending their proposed solutions.

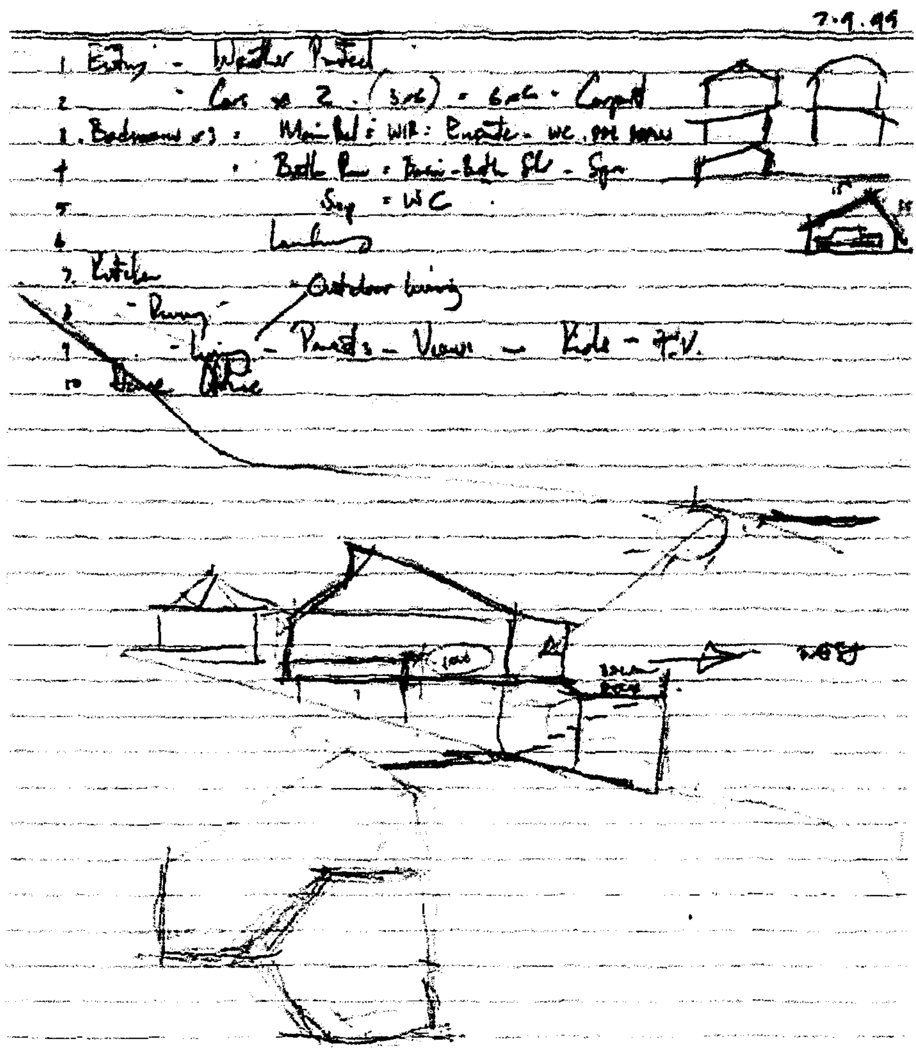


Figure 31. Sketch and notes format as used in exemplar office drawings

Analysis of Phase Two data showed that the timely provision (see quote below from Student 9) of specialist knowledge or problem solving tips by the mentors and others was said by many students to be a key part of overcoming barriers to their learning. For example, Student 9 said that much of what Mentor 15 did to help him through difficult aspects of the work centred on discussion and sketching. Associates of the mentor provided other help. He also said that when he became "bogged down" with a complex roof form, a building consultant who worked with his mentor provided detailed explanations with quick sketches that helped him to visualise and understand the interrelationship of components needed to resolve the roof design. Commenting on this, Student 9 said:

> After I managed to get the plan reasonably right, I started on the sections and elevations. I couldn't work out the roof plan and so he (building consultant in office) showed me how to extend the roof out this way so that it came out a bit and sorted it out.

Analysis of Phase Two data also showed that the students, who worked in design office situations where they had contact with other designers or consultants from associated disciplines working in association with their mentor, were assisted in their learning by the advice and assistance provided by them. For example, Student 13 made the following comment when discussing how an associate of his mentor had helped him to take a different view of design when she was not progressing:

> He had a lot of different ideas and different ways of putting it across. That was the great thing about it, he had such a lot of experience he is able to say look I've tried it this way or that way and he gave me examples of where it worked or failed.

Student learning was enhanced by the students having access to the experience of multiple experts who provided opinions, heuristic design strategies and working practices, together with their tacit knowledge of typical design procedures shown by them to be successful when applied to authentic projects.

The mentors and others used the following scaffolding methods to assist student learning:

- freehand sketching backed up with detailed explanations of the reasons for using the design/construction strategies or details presented;
- exemplar "office set" drawings illustrating heuristic design strategies, problem solving procedures and benchmarking standards;
- over-sketching of hand drawn and CAD based drawings to show multiple alternative design strategies or solutions;
- timely presentation of "tips and tricks" based on authentic commissions and tacit knowledge;
- use of a diverse range of non-context specific materials such as magazines, journals, pictures and the like, as well as discipline specific codes and regulations;
- notes on sketches and drawings for focussing student use of design procedures and to convey declarative knowledge of design situations, regulations or usual office practices;
- use of notes and schedules for sequencing of learning events in design and to link these to incremental tasks that progressively build on student knowledge and design skills; and
- providing a CAD data base of pre-drawn elements to address individual problem aspects of design and facilitate rapid exploration of multiple design ideas.

Theme 4: Design office experience and learning

In this section findings are reported from analysis of data coded using the following categories:

4.1 *Developing a creative, innovative approach to design;*

4.2 *Reifying knowledge in design office learning;* and

4.3 Exploration, Reflection and Visualisation in the development of design style.

Findings that emerged from analysis of data using each of these categories are now discussed along with supporting data.

Category 4.1 Developing a creative, innovative approach to design

Analysis of Phase Two data showed that most of the students considered that working with a mentor inspired them to achieve excellence in their design work and most also said that they had learned a great deal from the experience. For example, the following comments made by Student 8 are regarded by me to be typical of many others in data coded in this category.

> Working with him I felt really charged up. It made me aware of how important it was to get stuff done on time and it made me then put in a big effort to get everything else done that I had been letting go for some time. I feel more confident and positive about what I am doing. Before that I would do my designs and I'd think I would wonder if this will work and I'd think no that's just a shit idea, but now he has broadened my horizons a bit and now I think hang on maybe that might work and I'll try it out.

In these comments, Student 8 has mentioned several points said by most of the mentors to be key goals they sought to achieve when working with students. These are:

- development of a confident positive attitude;
- feeling inspired about design work;
- planning design stages by using time schedules; and
- being innovative and adventurous when exploring alternative design ideas.

Most of the mentors said that they sought to inspire students to develop an imaginative, creative and innovative approach to design. Findings from analysis of study data showed that they used various methods to achieve this including discussion, showing pictures and drawings of other works, going to the site of works in progress and hand sketching of ideas with the students during work sessions. Mentor 4 explained that he sought to generate enthusiasm with the students as a means of taking them on a "journey of discovery" in which he stimulated their imagination using a diverse range of verbal and visual images, including those displayed in his own work environment. Mentor 4 said of this approach:

> My approach is to generate enthusiasm. This enthusiasm can be interpreted in a couple of ways, one: it can be on the project which they have; two, Is about the future they have in the industry itself, their career. Essentially what they do when they come into my office is they are

> impressed by the environment, the environment suys eveiything, this is the lead or key point. Once you have established the environment the expectation, the excitement, the enthusiasm starts to flow from there, it sets the goal or focus or leadership aspect.

The video recordings of work sessions in which Mentor 4 worked with Student 23 were studied to determine how Mentor 4 applied the approach that he described above. In those work sessions, the mentor began by talking about different design commissions that he had undertaken and showed Student 23 examples of these by using photographs and drawings that were displayed on the office walls. With each project discussed, he described what it was that inspired him in the design and what he hoped to portray in its aesthetic treatment and spatial construction. Throughout this process, he placed great emphasis on inspiring new thought by using descriptive language with sketching to encourage Student 23 to visualise ideas and design concepts. At the same time, he encouraged Student 23 to sketch out ideas for his own design project. When the student had "mn out of ideas", Mentor 4 used photographs and images in travel brochures and the like to introduce new concepts, or to create an imaginary situation from which innovative design ideas might be created by the student. Activities of this kind took place during 44% of the work session times. Commenting on this approach, Student 14 said:

> I try to be creative and innovative in my design work so it was good to have a mentor who did the same and was prepared to look at things that were a bit out of the ordinary even if they were a bit radical. He came up with ideas from almost anything. He used pictures of all sorts of situations to make up stories about peoples' lifestyles, like the shots of those houses that the opal miners live in. From those I got some radical ideas going like building it partly underground.

The manner in which Mentor 4 used images in resource materials he introduced to inspire creative ideas was to start out by sketching geometric shapes in loose form sketches. These, he said, provided a vehicle for him to explore with Student 23, alternative ideas before settling on a design theme to follow. During my observation of the work sessions involving Mentor 4 and Student 23, I saw them develop the rough concept sketch, shown here as Figure 32 (p. 236) and Figure 33 (p. 236), to a final presentation design. Much of what took place in those work sessions consisted of quick sketching over CAD drawn outline plans, supported with very descriptive explanations of how the details of the design might be developed and the reasons for executing them in particular ways. Throughout this process, Mentor 4 sought to inspire Student 23 to explore and develop his own solutions, rather than have him provide them. He did this by encouraging Student 23 to articulate each stage of design development from visualised concepts of raw ideas down to structural systems and finishing details, often with very little of this being put to paper. For example, the bold triangular forms explored by Student 23 in a work session with Mentor 4 dominate the concept design sketch shown here in Figure 32 and again in Figure 33. These forms can still be seen in the final presentation drawing (see Figure 34, p. 237) that Student 23 developed from ideas inspired during the work session with his mentor.

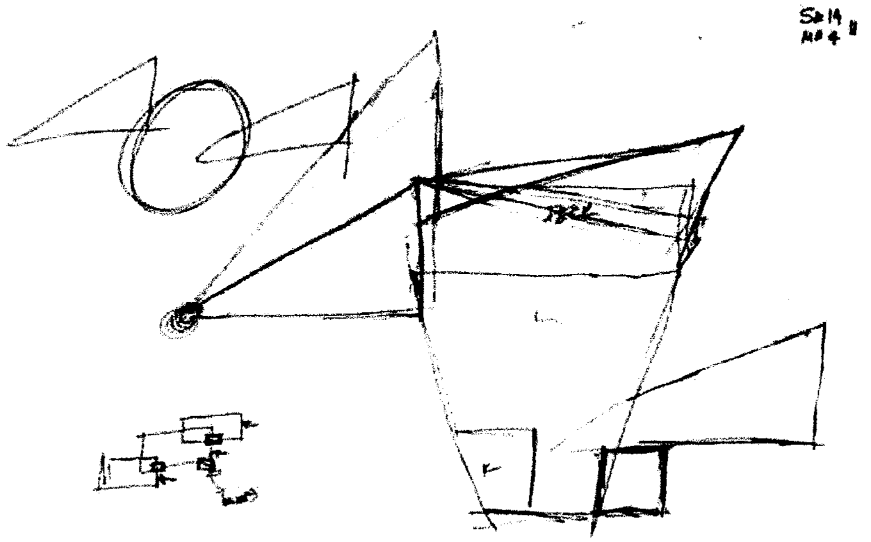


Figure 32. Design concept sketch.

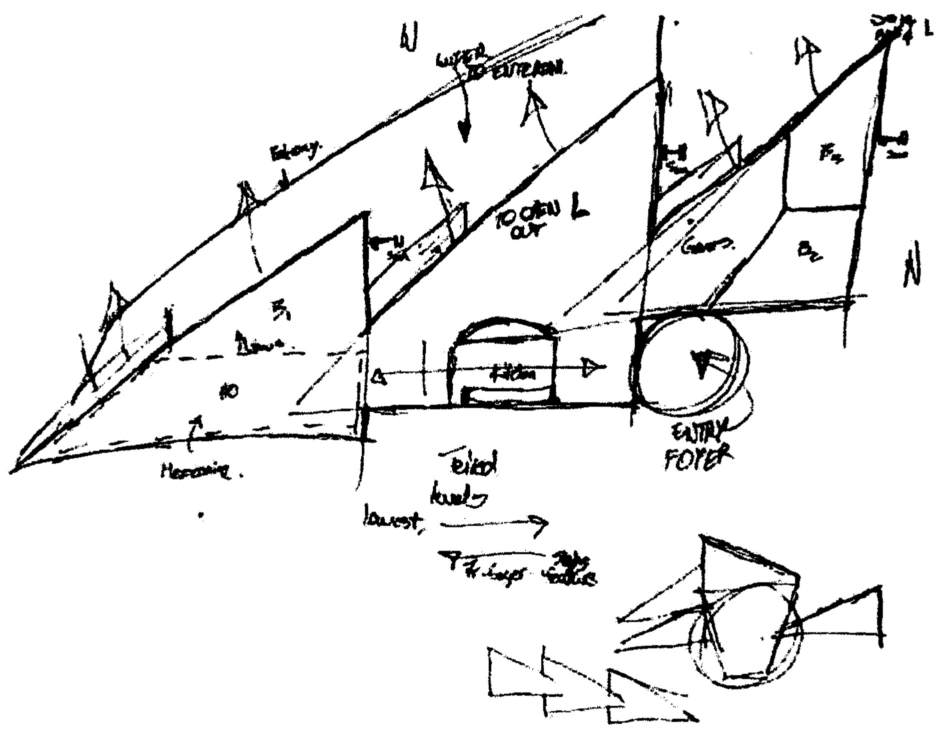


Figure 33. Concept sketch for triangulated plan forms.

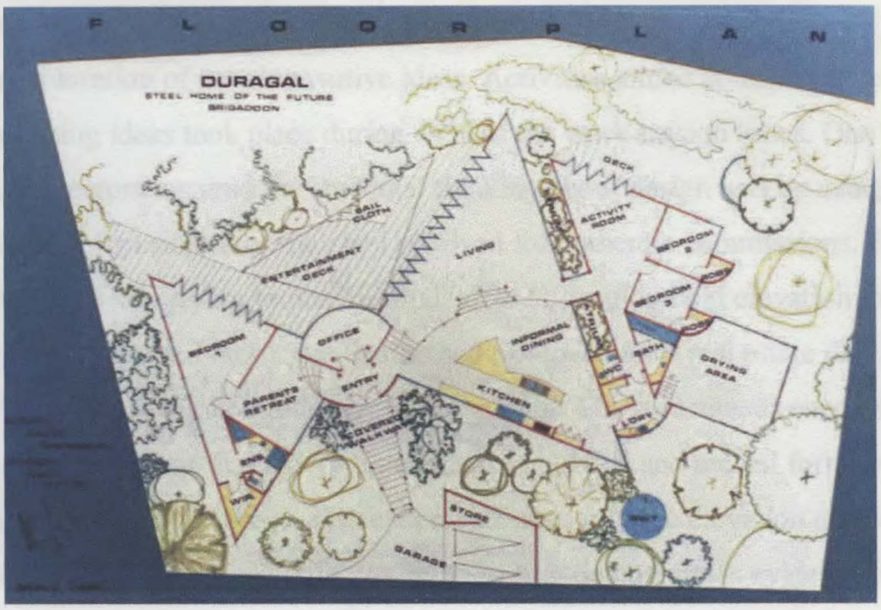


Figure 34. Presentation drawing showing triangulated forms.

The design development seen in the Figures 32, 33, 34 demonstrate how Student 23 applied his conceptual learning using knowledge and design skills acquired as a result of working with Mentor 4. A feature of the design methods used by Mentor 4 and applied by Student 23 in his design project was exploration of multiple potential design ideas using "brainstorming" discussions in work sessions. Most of the mentors said that they used questioning to stimulate discussion and to encourage the students to openly express their ideas irrespective of how radical they might be, or whether or not they were suitable for the design task at hand. Similarly, most of the mentors also encouraged the students to respond quickly to their inspirations by sketching out ideas in rough form without trying to resolve them immediately. This they said paved the way for exploring multiple solutions rapidly and branching off new ideas for further development. Of this approach Mentor 7 said:

> I tried to explain to him that it is most important to quickly get down your ideas in a basic design sketch without worrying too much about the details; just sketch it in roughly at first then take time later to refine it.

During Phase Three, I observed 5 mentors using ideas presented by students in this manner, and encouraging the students to defend their ideas by articulating their views and sketching possible solutions. The mentors also encouraged the students to explore other aspects of those design ideas by branching off to new lines of inquiry as each idea was exhausted. Throughout these work sessions the mentors maintained the student's enthusiasm by providing immediate feedback on ideas they presented and by backing this up with heuristic design strategies or problem solving solutions to resolve emergent design problems. Some mentors said that this approach led to student exploration of new innovative ideas. Activities aimed at inspiring new thought and visualising ideas took place during 44% of the work session times. One way in which the mentors inspired the students' thinking about design was by using anecdotes of design problem situations they had resolved for authentic commissions. For example, when Mentor 6 was trying to inspire Student 24 to develop bold elevation forms for his design project, he used brochures that he had produced for a real estate developer to raise finance for a church building re-development. The student was encouraged to sketch elevation forms that incorporated the triangulated and arched forms of the church portico shown in the brochure. These elements appear in the elevation developed later by Student 24, as shown below in Figure 35, which demonstrates evidence of learning in his final design submission. In this way, ideas introduced by the mentor using brochures to stimulate exploration of new ideas, led to Student 24 creating his own design solution, but inspired by design elements acquired from the mentor.

Figure 35. Elevation developed by Student 24 from Mentor inspired concept.

Most mentors provided students with ways for resolving design forms by sketching solutions they had developed for their own works, while articulating the reasons behind design decisions made and design strategies employed. Mentor 4 said that he sought to balance the technical side of design against the creative/artistic side, by maintaining the flow of ideas to inspire a global vision of the design tasks. Of this approach Mentor 4 said:

> I tell them (the students) that we don't need to give them too much to begin with because we can get bogged down and confused. I tell them we need to always be able to see the light at the end of the tunnel and I talk to them about how they need to have that vision in what they are doing and they relate to that.

Analysis of Phase Three data showed that when students presented impractical ideas, some of the mentors used these to stimulate student creativity by helping them to refine useful elements into viable solutions. When discussing how he worked with Student 16 in this manner Mentor 5 said:

> She (the student) had a few good ideas which worked well but it (her design) kept coming back to standard stuff, nothing that you would look at and go wow. What we were trying to bring out in her was to do something really different. We tried to get her to be more creative and we pushed that and small elements came out but I think that if we hadn't pushed it she would not have come out with it at all.

Mentor 15 also used deliberate strategies to encourage a creative approach to design for Student 9. In their collaboration, ideas presented by Student 9 were developed and explored using a variety of materials. Of his experience, Student 9 said:

> I just had an idea on paper and then we used books and drawings to come out with other ideas and then sort of created more ideas off those and from there we came up something that looked interesting.

Most of the mentors said that they sought to encourage students to think problems through for themselves. To achieve this, the mentors worked to find a balance between doing the work for the students and having them develop their own creative design skills with the use of appropriate scaffolding. Findings from the data indicated that the mentors were not concerned with the student designs being perfect solutions, but were looking instead to have the students develop procedures that allowed them to refine and resolve the designs methodically, as well as developing long term skills. When discussing this aspect of his working practices, Mentor 1 commented:

> We want them to be able to think. We don't want to have to hand feed them. The big problem is getting someone in here who keeps saying what do I do now? We want someone who goes away and thinks well maybe if I do this. We don't care if they make mistakes, but at least it shows that they are thinking about the problems.

Analysis of work sessions involving Mentor 1, 1a and Student 25 showed that the mentors introduced design activities intended to inspire new thought during 44% of the work session times. These activities led to other activities regarded by me to involve student visualisation of ideas, which they then explored and defended during 61% of the work session times. Mentor 1 used this approach in six work sessions that he and Mentor 1a shared with Student 25. Findings from Phase Three data showed this approach to be commonly used by all of the Phase Three mentors when seeking to inspire the students under their direction to think through, present and justify ideas. When commenting on how Mentor 3 guided him through the design process, Student 13 said:

> He was great because he let me put up all sorts of ideas and we worked through them. He made me discuss and justify everything that I suggested, just as he did the same by always saying why he did things the way he did. We worked through the design together by resolving one little bit at a time, then strung it all together to get a final result. For each new part that be brought into the design process, he made me explain my reasons for dealing with it in the way that I did. When I couldn't give him good reasons, he would go through his way of doing it and tell me why each part was done as it was. That really helped because he explained as he went.

I concluded that mentor use of structured design tasks assisted students to acquire creative ways for visualising and defending design ideas. Throughout this study, most of the mentors commented that forcing the design process, or pushing too hard for results stifled creativity, enthusiasm and vision which prevented students making the transition from simply drawing to designing. Mentor 3 said that he took a guiding approach to avoid having students feel too pressured to perform and thereby loose their creativity. Commenting on this, Mentor 3 said:

> In the beginning the students don't know much in the way of design but they get aspects of it which we can influence by showing them how we would like to go about it. We try to give them ideas by using little design tasks that make them come up with quick simple solutions which we can then use to discuss different ways of resolving the problems commonly found in those situations.

Most of the mentors said that they sought to encourage student creativity by inspiring students to explore new directions in their work and to develop solutions to a variety of problem situations. One way in which some mentors encouraged student creativity was to provide positive feedback and support for the exploration and development of alternative solutions when students present their work for criticism. Mentor 3 made the following comments in relation to his use of this approach when working with Student 13:

> He worked his own design up, I just indicated to him areas that could be done better and offered two or three solutions that might be applied, you can't just say that's no bloody good or you've lost them and crushed their spirit. That's the nature of how I try to run the business it's all about learning new information, for all of us we never stop learning and the design process is a learning experience and the nature of our business is ever changing. So there is no point in making someone upset or humiliating them, what you have to do is give them the positive side by saying it's OK, now let's try to do that better or differently.

When discussing his approach to progressively building on a design development with Student 20, Mentor I commented:

> Once the basic design is in place, then we go through it again and suggest changes or extra stuff that need to be included. We leave them as much as possible to their own devices and when you do that they soon develop design flair.

This approach, according to Mentor 1 had to be done in a manner that did not push the student to a point where they were overcome by the magnitude of the task, or felt that they were too far out of their depth. Some mentors commented that being too critical of the student's work at this stage might result in a loss of confidence for the students and reduce their ability to complete the task. On this point Mentor 1 said:

> Sometimes, like with David they try too hard and that's not how design works, you just can't force it, when that happens we just throw it away and start again.

Student 8 experienced this approach first hand when working with Mentor 28. He said:

> In the first few meetings I came in with a lot of stuff just sketched out but I had a lot of wacky ideas. They got canned pretty quick. He said that some of the ideas wouldn't work, so we put them aside and then used other parts to build up the design.

When students presented ideas that are were too radical, the mentors did not discard them outright, but tried instead to modify and incorporate them into the design. Student 18 found that Mentor 26 worked through his ideas by first discussing which aspects of them were likely to be appropriate to the design, then explored variations of those ideas with him to find creative solutions. Of this approach, Student 18 said:

> I came up with quite a few ideas that she was able to look at and say this will work and that won't. She was able to tell me why, so that helped me to understand why some of my ideas were not going to be practical in the situation. We picked out all the parts that fitted together well and built up a good design from them.

Commenting on how Mentor 26 used this approach when working with him, Student 18 said:

> In the kitchen I had the fridge and the pantry in one corner and she *(Mentor 26)* suggested swapping them around and cutting off the corner to make access to the room easier and putting it all at 45 degrees to open it out. She did a lot of stuff like that while we were sketching out ideas just to test other ways of doing things. In the end the design was mostly my ideas, but with some of hers in there as well.

Here, Student 18 has highlighted how his mentor was able to reify her tacit knowledge and how he then used knowledge and skills he had thus acquired to synthesise the mentor's ideas with his own to develop a design solution. This suggested that the methods used be Mentor 26 had facilitated learning for Student 18.

During three Phase Two work sessions involving Student 18 and Mentor 26, I observed numerous situations similar to the one described above as the participants worked towards a design solution. Mentor 26 made extensive use of examples from her own design commissions to provide multiple design elements for Student 18 to consider for inclusion in his design. In this way, she reified her tacit knowledge of many different design situations as well as the solutions that she had developed for them. She then encouraged Student 18 to apply the methods she had modelled as her approach to design to develop his own multiple design variations for each new design element explored. Mentor 26 also encouraged Student 18 to explain his reasons for using particular design methods and for including elements in the final design solution. This approach emerged as being commonly used by mentors to encourage students to develop their own ideas even if it meant that they were not what the mentor might choose to use as a solution. Mentor 3 encouraged Student 13 to explore multiple solutions, so as to create choices and introduce alternative ideas. Of the solutions presented by Student 13, Mentor 3 said:

> It might not be what I would do but I thought it was really good and I commended him for that. It's not important that they get it perfect first time. What is important is that they have a go at doing it for themselves and explore all possible variations on a design solution to evaluate their ideas before accepting a final solution.

Some students said that they came to the project thinking that the mentors would simply come up with a design in a flash, but found instead that the mentors used multi-staged replicable procedures in a structured, methodical approach to develop design ideas. When discussing his approach to working on designs with Student 16, Mentor 6 commented:

> There were no great thunderbolts, it was mainly little clicks and penny drops along the way you know, a process of building up one idea on top of another.

In contrast to this approach, some students expressed the view that learning in TAFE had stifled their creativity because it supported only a single approach to design. Student 8 made the following observation about his TAFE experiences:

> As students we are taught in a way that very much knocked out our imagination. Maybe they (TAFE) don't put an emphasis on giving you a way of sticking it in a certain category, or how to design a house to guide you on what is wrong and what is right.

Findings from analysis of data in this category led me to contend that mentor modelling of multi-staged replicable procedures to resolve difficult design tasks assisted student learning by bringing structure to the creative process and this facilitated student exploration of multiple design concepts and creative thinking. Working with a mentor in this way gave students the confidence to attempt radical and innovative works through a process of exploration and discovery based on quick sketching and discussion methods of evaluation.

Learning these different approaches from the mentors gave the students a broad view of design. On this point Student 8 said:

> It was good learning his approach to design and it was also good that he let me change it to my ideas. In the end I found that I was thinking through my design ideas just like he showed me he did with his. That really helped me because I felt like I was working like a real designer and I knew that if I came unstuck he was there to help me sort it out without making me feel like shit.

For many students, just seeing mentors develop ideas inspired them to do the same. For some students, it encouraged them to be innovative and be prepared to "have a go" at the design without fear of failure or ridicule. Most students said that the experience of working with a mentor had greatly enhanced their confidence in their own ability to design and document a real work design project and to work with an authentic brief in a design office. Student 9 said:

> I now feel more confident and positive about what I am doing. Before that, (working with the mentor) I would do my designs and I'd think I wonder if this will work and I'd think no that's just a shit idea. But now he has broadened my horizons a bit and now I think, hang-on maybe that might work and I'll try it out.

The mentors encouraged the development of a creative and innovative approach to design in the students by:

- use of a diverse range of resource materials and rich descriptive language to create verbal images, supported by visual images using sketching or other illustrations;
- use of questioning, discussion and sketching to coach students in techniques supporting the exploration of ideas and branching of lines of inquiry;
- encouraging and supporting student exploration, defence and development of ideas;
- exploring multiple design solutions generated from the stem of each new idea revealed during the development of student design concepts;
- not forcing the design process, or pushing too hard for results;
- use of multi-staged replicable procedures to resolve difficult design tasks and to facilitate innovative exploration of multiple design concepts; and
- supporting students in their development of autonomous ways of using design knowledge and procedures when visualising concept forms and possible solutions.

Category 4.2 Reifying knowledge in design office learning

A common theme to emerge from analysis of the study data was that most of the mentors said that they worked at some stages in an almost intuitive manner when making design decisions and would often call upon specialist consultants where issues of safety or structural integrity are in question. Working in this manner, the mentors drew upon tacit knowledge they have acquired over years of professional practice in the building design discipline. To make such knowledge and design practices visible when mentoring students was said by some mentors to require of them different ways of working. This they said was because they had to consciously think about how they drew upon their knowledge and heuristic design strategies. These they said were largely invisible in their everyday practices, something that I regarded as illustrating their metacognitive ways of dealing with design problems. Commenting on this aspect of working with students, Mentor 10 said:

> After working as a building designer for so long, I don't have to think about how to go about resolving difficult or new design problems, I just rely on my accumulated knowledge of other similar jobs and apply the same procedures that have worked well for me many times. When you come to have a student sitting there in front of you and you want to say to him we'll handle this like the Massey job or the Blakensee job, but that means nothing to them. You have to get back to thinking how do I do this and break it down for them with explanations and sketches that spell out the reasons why it's done that way. Don't give them a solution, but give them a method and a way of thinking so they can nut it out for themselves.

To understand how the mentors reified their knowledge and working practices, I compared Phase Two data about what was said to have occurred in the student/mentor collaborative work sessions with findings from analysis of Phase Three data, which was based on actual observation of actual work sessions.

Each of the five mentors observed during Phase Three had slightly different approaches to design practice, but they shared similarities in their manner of working with students. Generally, they all began by establishing design criteria from analysis of the brief and questioning the students about their interpretation of these. Following this, the mentors all modelled their own design methods with the aid of exemplar "office set" drawings, while sketching and articulating detailed explanations of their use of particular work practices or design strategies. Student application of the mentors' work practices to their own design problems was supported by mentor coaching in the correct use of common design procedures, along with appropriate scaffolding such as "tips and tricks" based on their tacit knowledge of similar situations to those being addressed by students. In this way, students acquired skills to visualise and explore multiple design solutions in order to evaluate and defend them for inclusion in final design solutions. Commenting on his approach to encouraging student use of common design strategies, Mentor I said:

> We work with the students mostly by showing them the way at first then let them have a go at it themselves and have time to think it over before we get back to working through their ideas with them. We said to him go away and think about it, then come back when you have the design under way.

Mentor 7 used a similar approach when working with the students. He summed up his approach as follows:

> We'll start out with a concept based on the brief. We break the brief down so that they understand each part and have a handle on it otherwise you can't do anything. Once I am comfortable that they are at that point, then we start. We get some ideas down. I just bounce some ideas off them and get them to think about what might be possible, you know, be creative, let it flow.
> I get them to sketch their ideas and explain to me why they think it works. Then we analyse it together and I give them reasons why I think it's going to work or not based on jobs that I have done. I pull out drawing sets to show them similar situations and solutions that have worked in the past.
> Most of the time the ideas are there but they (the students) are too shy to say this is what I think. Some of them will jump in and talk about their ideas, but others are not confident to speak out. You have to get them to the point where they are confident enough to speak out and to back up their solutions with reasons why they think it is good or will work. They must justify it, because they might think this really is the solution, but I might say I would have done it differently why do you think your solution's right and then I get them to justify it. If they can't justify their ideas then they come to understand that perhaps it's not the best solution and then I'll do the same, I'll justify my solution and say it's appropriate for these reasons, but if theirs is just as good I'll go with theirs.

Findings from data coded in this category suggested that most of the mentors used methods similar to those outlined above by Mentor 7. The manner in which the mentors reified their tacit knowledge and heuristic design strategies was in part determined by the problems that emerged from the design tasks and the procedures that the mentors used to resolve them. Common to all of the mentors though was the use of sketching, supported by articulation of the reasons behind the methods used or underlying facts and procedures. Such methods were said by the mentors to be typical of their usual working methods with employees, other designers and consultants from associated disciplines. Mentor 1a said that he sought to guide students through the design process by giving detailed explanations of the reasons for doing things in a particular ways, early in the design process, then reducing his use of these explanations as the students develop further skills. Of his approach, Mentor 1a said:

> You tell them things like it's to let more light in there or the beam will not span that far, you tend to explain the reasons for doing things in a particular way as much as you can at first. When they start showing more of an understanding, you back off the explanations a bit and let them do the explaining so that you can see if they really know the how and why of it all. Once you see where they are at, you can then start filling in the gaps with information or techniques for solving problems that come out of each new part of a design as it is developed.

Mentor 3 reified his knowledge of design and construction by using examples of his own works to explain ways for identifying problem areas in a design and procedures used to resolve them. To do this, he sketched and explained in detail the reasons behind the design practices used to develop each of the exemplar designs represented by a diverse range of building types and situations. Of this approach Mentor 3 said:

> We do all sorts of work that is influenced by all sorts of people and situations and you can't train for all of that, you have to develop ways of solving each new task based on what you have learned from other jobs.

Some of the students said that the most useful learning situations for them took place on building sites. This occurred when their mentors took them to projects under construction, then pointed out and explained the positive and negative aspects of the design as built. Student 18, when working with Mentor 26, visited a number of building sites where the mentor had design commissions under construction. Of this experience Student 18 said:

> The first day that I was there working with her she had some appointments on site so I went along with her to some of the jobs that she had designed. She explained to me a lot of things about the way she designs and showed me them in those houses. Some of things that we looked at and talked about in her work I have put into my designs. Things like putting the walk-in robes away from the outside walls to free up window space and putting the bathrooms in place where there are odd shapes that would make furnishing a room difficult. I learnt heaps from seeing her projects as they were being built and having her talk about why she designed the way that she did. She asked me questions all the time wanting me to explain why I thought things should be done in a particular way.

In work sessions involving Mentor 3 and Student 22, the mentor used 74% of the work session time in activities reifying his design methods by sketching and verbalising the reasons for using particular practices. For example, he used detailed explanations and sketching to show design practices he had used to resolve problems in authentic commissions that were similar to those faced by the student in his design. For each design situation or method the mentor presented, he also articulated his reasons for the methods used and design decisions taken. When interviewed prior to the work sessions, Mentor 3 commented that he used this technique to introduce to the students a broad range of design ideas that had been proved through application in completed buildings.

During each of the work sessions, I observed that Mentor 3 demonstrated his design strategies by presenting examples of successful works, along with examples of design failures to illustrate where some strategies did not work. For example, Mentor 3 used "office set" drawings and correspondence from office files to show how a proposed design had been accepted by the client, but rejected by the planning authorities because of its impact on the "ambience of the street". By showing the modified design drawings, the correspondence between the designer and the council, as well as the designer and the client, the mentor was able to present a detailed explanation of why the design concept had failed, then how it was modified then accepted by client and council. Throughout his presentation of this authentic design situation, Mentor 3 supported his design processes and decisions by showing the student drawings and photographs, as well as giving rich anecdotal articulation of his personal views of how the various situations described may have been better handled.

Mentor 3 compared design problems, that he and Student 22 had identified in the project on which they were collaborating, with similar ones in project documents he presented as exemplars, along with the strategies and solutions he had used to resolve them. In this way, Mentor 3 reified his heuristic design strategies and tacit knowledge of problem situations and solutions that were then used as models for addressing the student's authentic design project. Activities such as this took place during 48% of the work session times. Mentor 3 structured activities with Student 22 to include exploration of multiple solutions and the reasons for accepting or rejecting them when developing the final design. In this way, Mentor 3 and Student 22 were able to link problem aspects of the student's design with solutions that the mentor had already tested and then accepted for inclusion in commissions of his own. The manner in which they worked together was highly interactive with both student and mentor each contributing to discussion and sketching activities. In this way, the mentor was able to introduce many ideas and design procedures for application to problems emergent from the student's design project.

Findings from analysis of Phase Three data confirmed the approach that Mentor 3 said was his way of working with students, during Phase Two. Mentor 3 gave Student 22 designer status during all of their work sessions. This, Mentor 3 said, helped to establish a balanced working relationship where both he and the student contributed ideas and strategies for resolving design solutions. It also assisted him to present his usual working practices in ways that were timely and appropriate to address problems that emerged from the student's project in collaborative ways rather than having a prescriptive approach. The approach used by Mentor 3 when working with Student 13 in Phase Two was evident also in his work with Student 22 during Phase Three. When commenting on his approach with Student 13, Mentor 3 said:

> He struck me as a very switched on self motivated young man and very with it, he was good because he was prepared to listen and ask the right questions, he got involved in the discussion and didn't just sit there, he was a participator and that was brilliant, it was a three way discussion and we worked as a team just as you would with any other designer. That's the way I see my role with them. They are here to be a designer and you have to work openly and cooperatively if it's going to work at all.

Mentor 3 placed emphasis on providing students with highly detailed explanations of design situations and methods that he used in his everyday practice. In each work session he linked aspects of the design problems that emerged from the student's design project to codes and regulations that govern many of the decisions taken to resolve design solutions. By expressing his tacit knowledge in this manner, Mentor 3 assisted Student 22 to acquire explicit knowledge for the interpretation and application of codes and regulations. Findings from analysis of work session data indicated that Mentor 3 used this approach during 51% of the first work session and on average for 20% of each of the remaining work sessions. Knowledge shared in this way was set by Mentor 3 in the context of its application to the procedures and processes used in his professional everyday activities.

When Mentor 3 introduced new concepts, ideas, or tips, he supported them with examples of his own works as seen in "office set" drawings. Often he sketched the item being discussed while giving a detailed description of why it was appropriate and what possible problems or shortfalls may be associated with its use. The highly visual and descriptive manner in which he did this helped Student 22 to acquire ways to apply those design practices.

Activities in which design ideas were explored by students and mentors using sketching and articulation to apply heuristic design strategies took place during 51% of the work session times. When interviewed following completion of the design project, Student 22 commented that this aspect of working with Mentor 3 greatly assisted him by providing him with ways of dealing with unfamiliar design problems. He also noted that much of what he had learnt through the mentor's explanations had assisted him in many other subject areas in his building design course of study particularly construction and structural mechanics.

I determined that the principal means by which mentors reified their design knowledge was through the use of detailed explanations and sketching to convey *how* they developed design solutions and by articulation of the reasons *why* they used particular design practices.

Analysis of the study data suggest that the mentors reify their knowledge and design procedures by:

- articulation of personal views and their reasons for working in the manner that they do when making design decisions;
- providing detailed explanations for all design procedures and decisions based on their tacit knowledge of codes and regulation developed through experience in the domain of practice;
- using sketching techniques that were more detailed than their usual methods when seeking to explain heuristic design strategies and construction details;
- extensive use of exemplar "office set" drawings to show examples of design situations, problems and solutions;
- linking problems that emerged from the student design projects with similar ones in current commissions to explain the use of problem solving strategies;
- encouraging students to use questioning to explore, defend and justify all design ideas, design strategies and proposed solutions for their authentic design project; and
- using examples of both successes and failures in design with reasons for the strategies used and outcomes achieved in resolving emergent problems.

Category 4.3 Visualisation, Exploration, Reflection and Design Style

Findings from analysis of Phase Two data suggested that most of the mentors contended that student development of basic problem solving skills and drawing methods were only the first stage of their becoming building designers. A view common to most of the mentors was that the key to becoming a building designer was to develop creative, imaginative ways for visualising and resolving design solutions, as well as the technical skills needed to communication these using industry standards. Analysis of the study data suggested that students first acquired knowledge and basic design procedures that together were used to facilitate the resolution of simple design problems. This approach was said by Mentors 1, 3 and 6a to use only procedural ways for developing solutions and did not utilise advanced skills for visualising and mentally manipulating design concepts in the manner required of building designers in their everyday practices. Commenting on how he encouraged students to develop design skills, Mentor 6a said:

> You first have to identify what the student is doing. Are they drawing or are they designing? If they are just drawing then you have no chance of them learning to design, that's just a mechanical skill, design is different. First get them thinking, then get them sketching and pretty soon you'll find that they start to design in their heads before trying to draw up ideas that are only half cocked.

Mentor 1a similarly encouraged creative thinking in his approach to mentoring. He said:

> We want them to be able to think, we don't want to have to hand feed them, the big problem is getting someone in here who keeps saying what do I do now? We want someone who goes away and thinks well maybe if I do this, we don't care if they make mistakes, but at least it shows that they are thinking about the problems.

The view of design practice expressed here by Mentor 1a suggests the need for student learning to be at a high cognitive level for them to be successful with design, because mere competency with drawing skills is insufficient.

An approach used by most of the mentors when guiding students through a design project is summed up in the following quote made by Mentor 4 when he described the manner in which he introduced his design methods.

> When a student comes in here I try to first of all inspire them and give then a structure to work with that may take them on that journey of discovery and lead them almost anywhere they want to go, you know, leave the destination open.
> When I get a student to work with I take the wad of detail paper and say to them, OK this is how we are going to go with this, big broad global approach with quick, loose sketches to get the big picture.
> You need to go through a sequence that is a collective thing before you can start to figure out where the plumbing is going to go you must know about a whole lot of other things first, it's a process of building knowledge about the brief. I begin by getting them to visualise the situation, the project, you know, get them to become part of the environment, for which they are designing.

Most of the mentors interviewed during Phase Two said that they began by encouraging students to visualise the design setting as presented by the client brief. They then sought to quickly sketch out ideas that flowed from their initial thoughts, without getting bogged down trying to solve all the emerging problems, until multiple ideas were there to work with. Of this approach Mentor 1a said:

> I give them a starting point with some sketches and then let them experiment with the ideas, when they come back with something too outrageous I just slowly pull them back by getting them to show me how they might actually build it. You might say to them what a great idea but get back to the real world.

Once the students had identified key design criteria and developed a broad design concept, the mentors then encouraged them to reflect on that design so as to explore all variations to that design or multiple design solutions. As part of that exploration, the students were encouraged to refine each potential design by resolving key elements for each, before evaluating the most suitable solution for inclusion in the final design. Mentor 6a said that he tried to lead students through the design process by encouraging them to constantly reflect on the overall design concept while exploring new elements and visualising possible solutions. This, he said, was an important way for assisting students in making the shift from simply using "paper based procedures" to visualising and resolving design concepts "mentally" before documenting solutions. Of this approach Mentor 6a said:

> It's really important for a student to visualise the process by which a design is brought up not just in plan form but through all of the related drawings so that at any one time the overall concept is evident. In that way they can mentally test ideas and resolve them before locking into something that is not fully developed.

Mentor 3 also supported this view. He commented that each of the students he had mentored did not develop their design skills until they made the transition from merely acquiring information and procedures to being able to visualise and explore design ideas "in their head" before looking to communicate them on paper or computer. Mentor 3 said:

> When Benny first came here he had excellent drawing skills and a good grip on construction methods. He was also quite capable when it came to examining the brief and working out the design criteria. What he did then though was launch into a design without thinking through or visualising the impact that his ideas would have on the site, or how alternative approaches to the development might be more appropriate. We had to get him thinking in a global way so that he could explore a range of options and reflect on what was going to be the best to refine for the final concept. (Mentor 3, member check interview, post Phase Three)

Once the students had formulated the basic design concepts for the project at hand, the mentors encouraged each to communicate what they had visualised by using sketches and three-dimensional CAD drawing methods. All of the mentors said that they sought to develop in the students a freehand sketching "vocabulary" with which they could communicate and defend their ideas. When commenting on this, Mentor 7 said:

> When they have been doing the course for two years there is not many of them who have visualisation skills. That comes after years and years, that takes a lot of experience to be able to close your eyes and to be able to see the house there. When they come in here they can sketch OK but from a technical viewpoint. What we do is teach them to use sketching like most people use words; its another language that lets you express a great deal with just a few quick lines. That's what we are after, see it in your head, then get it on the paper.

Mentor 7 said that a vital element in his approach to mentoring students was to recognise when a student was not able to visualise and communicate ideas and to coach them in ways that might assist them to develop those skills. On this point Mentor 7 said:

> That is where it is difficult for them to design and that's where the guidance from the mentor comes in. You should be able to pick up a problem quickly and say well that's wrong. We need to do something there, what are your ideas and then get them to focus on certain things 'cause they may not have the ability to do that for themselves.

Most of the mentors encouraged the students to develop their thinking skills in various ways. Some mentors sought to inspire and stimulate the student's imagination with books and other design images, others used a more direct approach by sitting down with the student and working one step at a time with them through the design. Student 14 said that Mentor 10 inspired him to be imaginative in design by accepting his ideas no matter how "radical" and being prepared to explore and evaluate them for use in the final design. Student 14 commented:

> I try to be creative and innovative in my design work so it was good to have a mentor who did the same and was prepared to look at things that were a bit out of the ordinary even if they were a bit radical. Together we came up with some really crazy ideas and that made me feel like trying anything and everything to get something different out of it (the design).

Mentor 10 confirmed that he took this approach with Student 14 so as to encourage him to take a lateral view of design and to further encourage his creative input. He also commented that he had coached Student 14 through problems that emerged from the developing design by introducing structured procedures to evaluate and focus new elements being introduced. This, Mentor 10 said, brought rigour to the work and demonstrated to the client or others who viewed the drawings that the design had evolved as a well-considered form rather than an inspired event that may not answer all of the demands of the original brief. On this point Mentor 10 said:

> I encourage them to take a bit of time to read the brief and understand the design problems and to them write down on their design drawings the reasons for making particular decisions. When people see those drawings they can see that he has put a bit of thought into this and designed it knowing the problems and solving them.

Student 13 and Student 14 both worked with mentors, who required them to first visualise their ideas, then justify every aspect of the design before accepting the work. Student 13 said:

> Anything that I did he made me explain why I did it that way, I had to justify everything in my work. It kept me really focussed and tied to the brief; I kept it practical.

Student 14 worked with a mentor who also used this approach. He said:

> He would get me to show him what I had done and he made me justify each part by saying why I had done it that way. If he saw in my design something that he thought should be done a different way he would ask me why I had done it that way. Then he would make suggestions about improving it, or sometimes if I had a good reason for it he would go with my idea.

Another finding to emerge from analysis of Phase Two data indicated that all of the mentors required the students to reflect on the development path taken and the ideas that had emerged. This process often led to exploration of new design ideas that stemmed from reflection on earlier concepts, as documented in the "office set" which provided a trail of evidence of the design development.

Most of the students interviewed during Phase Two said that their mentors often worked through ideas with them until all possible aspects of those ideas had been exhaustively examined. If the idea being investigated were shown to be unsuitable to the design, the mentor retraced their steps to the stem of the idea and then took a new approach to solving the problem. Three students said that this way of designing was not what they had been used to at TAFE, where according to them, often the first idea for the design became the only idea to be explored. The sketch, discuss and justify, approach taken by the mentors provided the students with a structure upon which to base their own design investigations and for many, changed their whole manner of problem solving in design. Student 9 commented:

> He would go back over them and say this didn't work and then we would come back to that earlier design and work from that and get away from the one that didn't work. He would follow an idea through and if that didn't work he would just come back to the earlier sketch and work from there again and expand on that idea until that hit a dead end and then sort of try again right from scratch.

This aspect of exploration in the development of design was studied using the video record of Phase Three work sessions. In work sessions involving Mentor 4 and Student 23, the mentor made extensive use of rich descriptive language as a scaffolding tool to build images to suggest the lifestyle around which the design might be developed. For example, the following sequence of sketches and mentor comments were used by Mentor 4 in one work session to scaffold Student 23 when he was "lost for ideas" with his design. After Student 23 had compiled a list of design criteria from the project brief, Mentor 4 asked him to imagine first the design setting and the kind of lifestyle that people choosing to live in the valley site might desire. The mentor began by describing what he imagined it would be like in the valley where the house was to be built by saying:

> Just imagine the misty coolness of the morning with the sun breaking through the trees at the top of the site and how that might be brought into the house. Think also of the end of the day when you want to sit down on a verandah to enjoy the view and the breeze flowing in from the south-west and imagine the relaxed life-style that goes with that kind of environment.

While Mentor 4 was describing this picture of the design setting, he was also sketching the rough forms shown in Figure 36. He went on to use these with Student 23 to plan the approach that they were to use together to develop the design.

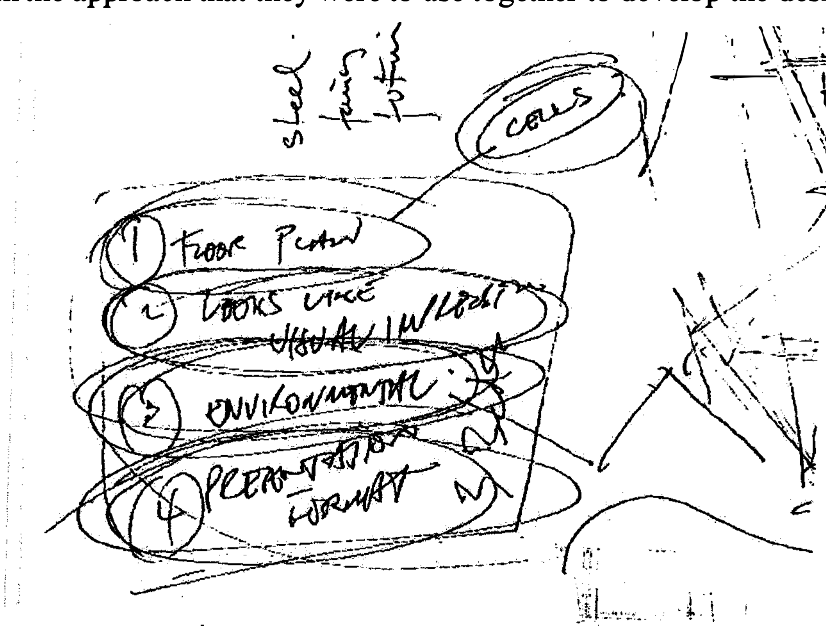


Figure 36. Design roots sketch.

He then encouraged Student 23 to describe his ideas about features of the design setting that would influence the layout of the house, like the fall of the land, the views down the valley, as well as orientation factors for wind and sun penetration. Using these, Mentor 4 and Student 23 together developed the sketch shown in Figure 37, which shows the first area relationships of the design.

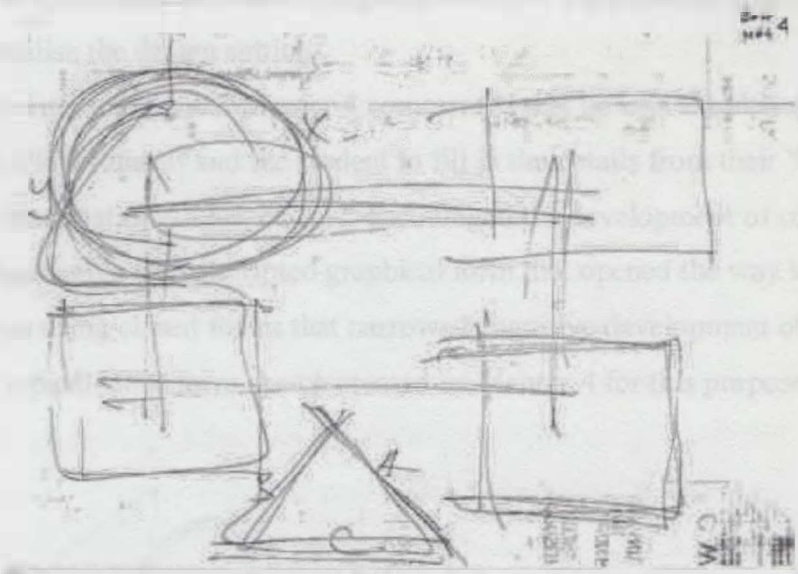


Figure 37. Area relationships in design.

This sketch was further developed to become the basis plan form shown in Figure 38, as both the student and the mentor discussed their visualisation of the use of space and form to create a design that became a "part of the setting".

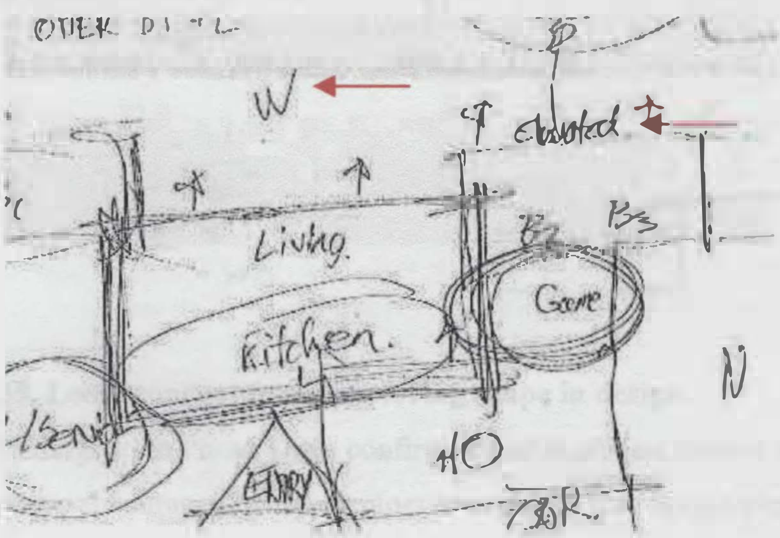


Figure 38. Plan based on student/mentor ideas.

In this sketch, reference to the orientation can be seen (W for West at the top) as well as comments that suggested the beginnings of visualisation of the three-dimensional aspects of the design (see "Elevated" note about section at top right of sketch).

Mentor 4 encouraged Student 23 to imagine the design environment and what it might mean or offer to the people who were to live in the building they were designing in their working collaboration. For 59% of the work session times during Phase Three, Mentor 4 used simple uncomplicated sketches like those shown above, around which he built stories of imagined events or experiences to encourage Student 23 to visualise the design setting.

In later interviews, Mentor 4 commented that he kept the sketches open and vague to allow himself and the student to fill in the details from their "free roaming ideas or imagination". This, he said, encouraged the development of creativity and design freedom in a non-scripted graphical form that opened the way to exploration rather than using closed forms that narrowed cognitive development of ideas. Figure 39 shows a typical loose form sketch created by Mentor 4 for this purpose.

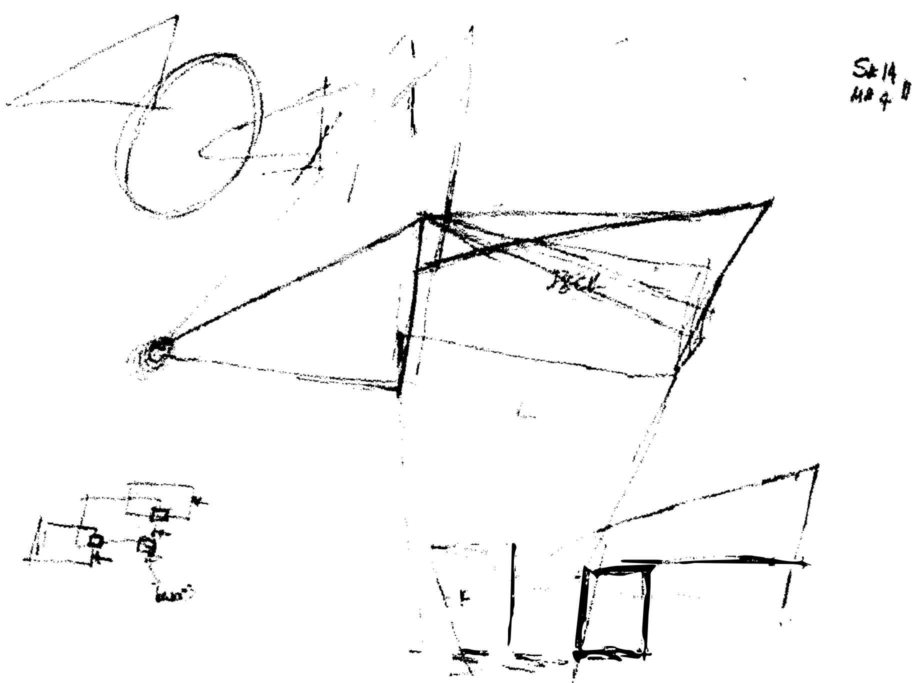


Figure 39. Loose concept forms exploring shape in design.

Findings from Phase Three confirmed that in student/mentor work sessions the students were encouraged by the mentors to explore every design element through to resolution before branching to other lines of inquiry to build a comprehensive picture of the overall design situation. This approach assisted students to develop skills for reflecting on design problems and potential solutions by encouraging metacognitive ways for visualising and resolving design problems.

Findings here have also suggested that the use of reflective design practices by students was a key element in their transition from simple application of the vocabulary and tools of design, to having a discovery focussed metacognitive approach. Other findings to emerge from analysis of the study data have suggested that as students acquired ways for resolving design problems in the manner modelled by experts, they also underwent a transition from using paper-based design procedures, to using more metacognitive methods to create, explore and develop innovative solutions. Other findings to emerge suggested that this led to the students making connections between design theory and the methods used by experts to solve complex design problems in the context and culture of professional design practice.

Exploration of potential solutions often led to testing of ideas for acceptance in, or rejection from, final design solutions. Students working in this manner shared rich context specific experiences with their mentors whose collaborative involvement left space for personal development and investigation. At the same time, the students' exploration of design ideas and reflection on alternative solutions led to their development of personal design styles. This occurred when the students synthesised elements of different historical design styles with characteristics of the mentor's own style, those of other designers and style elements based on the student's own preferences. This aspect of student learning is discussed next.

Personal Design Style.

Most of the mentors and most of the students said that they sought to have their own style in design. Some of the students said that they took note of their mentor's design style, but tried to develop a style of their own. The following comment made by Student 16 is typical of others found in data coded in this category.

> Working with Sam and Jack gave me an insight into how they did their design work and what their design style was. I have my own ideas that are more focussed on alternative lifestyles for down South that I would like to design for.

Some of the students said that they had copied design elements they had seen their mentor using and in so doing developed their design style using a synthesis of the mentor's style and their own ideas. Student 18 said of his use of Mentor 26's design style elements:

> She likes the idea of columns to separate areas like the lounge and dining, that's why I have used them in my design. I saw that in the houses that we looked through together and on the drawings that she showed me.

The most common feature of the development of a personal style in design emerged as student integration of the mentor's design features and design strategies into their own design practices and personal preferences. Student 13 said that he had acquired aspects of his mentor's (Mentor 3) design methods for use in his own design practices. In the following quotation, Student 13 has expressed a number of key aspects of his experience of working with Mentor 3 that define some of his learning outcomes. He has also referred to the effect that this has had on his design practices now that he is employed under another designer who had also worked with Mentor 3.

> There u heaps of things that I learnt there with Barry that I now use, perhaps not everyday but usually you come across a little problem similar to things I did there. I find myself thinking of what Barry has said worked for that situation and then I try it out for the problem that's there. Sometimes I see in the drawings that I am doing and that Mario is doing things that Barry showed me how to do. You get little reminders all the time about how things work and how the aesthetics might be developed using his style of design.

Analysis of Phase Three data showed that Mentor 3 placed great emphasis on the importance of reflective practices in design for developing a personal style in the use of architectural features and problem solving methods. During 55% of the work session times, Mentor 3 used questioning and explanation-building methods to review every aspect of the design presented by Student 22. Throughout this process of review, Mentor 3 encouraged Student 22 to explore many other ideas and concepts by visualising how he might resolve them into a design style of his own. This process Mentor 3 said increased student understanding and led to a greater sophistication of the design solutions produced, as well as the emergence of a personal design style.

The manner in which Student 22 developed his personal design style was said by Mentor 3 to come from the immediate feedback he provided concerning the functionality and basic guidelines for the aesthetics of the final design form and from sketching multiple variations of design ideas. Commenting on this, Mentor 3 said:

> I work on the basis of being fully informed before making any design decisions. That's what I wanted him to do also, so I gave him encouragement and feedback on each aspect of the design that we worked on so that at any time we both knew where it was at. Every time he came up with an idea I got him to explain the reasons why he wanted to use it and I'd get him to sketch how he was going to implement them. I made sure that he understood how to resolve the problems that came out of those ideas and when he could not readily explain, then I would give him some alternatives and explain why and how I would use them. This went for everything from fixing details to the aesthetics of the final design.

The basic forms suggested by the sketches developed in the work sessions (see Figure 40, p.259) by this student/mentor collaboration can still be seen in the final design drawings (see Figure 41, p. 260). The curved shapes first suggested in Figure 42

(p. 261) can be seen in the final design elevations shown in Figure 43 (p. 262). The formal box like plan layout shown in Figure 40 (p. 259) has been refined in the final design (Figure 41, p. 260) by Student 22 to reflect the functional and practical approach for which his mentor is known.

From my observation of the student/mentor collaborative work sessions and analysis of the study data, I have concluded that student development of design practices based on exploration and reflection contributed to the emergence of individual style in design. Student personal design styles evolved from the synthesis of their own ideas with those of their mentor, along with other influences such as traditional design styles or those of other recognised designers.

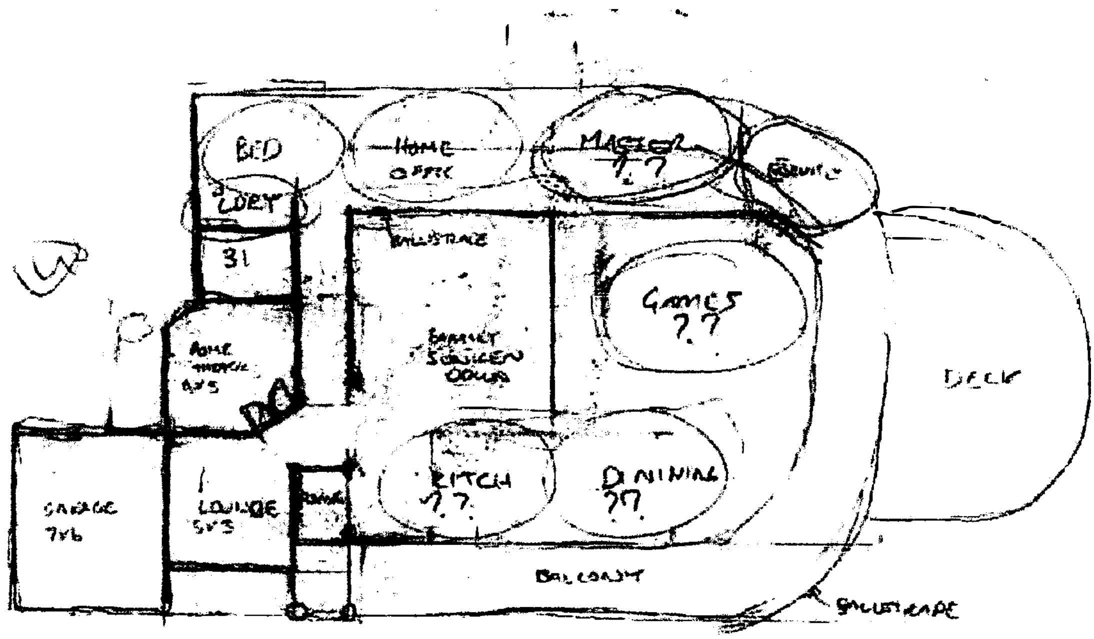


Figure 40. Sketch showing initial formalisation of plan.

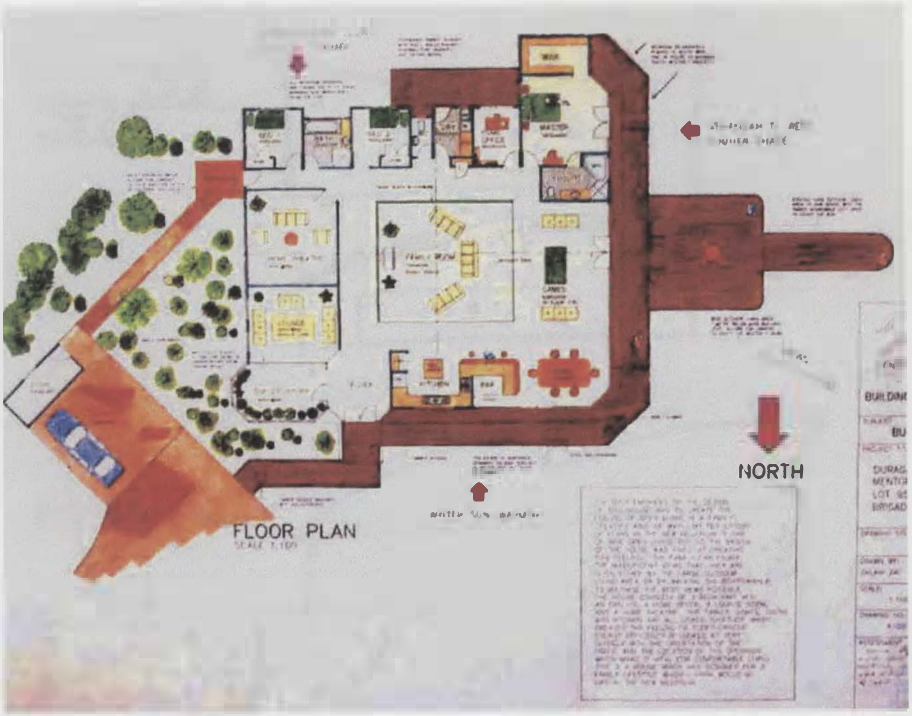


Figure 41. Final layout plan for student 22.

Student 22 commented at the conclusion of the study project that the curved roof forms in his design were his own idea and represented a particular style that he wished to develop. He noted also that he had derived inspiration for that style from project drawings he had seen in the office of Mentor 3 and from a book of the design works given to him on loan by Mentor 3 for inspiration. Note that in Figure 42 (p. 261), some parts of the drawing appear to be upside down. This occurred because the mentor and the student sat opposite each other at a desk sketching on the same paper as they developed ideas together. I observed this taking place as Mentor 3 and Student 22 produced the sketch shown in Figure 42.

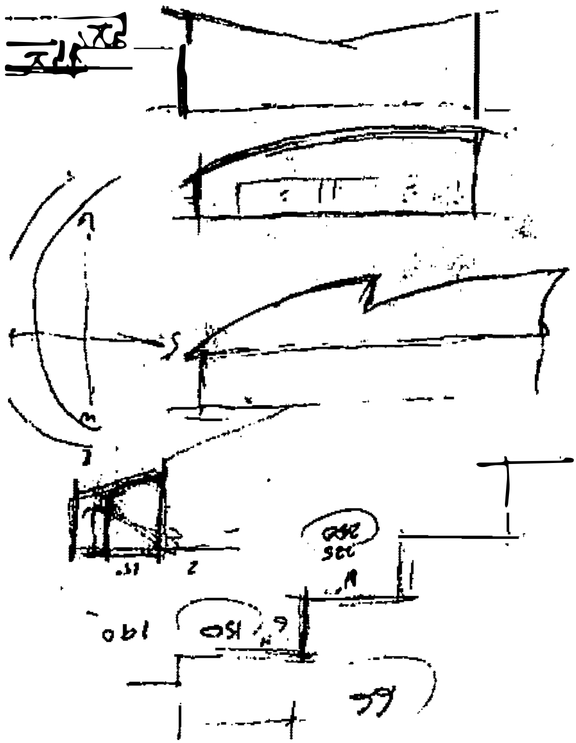


Figure 42. Sketch showing alternative roof and section design forms.

In this instance, Student 22 developed his own design style which he said was a "blend" or synthesis of that of his mentor, influences acquired from a study of the works of other recognised designers and his own personal views as expressed in the elevational treatments given the building. The curved roof forms explored in Figure 42 (p. 261) can be seen in the final design elevations shown in Figure 43 (p. 262).

Figure 43. Elevation treatment for final design.

Mentor 3 mentored Student 13 in Phase Two and Student 22 in Phase Three. He commented that these students did not develop design skills until they had made the transition from merely acquiring information and procedures, to being able to visualise and explore design ideas "in their head" before looking to communicate them on paper or by using a computer. Six other mentors also supported this view in member check interviews conducted after the study data were analysed and preliminary findings were reported. When interviewed at the conclusion of the project, Student 22 confirmed that working with Mentor 3 had provided him with inspiration and support, leaving him free to explore his own ideas and to discover his own design style. He said that he had begun to feel confident in his design ability skills after having first developed an understanding of the tools modelled by his mentor as those typically used in the everyday practices of a building design office.

Findings from analysis of the study data suggested that student development of skills for visualising and refining design ideas was assisted by:

- exploration of every design element through to resolution before branching to other lines of inquiry to build a comprehensive picture of the overall design situation;
- reflection on design problems and potential solutions to enhance visualisation skills and metacognitive resolution of design problems;
- reflection on design processes to develop metacognitive ways for applying knowledge and design tools in creative, innovative ways;

- making connections between design theory and the methods used by experts to solve complex design problems in the context and culture of professional design practice;
- quick sketching methods to explore multiple design ideas that stemmed from design criteria determined by the project client brief;
- use of pre-drawn CAD design components and "office set" document sets to rapidly explore multiple design ideas when emergent design problems could be linked to similar situations for which solutions had already been developed and proved; and
- development of student personal design styles through synthesis of their own ideas with those of their mentor and other influences such as traditional design styles or those of other contemporary designers.

Summary of findings.

Three phases of student learning in the design office situations of this study emerged from the study findings. They are:

- student entry to the design office culture of practice;
- student acquisition of declarative knowledge, procedural knowledge and tacit knowledge needed to resolve problems emergent from authentic building design tasks; and
- student development of metacognitive ways for creating and refining design solutions.

The relationships between these three learning phases and the key activities identified in these findings as facilitating student learning in each phase are described in the following summary of findings. The study findings are reported here using numbered headings that together represent the categories used for analysis of the study data as well as the key teaching strategies of a cognitive apprenticeship learning approach (Collins, et al., 1989).

Findings that emerged from analysis of the study data have indicated that the students begun the first phase of their learning in the study situation by obtaining entry to the design office culture of practice through their collaboration with their assigned mentor. The manner in which this took place was influenced by expectations held by the students and the mentors about how their collaboration might be shaped, as well as each individual's expectations about work practices and learning outcomes. Some of the findings to emerge here suggested that student and mentor confidence assisted student entry to the design office culture of practice, as did team-based work practices.

The second phase of student learning in this study took place when the students commenced work with the mentors on the authentic design projects. Working with the mentors facilitated acquisition of declarative knowledge, procedural knowledge and tacit knowledge needed to resolve design problems. The mentors used discussion, articulation and sketching when modelling, coaching and scaffolding methods to demonstrate, explain and assist students to implement design knowledge and procedures.

In the third phase, the students implemented heuristic design strategies acquired from their design experiences with the mentors, who had reified their tacit knowledge of design when using cognitive apprenticeship teaching strategies and other practices typical of their design office operations. This assisted the students to develop metacognitive ways for exploring and refining design ideas they had visualised and this I contend facilitated their development of creative and innovative design practices. For example Student 13 said:

> ... there are heaps of things that I learnt there with Barry that I now use, perhaps not everyday but usually you come across a little problem similar to things I did there, and I find myself thinking of what Barry has said worked for that situation and then I try it out for the problem that's there.
> ... I find that I can be a lot more creative now because I'm confident to have a go, and I can visualise a heap of different solutions before deciding on which one to run with. That's what I got out of doing the project with Barry.

Each of the activities or elements that emerged as assisting student learning is summarised here using headings that together represent the categories used for analysis of the study data.

Phase One

1. Student entry to the culture of practice and development of their social construction of knowledge took place by:

- students adopting a professional manner of speaking including not swearing and the use of a technical vocabulary; dress standards based on smart casual wear as typical of the design office;
- students participating in the broad scope of design office activities;
- observation of others in the design office;
- using job management schedules as modelled by the mentors;
- being accepted by the mentor and others in the design office as a designer; and
- development of a passion for design and a desire to achieve professional status as modelled by the mentors and others.

2. Student and mentor expectations affected student learning in the following ways:

- student anxiety about having inadequate skills and mentor domination of the design process were dispelled by mentor confidence in students and their willingness to give students apprentice designer status;
- mentor use of a sequenced approach to design removed student anxiety over work loads and knowledge/skills development;

- constructive feedback by mentors and acceptance of student ideas built student confidence to be innovative and to explore new design ideas;
- mentor expectations about student performance were met by affording students apprentice designer status and by having them undertake small easily achieved design tasks to build knowledge and skills needed to address problems emergent from their main design project. This encouraged student ownership of emerging design solutions; and
- mentor modelling of enthusiastic attitudes towards design led to student development of similar attitudes and willingness to contribute to the collaboration.

3. Confidence in their mentor and in their own abilities assisted student learning by:

- being accepted by the mentor as a fellow building designer;
- having a mentor model confidence in the student's ability to resolve complex design problems;
- mentor use of non-judgemental, positive reinforcement, in feedback when assessing, coaching, or scaffolding the student's work;
- mentor support for student presentation of original ideas and design strategies;
- mentor encouragement of reflective practices when self assessing design ideas;
- mentor support for student defence of ideas; and
- autonomous use of design strategies and procedures by students as modelled by the mentor.

4. Team-based methods used by students and mentors in the design office situation assisted student learning by:

- providing students with opportunities to work in design office situations where they witnessed and participated in all aspects of usual design office practices including exchanges with expert consultants in disciplines associated with building designer and construction;
- making available design office personnel to ensure continuity of support in work sessions when the principal mentor was not available provided students with a community of practice having multiple sources of knowledge and expertise to assist learning; and
- including students in teams working on authentic design office commissions in ways that allow them to make a contribution to design solutions and to the processes used to develop them.

Phase Two

5. Declarative and tacit knowledge transfer was facilitated through the application of design processes and procedures by mentors using cognitive apprenticeship teaching strategies and by:

- examination of the design brief and all influencing factors in preparation for a design development;
- extensive use of questioning and thinking aloud to:
  - introduce, explore and defend design ideas;
  - explain the processes used to develop design solutions; and
  - to evaluate and test design elements.
- the use of extensive and diverse non-context specific resource materials;
- extensive use of reflection on past and current design projects as design resources;

- matching of proved design and construction practices to design concepts being explored in the student/mentor collaboration;
- use of the "office set" approach to provide visual representation of ideas explored, information researched, variations on design concepts or details, branching of lines of inquiry, evaluation of design elements and influencing factors;
- extensive use of visualisation to explore multiple perspectives and solutions;
- the use of CAD design and drawing methods to quickly explore new ideas or concepts;
- mentor availability and the extended support offered by contact with others in the work place or associated discipline consultants; and
- student participation site visits and current office projects in which the mentors link actual practices with theory or concepts.

6. Discussion was used to assist learning in the following ways:

- work session discussions assisted students to acquire a technical vocabulary and ways of speaking used in the design office culture of practice;
- discussions between students and mentors that facilitated transfer of declarative knowledge about design situations, codes, regulations and practices;
- work session discussions facilitated student acquisition of ways for explaining design ideas and using processes, procedures and heuristic design strategies used by building designers to resolve complex problems;
- work session discussions exposed students to the mentors' methods of questioning, evaluating and defending ideas; and
- work session discussions assisted students to acquire ways of reflecting on design methods and creative ideas leading to exploration of multiple concept forms and design solutions.

7. Articulation was used by the mentors and the students to:

- facilitate transfer of tacit knowledge;
- express declarative knowledge about multiple design situations;
- explain procedural knowledge necessary of application of design processes;
- explain the use of heuristic design strategies and to provide reasons for their application;
- provide insights into decision making methods employed for problem solving and the exploration of multiple design ideas or solutions; and
- reflect on and defend design decisions.

8. Sketching was used as a communication tool and to scaffold learning by:

- providing visual communication of concepts, ideas, problem solving methods and solutions;
- facilitating exploration of multiple design forms and refining variations;
- showing a visual audit trail of design thinking and processes or procedures used in developing solutions;
- providing immediate feedback on concepts or ideas that emerge during design;
- representing three dimensional complex planar relationships.
- facilitating acquisition of declarative knowledge about multiple design situations as seen In exemplar "office set" drawings of authentic commissions;

- assisting students to acquire tacit knowledge through experimentation with design methods reified by the mentors using sketching to show similar problem design situations and the methods they had used to develop design solutions;
- showing procedures, knowledge and alternative design practices used by the mentors through overlay sketching of exemplar drawings to reify their use of heuristic design strategies as applies to the student's own project; and
- showing design methods and multiple solutions to problems typically addressed in everyday design situations that emerged from authentic projects as demonstrated by the mentors when sketching design elements from their own works to illustrate potential ways for resolving problems that emerged from the student's design project.

9. Modelling was used by the mentors to:

- demonstrate their usual design methods, problem solving strategies and a structured approach to design through the use of authentic "office set" drawings, sketching, over-sketching of CAD drawings, schedules, lists and notes;
- demonstrate to the students design tools, heuristic design strategies, defined directions and set time lines for completion of tasks;
- provide declarative knowledge of design situations, regulations, codes and standards as well as procedural knowledge for applying design methods; and
- structure design activities to replicate the sequencing of design production in authentic practices.

10. Coaching took place through:

- guiding students' application of design, heuristic design strategies for resolving emergent design problems and for refining design solutions;
- explanation building to detail the reasons underlying design processes and decisions, based on personal experiences;
- over-sketching of students' drawings to provide immediate feedback on ideas explored or solutions accepted; and
- assisting exploration of new design ideas that stemmed from earlier concepts, as documented in the "office set".

11. Scaffolding was used by the mentors to assist student learning by:

- freehand sketching backed up with detailed explanations of the reasons for using the design/construction strategies or details presented;
- use of CAD design components and exemplar "office set" drawings that illustrated heuristic design strategies, problem solving procedures, benchmarking standards and declarative knowledge about the following design situations and elements:
    - commonly used solutions for room layouts in kitchens, bathrooms, bedrooms and technical areas like medical or industrial settings;
    - relationships between rooms for traffic flow in various settings;
    - regulations and codes as applied to specific design situations;
    - construction details such as footings, roof structures, truss and beam fixings and the like;
    - colour and texture of surface finishes; and
    - appropriate selection of materials and different construction methods as determined by specific design problems or situations.

- over-sketching of hand drawn and CAD based drawings to show multiple alternative design strategies or solutions;
- timely presentation of "tips and tricks" based on authentic commissions and tacit knowledge;
- use of a diverse range of non-context specific materials such as magazines, journals, pictures and the like, as well as discipline specific codes and regulations;
- use of notes on sketches and drawings for focussing student use of design procedures and to convey declarative knowledge of design situations, regulations or usual office practices;
- use of notes and schedules for sequencing of learning events in design and to link these to tasks that progressively build on student knowledge and design skills;
- provision of CAD data base of pre-drawn elements to address individual problem aspects of design and to facilitate rapid exploration of multiple design ideas.

Phase Three

12. The mentors reified their tacit knowledge, declarative knowledge and procedural knowledge through:

- articulation of personal views and their reasons for working in the manner that they do when making design decisions;
- providing detailed explanations for all design procedures and decisions based on their tacit knowledge of codes and regulation developed through experience in the domain of practice;
- using sketching techniques that were more detailed than their usual methods when seeking to explain heuristic design strategies and construction details;
- extensive use of exemplar "office set" drawings to show examples of design situations, problems and solutions;
- linking problems that emerged from the student design projects with similar ones in current commissions to explain the use of problem solving strategies;
- encouraging students to use questioning to explore, defend and justify all design ideas, design strategies and proposed solutions for their authentic design project; and
- using examples of both successes and failures in design with reasons for the strategies used and outcomes achieved in resolving emergent problems.

13. Visualising and Refining of design ideas by students was assisted by:

- exploration of every design element through to resolution before branching to other lines of inquiry to build a comprehensive picture of the overall design situation;
- reflection on design problems and potential solutions to enhance visualisation skills and metacognitive resolution of design problems;
- reflection on design processes to develop metacognitive ways for applying knowledge and design tools in creative, innovative ways;
- making connections between design theory and the methods used by experts to solve complex design problems in the context and culture of professional design practice;
- quick sketching methods to explore multiple design ideas that stemmed from design criteria determined by the project client brief;
- use of pre-drawn CAD design components and "office set" document sets to rapidly explore multiple design ideas when emergent design problems could be linked to similar situations for which solutions had already been developed and proved; and

- development of student personal design styles through synthesis of their own ideas with those of their mentor and other influences such as traditional design styles or those of other contemporary designers.

14. A Creative and Innovative approach to design by students was facilitated by:

- use of a diverse range of resource materials and rich descriptive language to create verbal images, supported by visual images using sketching or other illustrations;
- use of questioning, discussion and sketching to coach students in techniques supporting the exploration of ideas and branching of lines of inquiry;
- encouraging and supporting student exploration, defence and development of ideas;
- exploring multiple design solutions generated from the stem of each new idea revealed during the development of student design concepts;
- not forcing the design process, or pushing too hard for results;
- use of multi-staged replicable procedures to resolve difficult design tasks and to facilitate innovative exploration of multiple design concepts; and
- supporting students in their development of autonomous ways of using design knowledge and procedures when visualising concept forms and possible solutions.

Confirmation of student learning outcomes - judging of designs

At the conclusion of each of the authentic design projects, a panel of judges who were independent from this study assessed the students' designs. Data collected from this process provided independent opinions about the standards of design and presentation achieved by the students, assessed according to industry standards of practice. Findings from analysis of these data were regarded by me to confirm student learning outcomes as described throughout this Chapter and in the summary of findings shown above.

Judging of the students' designs.

A new judging team was selected to evaluate the student designs for each of the three authentic design projects used for the three phases of this study. The judging of the student designs that resulted from their working with a mentor in a design office situation was an integral part of undertaking their undertaking authentic design projects. This was because their evaluation involved the same processes and accountability that professional building designers encounter as part of their everyday culture of practice activities in design. Therefore, the assessment of the student designs was seen as part of the usual process that they would experience in industry. In addition, the judging of the students' work by expert building designers and others provided feedback about the success of their design efforts that was independent of the mentors with whom they had worked. For these reasons the judging of the students' works was regarded as important to the research questions because it provided another source of information about their learning.

The evaluation of student designs from Phase Three was viewed with particular interest. This was because the results of the judging could readily be compared with other data. These data included Phase Two data about what the students and the mentors said had occurred and Phase Three data that were based on my observation of what took place in the work sessions in which the students developed their designs. Analysis of these data assisted in confirming some aspects of the students' learning outcomes.

Each judging team included experts recognised for their specialised knowledge of design and industry specific aspects of the design project brief. Judging was conducted using checklist sheets to address various aspects of the building designs, as per industry standards set by the judges, expert building designers and TAFE lecturers. An example of the checklist used for assessment of Phase Three student designs is shown in Appendix H. Written comments made by the judges on the judging checklists (see Appendix H) when analysed provided information about student learning outcomes as seen by independent industry experts. During the judging process, and as part of informal discussions immediately following the judging, I recorded personal journal notes about what the judges said about each of the student designs. Data collected in this way were analysed by coding in the same manner as other similar data collected using other methods. These data provided information about what experts in the building design profession saw as the students' design achievements compared to the experts' industry standards. Findings from this process provided confirmation of student learning outcomes as assessed by the independent experts.

Data collected by using the judging sheets served as a basis for post judging discussions with the expert judges to ascertain their views on the standard of work presented by the student/mentor collaborative design teams. This was done to explore links between what industry determined was an acceptable standard and what actually was produced by the students in the mentor supported design office learning situations.

Judging Criteria

The design criteria documented in the brief used by students working on this project were developed in consultation with specialist experts in the steel industry and with experienced building designers. The judging panel, using a checklist developed by three industry experts and two TAFE lecturers, assessed the students' design solutions. Having building design industry experts and a TAFE lecturer on the judging panel provided industry expert knowledge as well as education expert knowledge.

Each judge was asked to allocate marks for all categories in each of two sections of the judging form. The assessment categories were:

- satisfaction of the design brief (40 marks);
- Duragall products (use of) (40 marks);
- exterior aesthetic (40 marks);
- design for climate and energy efficiency (40 marks);
- project presentation (40 marks);
- zoning of activities (20 marks);
- indoor/outdoor relationships (20 marks);
- traffic flows(20 marks); and
- furnishabilty of spaces (20 marks).

The maximum number of points available to each student from this judging form was 280. Six different judges assessed the student designs. The sum of all of the judges' scores meant that the maximum score available to each student was 1680. A total of 20 students, all of whom had worked with a mentor in a design office, had their designs judged. Four of those students were the ones who were closely studied in Phase Three of this study. All of the student designs were judged to be of an industry standard of design and presentation. Some were better than others, as evidenced by the spread of scores. These ranged from 975 to 1169. The top three scores were:

First	1169
Second	1164
Third	1161

Two of the four students who were closely studied in Phase Three of this study attained the first and second placing in the overall scores. Another of the four scored in top 25% of the student group and the fourth student scored in the 50-75% range.

Comments from the judges

The industry representative from the steel industry commented that:

> The students and mentors have really come up with some new ideas for us to take back to the company. Some of the designs are quite radical and might be challenging to build, but that is what we wanted, you know, something different to get new ideas into the market. (Judge 1).

This view was supported by the judge from a large construction company commented that:

> I am amazed at the professional standard of the designs, particularly the CAD based drawings. This is the type of work that we see coming out of the design offices of our consultant firms. There is some really useful

> material here, a lot more than I had expected from a student project. (Judge 4)

Another of the judges, when discussing the top three award winning designs said:

> ... each of these has something special happening to make the best use of natural heating, cooling and ventilation. What is interesting is that they all do it in different ways, but quite effectively. (Judge 3)

This judge went on to say that the designs had provided some new ideas for him to incorporate in his promotional materials. Judge 3 also commented that:

> The students seem to have a broad freethinking approach to the use of lightweight materials to do tasks that we all too often think of as needing heavy masonry. They've come up with some different thinking here, so maybe we have to do a little rethinking ourselves now.

Critical comment by the Building Design Association (BDA) judging panel member was regarded as being especially important because of his close links to the building design industry and current knowledge of standards of design and drawing presentation used by professional designers. He commented that:

> ... the overall standard of the designs presented here are the best I've seen for student work for this type of project. The top five or six designs show clever use of the structural steel system that was an essential requirement for this project. The designs are creative and quite innovative in their use of a variety of other building materials and design ideas like how they achieved solar energy efficiency, in an aesthetically pleasing but functional design. (Judge 5)

Judge 5 also said that he was particularly impressed by the attention paid by the students to detailing the designs and to the presentation of their drawings. These he said were key elements in selling an idea to a client in the commercial setting. When commenting on the top three student designs, he said that they were as good as most professional design offices present in their day to day operations and could thus be considered as meeting industry standards of professional design.

The TAFE lecturer (Judge 6) who performed judging duties had ten year's experience teaching building design and five year's experience working with students on authentic projects under the direction of a mentor. With this background, Judge 6 was well placed to assess the student designs and to make comment on them using comparisons with work that she had seen produced by students in classroom design projects that were not guided by professional designers as mentors.

When commenting on the overall standard of the design submissions, Judge 6 noted that the students had achieved levels of design and presentation significantly higher than those of their peers in current design classes undertaking classroom based design projects. This she based on having already assessed student submissions based on the same design brief used by the students for their authentic projects, but executed by other students in classroom based situations without input from a practising building designer acting as a mentor. She also noted that "these designs (the study project) show a greater sense of style and innovation and are far more creative in their use of building materials". Judge 6 also commented:

> ... the range of presentation methods used by the students is more diverse and professionally executed than the sort of thing that you see in the newspaper presented by most of the big firms when they are promoting developments and schemes.

Analysis of data such as those shown in the above examples led me to contend that the students in this study achieved standards of design and presentation that the judges assessed as meeting and in some instances exceeding industry standards. Overall, I believe that the quality of the works produced by the student/mentor collaborations in the design office situations used were regarded by the judging panel to have exceeded standards that they normally expected of students at this level of training. From this, I contend that learning outcomes for students studied here were of a higher standard and resulted from their learning in a mentor supported design office situation organised using cognitive apprenticeship teaching strategies.

Conclusion To This Chapter

The collection, recording, transcribing and analysis of data in this study followed a three phased cumulative process, with analysis commencing with the first data collected. Multiple collection methods were used to gather data that were coded using categories that emerged during transcription and interpretation of different types of information recorded.

In this chapter, findings that emerged from analysis of the mostly interview based Phase Two data and the mostly observation based Phase Three data have been reported, along with data units which supported and illuminated those findings. During analysis of data collected here, replicable procedures were used within a coding framework established using NUD•IST (1998) software.

Data were collected over a 14-month period using a variety of different methods. Data were analysed using coding and other methods including summaries and tables based on themes that emerged as coding categories were developed for Index Tree frameworks that evolved as new data were collected. As new themes emerged, some categories were merged and collapsed as similar data were identified and re-coded. Coding of data was undertaken in three phases, as determined by the collection methods and the work focussed tasks being undertaken by the study participants

The first phase of coding and analysis was based on what took place in the real work design project implemented as part of the pilot study. During this first stage an overall view was sought to describe the events and activities that shaped the student/mentor collaborative work situations developed using authentic design projects.

The second phase of coding and analysis focussed more on identifying the individual activities carried out by the study participants in the student/mentor collaborative design work sessions. Themes that emerged from this phase of the study shaped the investigative structure developed for Phase Three, which involved the observation of actual work sessions involving the students and their mentors.

The third phase of data collection and analysis sought to confirm findings that emerged from analysis of Phase Two data and to also identify any new aspects of the study situation or events thought to influence learning. With each new phase of data collection and analysis, emerging trends themes defined by "intensity and frequency" (Holsti, 1969, p. 126) of the participants' responses were used to further develop the study framework as well as the tools for data collection and ongoing analysis. Key elements, noted as important to learning in the study situation, were used as major coding categories to organise and implement other emerging aspects of the situation, events, views and activities revealed through analysis of the accumulated data.

The authentic nature of data collected in face-to-face interviews, informal discussions, video recorded work session in which the researcher played an active role, was confirmed through comparison with the physical evidence of sketches and drawings, as well as in member checks conducted throughout each phase of this study. Every effort was made to ensure that data collection methods used in all three phases of this research were consistently applied. Using the same methods for collection and analysis within each phase assisted in ensuring the data reliability and consistency of data through replicable procedures. This I regard added rigour to the study. The interactive nature of all of the data collection methods used, provided opportunities at every stage for me to confirm my interpretation of events as they transpired, by using member checks and for the study participants to exchange their views with me.

At all times the participants remained volunteers in the study and were kept informed of the measures being maintained to ensure their anonymity and the confidentiality of all information that they provided. None of the participants withdrew from the study, or declined to participate in any part of the study. This meant that the data were collected from willing participants. For this reason, I regard the study data to be from authentic sources and likely to have provided a trustworthy and reasonable record of what the study participants actually experienced.

This Chapter sought to provide a holistic picture of the processes used to interpret the study data and findings that emerged during analysis. It reported findings about what occurred when mentors and students worked together on authentic projects and how the design solutions produced by the student/mentor collaborations were judged as part of determining learning outcomes.

In the next Chapter, the research questions are answered using findings that emerged from analysis of the study data.

CHAPTER SEVEN

ANSWERING THE RESEARCH QUESTIONS AND DISCUSSION

Introduction

In this chapter, the research questions are answered. This is followed by a discussion of the study findings with reference to pertinent literature. The use generally of cognitive apprenticeship methods for learning in the building design discipline and other similar domains is also discussed here as an extension of the findings that have emerged from this research.

This study set out to investigate student learning in a cognitive apprenticeship situation. The setting used for the main data gathering part of this study consisted of 10 commercial building design offices, in each of which students worked with expert building designers, acting as mentors, on authentic projects. Data about the events experienced by students in their collaboration with the mentors were collected from multiple sources, using a variety of collection methods. The previous two Chapters have detailed data analysis and findings about many different aspects of the study situation which I regarded as affecting student learning. Here, the research questions are answered using summaries of the findings from the previous Chapter.

Research Question 1

What kind of declarative knowledge and procedural knowledge is acquired by students in the building design profession in a cognitive apprenticeship learning situation?

Five broad aspects of student learning emerged as being outcomes in this study. They were:

1 Students acquired ways of speaking, behaving and self-presentation similar to those used by professional designers in the building design office culture of practice;

2 Students acquired declarative knowledge about:

- the organisation of a commercial design office;
- regulatory factors governing building design;
- the organisation of design office methods for planning and implementing authentic design projects;
- multiple design situations frequently encountered by building designers when undertaking authentic projects;
- the knowledge necessary for successful application of heuristic design strategies used by expert building designers to create and refine design solutions; and
- building design industry standards applied to construction detailing and presentation methods commonly used in drawing practices.

3 Students acquired procedural knowledge about:

- the methods used by building designers to analyse design brief specifications;
- ways for assembling resources necessary to address authentic design criteria;
- ways for organising authentic design projects using planned stages of development and review;
- the methods used by experts to implement their usual heuristic design strategies to develop solutions to problems emergent from authentic design tasks; and
- the methods used by building design experts to present and defend their design solutions to clients and others.

4 Students developed autonomous ways of creating, visualising, exploring and resolving original design ideas; and

5 Students developed personalised, individualistic design styles that emerged from a synthesis of the student's own ideas with those of the mentors', historical style elements and other factors.

These five student learning outcomes indicated that mentor use of cognitive apprenticeship teaching strategies was an effective means for assisting student learning in a design office situation. In broad terms, the study findings have suggested that the students gained entry to the design office culture of practice and acquired design knowledge and design skills used by expert building designers to create and refine solutions to complex design problems. The principal learning outcome for the students was that they developed autonomous ways of creating, visualising, exploring and resolving original design ideas. In developing those skills, the students also gained confidence in their use of information and design methods modelled by the mentors and developed multiple design perspectives in their application of innovative ways to resolve emergent design problems in ways that became their own design style.

This led most students to develop a strong sense of achievement and a strong sense of satisfaction and confidence in learning new skills and design strategies. The students underwent a transition from using simple design procedures to resolve commonly encountered design problems, to visualising, exploring and resolving design problems often using metacognitive strategies. Students increasingly used articulation to explain the reasons for design decisions they had taken when defending design elements or solutions developed by them. This method of design practice was often representative of the working methods used by the mentors to visualise, create and refine, innovative design ideas. Student adoption of this manner of design practice indicated their development of mastery of design, as used by expert building designers.

Research Question 2

What kinds of declarative knowledge and procedural knowledge is transferred in this (design office cognitive apprenticeship) learning situation?

Declarative knowledge transferred

Findings from this study have suggested that the students acquired declarative knowledge of many aspects of design practice, as well as other knowledge necessary for them to apply design procedures as modelled by the mentors. The kinds of declarative knowledge acquired by the students included knowledge about:

- climatic, geographical, geological and environmental factors that influence design;
- codes and regulations that govern building design practice;
- building construction standards and construction details used in frequently occurring situations common to a variety of building types;
- various sources of information such as legal interpretations and rulings about planning or design guidelines, as well as existing design solutions used by building designers as resources to create and refine new design solutions;
- reasons why expert building designers make particular choices when using heuristic design strategies to create and resolve design solutions; and
- roles played by experts in discipline areas associated with building design and how they influence and support the building design domain of practice.

Students acquired declarative knowledge from their mentors who provided them with explicit information about the organisation of the design office, availability of resources and the relationships that link the building designer's activities with associated disciplines such as engineering, electrical services, plumbing consultants and the like. Findings from this study showed that transfer of declarative knowledge of these kinds mostly took place using discussion and sketching. Extensive use was also made of "office set" contract documents for transfer of knowledge about design situations and methods used by experts to resolve design problems encountered by them in the various disciplines that together represent the building design domain of practice.

Mentor modelling of personal design preferences or elements led students to acquire declarative knowledge about:

- a broad range of design situations typically encountered by building designers in their usual culture of practice activities:
- the kinds of information assembled by expert building designers when preparing to use heuristic design strategies to develop solutions to problems emergent from the design process;
- the reasons given by expert building designers for using particular design strategies when addressing a range of different building design situations;

- multiple design solutions used by the mentors in various commissions covering a range of commonly occurring design situations; and
- the tools used by expert building designers to refine and present their design solutions in accordance with standards of practice determined by building design industry common practices.

Transfer of declarative knowledge took place simultaneously with transfer of procedural knowledge as the students developed their overall understanding of the problem situations addressed by building designers, the methods they use to resolve them and the reasons why they apply particular strategies or practices.

Procedural knowledge transferred

Students acquired building design knowledge and problem solving skills as modelled by the mentors. Transfer of procedural knowledge mostly occurred through mentor modelling and coaching during design office work sessions. Procedural knowledge acquired included the following aspects of design office practice:

- procedures for dealing with the everyday operations of a design office including management of personnel and resources such as:
  - technical information libraries including codes and regulations;
  - past project "office set" documents;
  - CAD based design element databases;
  - client brief documentation; and
  - contract documents for authentic commissions.
- protocols and procedures found in design office hierarchies including:
  - how to participate in team-based design procedures with other design office staff;
  - how to incorporate design contributions from associated discipline experts or consultants, regulatory authorities, local government agencies and the like.
- procedures used by experts to assemble and utilise a broad range of design resources including:
  - books, magazines, trade literature and advertising materials having images of aspects of design, colour, texture, construction materials which stimulated design ideas and solutions; and
  - drawing sets and photographs of completed design commissions covering a broad range of building design situations or other objects including furniture, cars and fashion items.
- procedures used by expert building designers to identify, in a new design commission, frequently occurring design situations and appropriate methods to resolve them based on commonly used solutions suitable for the emerging new design;
- methods used by expert building designers to create, explore and refine new design solutions through the application of heuristic design strategies and design office procedures including the "office set" overlaid drawing design technique and CAD based methods; and
- methods used by expert building designers to incorporate personal design style elements in new design solutions.

Research Question 3

How is tacit knowledge transferred in a cognitive apprenticeship learning situation?

Transfer of tacit knowledge took place in the following ways:

- the mentors verbalised their thoughts and their reasons for using particular courses of action when modelling their usual design practices and when coaching students in the application of these;
- mentors provided detailed descriptions of multiple design situations they regarded as typical or frequently occurring, the design problems encountered with these and the solutions that they and others had developed to resolve those problems in accordance with building codes and regulations governing standards of construction practice;
- mentors used exemplar "office set" drawings of authentic commissions to demonstrate procedures they used to identify common design situations and the procedures used by them to adapt commonly used design solutions to problems emergent from those situations;
- students undertook sequenced authentic design tasks of increasing complexity, with coaching by the mentors in the application of heuristic design strategies based on their design experience, with articulation and sketching being used to convey their reasons for using particular design methods or for taking design decisions;
- mentors' analysis of the student's own design project in terms of typical design problems and possible solutions based on others they had used in their everyday domain of practice;
- mentors and students using notes on sketches and drawings that provided a vehicle for the expression and exchange of tacit knowledge about design decisions and procedures used in the exploration and evaluation of ideas that led to their design solutions;
- students' defence of their own design solutions to others and having them suggest alternative procedures for resolving emergent design problems;
- student participation in construction site visits during which the mentors linked theoretical design knowledge to design solutions as seen constructed, while also explaining their reasons for the methods used as shaped by their design experiences and tacit knowledge of multiple similar situations; and
- student interaction with other designers and consultants from associated disciplines in design office work sessions and in informal ways as part of everyday workplace exchanges or in workplace social gatherings.

Knowledge transfer was facilitated through discussion, articulation and sketching being used together by students and mentors to exchange information and to express their interpretation of complex design situations and design solutions.

Research Question 4

If problem solving heuristic strategies are used, how are they picked up by the student?

Data collected here include many instances in which the mentors were observed using problem solving methods based on "rules of thumb" (Brown, et. al, 1989, p. 469) ways to resolve building design problems and other heuristic strategies based on their experience with resolving design problems in many different situations. Problem solving heuristic strategies, were modelled for students and demonstrated further in coaching sessions in the following ways:

- through modelling and coaching by mentors and other experts from supporting disciplines during collaborative work sessions in which the students and the mentors explored multiple design strategies and solutions as applied to the authentic student project they were undertaking;
- in construction site visit sessions in which the mentors demonstrated their design commission solutions and described in detail various aspects of the buildings along with the heuristic design strategies they had applied in developing the design solutions used for construction;
- in design office critique sessions where the students and the mentors defended their design methods and decision making, while also sharing multiple or alternative strategies for dealing with problems emergent from the students' authentic design project; and
- application by the students of the mentor's design office practices including preparation and research of materials, scheduling and sequencing of design tasks and procedures as modelled by mentors for creating, exploring, testing and refining design solutions.

Heuristic strategies were mostly implemented by the mentors and the students using quick sketching methods, as well as detailed over-sketching of "office set" drawings of exemplar design projects and of the students' own design drawings. Working in this way, the mentors reified their heuristic design strategies and demonstrated how they could be applied by students to their own design project problems. As part of this approach, the mentors also often simultaneously explained the reasons for using the methods being presented. In design office situations where the students worked with other staff on current commissions that were part of the mentors usual culture of practice activities, they also participated in design activities where heuristic design strategies were being applied by others. In this way, the students gained experience in the use of those heuristic design strategies, in the context of the domain of practice.

Research Question 5

What features of this learning situation promoted student learning?

The authentic design office situations used as the setting for the student/mentor collaborations provided many different opportunities for students to acquire design knowledge and skills. The one-on-one and sometimes multiple, mentor support that students experienced when tackling their design project provided them with opportunities to acquire knowledge and design methods used by experts as part of their usual practices. Student learning mostly took place by having expert building designers model and discuss in detail their ways for resolving design problems and by the mentors using their tacit knowledge and heuristic design strategies when coaching the students in their application of those knowledge and strategies to authentic projects.

Many features of this learning environment promoted and supported knowledge transfer. Three aspects of the study situation that promoted and supported knowledge transfer emerged from the study findings are used here to present those features. They are:

- design office culture of practice factors;
- design office facilities and resources; and
- work activities and practices.

Design office culture of practice factors.

These features were shown to promote and support knowledge transfer:

- acceptance and respect shown by the mentors and others for the student as a designer in the design office team;
- mentor commitment to the collaboration as demonstrated by preparation of resources, provision of back-up personnel and different learning opportunities such as site visits;
- implementing the student/mentor collaboration in a manner that replicated the working situation typical of the everyday culture of practice activities of the design office in which all parties contributed design ideas and problem solving strategies to develop a design solution;
- student observation of the mentor and others reifying design knowledge and practices while collaborating on authentic design office commissions within the same work-space as the student/mentor collaboration;
- student inclusion in design office tasks which enabled them to experience duties typical of design office practices as required of all design team members;
- social interaction with others in the design office which facilitated informal communication and transfer of less formal kinds of knowledge; and

- access to professionals from other disciplines who provided insights into business practices in the design office and also into the wider domain of construction industry practice.

Design office facilities and resources.

The availability of the following facilities and resources were shown to promote student learning:

- provision of a work station within the design office which provided ready access to other designers with whom the students could readily exchange ideas or from whom they could seek assistance which gave the students access to multiple points of view and different design practices;
- access to a vast array of resources such as a technical library, codes and regulations, sets of office commission drawings and files, CAD database resources and other materials typically used for design development which are not typically available in classroom based learning situations;
- access to computers, photocopying machines, reprographics equipment, drawing mounting and binding facilities which provided students with the means to develop and present their design works in the manner used by professional building designers;
- ready access to the design office for researching information and drawing production as offered by most of the design mentors; and
- extended mentor support during out of hours times as well as having access to design office support staff and other expert consultants from associated disciplines or expert services, as provided by some of the mentors.

Work activities and practices.

The following mentor supported design office activities and practices emerged as supporting and promoting student learning:

- frequent work sessions with mentor and others;
- student presentation and defence of design ideas and problem solving strategies;
- use of "office set" drawings as exemplars for creating design concepts, development, presentation and defence of design solutions;
- use of "office set" drawings to explore the evolution of building designs by reflecting on pathways explored before accepting design elements as part of final solutions;
- mentor use of methods to make the design process a guided journey of discovery to encourage student confidence and creative, innovative practices;
- mentor use of an extensive and diverse array of scaffolding materials;
- mentors reifying their creative design practices to encourage student visualisation and exploration of ideas to enhance metacognition;
- mentor and student use of questioning, reflecting and defending of ideas to develop multiple perspectives and design solutions;
- setting of standards by mentor assessment of student works using design office commissions to define industry standards and benchmarks for student performance;
- use of multi-staged, replicable procedures to resolve emerging problems in the context and culture of practice of usual design office methods;

- mentor sequencing of design tasks to avoid pushing students too hard for ideas in design so as not to discourage creativity;
- linking design solutions of exemplar commissions to the processes and procedures used to develop them in order to scaffold students over barriers to their progress created by problems emerging from the real work design project;
- placing emphasis on explanation building and reflection on the development path of design with exploration of all ideas shown through sketching and notes, backed up by articulation of the reasons behind the acceptance or rejection of the ideas presented to facilitate metacognitive ways for visualising and exploring design forms; and
- over-sketching of drawings to provide a visual audit trail of the ideas explored and to promote greater depth of design analysis and metacognition in design.

Summary Of Answers To The Research Questions

This study has found that the use of cognitive apprenticeship teaching methods by expert building designers in design office settings provided an effective means for assisting student learning. Findings here show that the students gained entry to the design office culture of practice and acquired design knowledge and design skills used by expert building designers to create and refine solutions to complex design problems. This gave them confidence in their autonomous use of ways for creating, visualising, exploring, resolving and presenting original design ideas.

The students acquired declarative knowledge necessary for resolving problems that emerged from authentic building design tasks. Knowledge acquired from interaction with the mentors and through participation in authentic design tasks covered a broad range of topics encountered by expert building designers in their everyday activities. These included explicit information about design situations, regulatory factors, usual design practices and the reasons for using various design strategies for particular problems. Much of what the students learned focussed on why and how expert building designers work in the manner that they do. This assisted students to apply procedural knowledge and to implement problem-solving methods when using heuristic design strategies.

Transfer of procedural knowledge mostly occurred through mentor modelling, coaching and scaffolding during design office work sessions. The kinds of procedural knowledge acquired by students focussed on the use of everyday design office practices. These included the management of design projects, protocols for dealing with associated discipline professionals in the building designer domain of practice, managing and using design resources and the application of heuristic design strategies with common design office procedures for resolving building design problems.

Students in this learning situation also acquired tacit knowledge from the mentors. Transfer of tacit knowledge mostly took place by the mentors verbalising their thoughts during work sessions in which they modelled design methods and coached students in the use of heuristic design strategies. A key part of the mentors' reifying their tacit knowledge was their use of detailed descriptions of various design situations they had experienced and their reasons for using their particular strategies or solutions. As well as these descriptions, the mentors also used a diverse range of scaffolding materials and methods including sketches and sets of drawings to illustrate each of the situations and solutions that they presented. In so doing, the mentors provided rich verbal and visual images to confirm their tacit knowledge of a broad range of building design practice. The mentors also encouraged the students to use this approach to defend their design solutions by expressing how those solutions had evolved and why particular design methods or decisions had been adopted.

Mentor modelling of their heuristic design strategies followed by coaching students in their correct application led to the students adopting for use in their own projects. The use of heuristic design strategies was often confirmed by the mentors by using visits to construction sites to demonstrate outcomes from design office practices and in critique sessions with students in which design strategies and decisions were presented and defended by the students. Application of mentor modelled heuristic design strategies by students led them to acquire those methods for their own use and to adapt them as needed to resolve problems that emerged from their authentic design tasks.

Student learning in design office situations where cognitive apprenticeship methods are used was influenced by many factors. These were grouped into three broad areas that I regarded as promoting student learning in this situation. The three areas were: *design office culture of practice factors; design office facilities and resources;* and *activities or practices used to promote learning and knowledge transfer*. When used together, these elements provided a learning environment in which students acquired from building design mentors ways for resolving design problems typical of the manner used by experts in their everyday culture of practice activities.

DISCUSSION OF THE STUDY FINDINGS

Having already provided answers to the research questions, a discussion of the overall findings is now presented with particular reference to the teaching strategies of the cognitive apprenticeship learning approach that underpins this study.

In this study, data were collected about the learning experiences of a group of students working on authentic design projects, in real design office settings, with expert building designers acting as their mentors. The mentors were initially regarded by me to broadly use cognitive apprenticeship (Collins, et al., 1989) teaching strategies. As the study progressed, this was confirmed through their particular use of modelling, coaching, scaffolding and fading, articulation, reflection and exploration in their work sessions with the students. The authentic design projects undertaken by the students were organised by the mentors to replicate their usual professional practices and applied by them in the context of the building design discipline domain. This approach utilised a learning situation structured in accordance with principles suggested by Schön (1983), who contended that much learning occurs as professional practitioners engage in every activity of their everyday world.

The authentic nature of the design office situations of this study meant that students worked in settings where professional designers applied specialist knowledge and sophisticated mental models in the social and cultural context of their usual practices. This allowed students to construct their domain expertise, in ways similar to that suggested by Hennessy, (1993).

All of the mentors who participated in this research were recognised by their professional organisation, the BDA, as being experienced experts in the field of building design, a profession that demands highly developed verbal and visual communication skills. Most of the mentors who participated in this study were invited to do so because of their previous classroom experience with buildiog design students.

Good communication skills and teaching experience were regarded as valuable attributes for the participating mentors because successful mentor interaction and communication with students was central to the student/mentor collaborative working situation. Their communication skills and interactive working practices based on commercial design office methods, provided an appropriate basis for learning using cognitive apprenticeship methods. In support of this view, Casey (1996, p. 82) contends that cognitive apprenticeship is heavily dependent on the ability of an expert to interact with the learner by: "modelling expert practices, observing student performance, supporting performance through scaffolding and fading of support as performance improves". This was clearly evident in data collected for this research.

From the outset of this study, most of the mentors extended, to the students, designer status. Working in this way meant that in all of their design office interactions, the students experienced the authentic culture of practice events in ways typical of the mentors' usual practices. This approach is in keeping with that proposed by Resnick (1987) who contended that authentic learning must involve situations where actual cognitive processes are involved rather than simulated processes as found in many classroom situations. Authentic experiences used as the basis of design tasks in this research study setting facilitated the students' enculturation (Collins, et al., 1989) into the mentors' culture of practice through authentic activities and social interaction (Wilson, 1993).

The study situation used here facilitated learning through cognitive apprenticeship methods by making visible to the students the largely tacit knowledge possessed by the mentors about design and problem solving procedures. Findings that emerged from this study have suggested that some of the mentors approached their work with the students by taking them on a guided journey of discovery. This, some mentors said, assisted students to deal with authentic tasks in the context and culture of everyday design office practices.

Most of the mentors commenced their work with the students by introducing them to typical design office methods for assembling resources appropriate to the design project described by the client brief. The mentors then modelled for the students their design methods and coached them in the application of those methods to the students' authentic design project. By working in this way, the students were provided with experience based learning situations in which they used self-evaluation and reflection when defending their design endeavours. The authentic experience-based learning situation allowed students to construct their knowledge about expert practices in ways that were modelled by the mentors (Kaufman, 1996).

This study has found that the cognitive apprenticeship situation developed in the design offices provided mentor support for progressive transfer of responsibility to the students for their own learning in ways similar to that suggested by Palinscar & Brown (1984). Collaboration between the students and the mentors also provided situated learning opportunities giving students critical opportunity to observe, engage in, or invent expert strategies in context (Hennessy, 1993; Collins, et al., 1989). The students then applied strategies they had learned to authentic tasks with the aid of mentors, in the design office culture of practice of the study setting. In this way, the students became engaged in authentic, meaningful real work design project tasks. This led them to develop design expertise within a cognitive apprenticeship framework, implemented using collaborative mentor/team-based office activities (Hennessy, 1993; Pieters & de Bruijin, 1992; Brown et al., 1989). It also facilitated student development of personalised ways for solving design problems and helped them to acquire declarative and procedural knowledge of design methods. This took place through activities situated in the usual context of their use by mentor supported "learning-through-guided-experience on cognitive and metacognitive, rather than physical, skills and processes" (Collins, et al., 1989, p. 457).

What has emerged from this research?

This study sought to determine the learning outcomes for students in a cognitive apprenticeship situation, to understand what kinds of knowledge were acquired by those students, what heuristic strategies were learnt and what was it in the study situation that facilitated student learning. In the Collins et al. (1989) model, some learning content is considered as strategic or tacit knowledge and this underlies an expert's ability to make use of concepts, facts and procedures to resolve problems emerging from authentic tasks. It also includes problem solving strategies and heuristic strategies used by experts when solving emergent problems in the context of their usual practices and when exploring new concepts (Collins, et al., 1989).

In this research the domain knowledge of the expert building designers, acting as mentors, was grounded in the discipline of their practice and included explicit factual knowledge and procedures used by them to solve problems in the context and manner of their usual culture of practice activities. Heuristic design strategies gave students discipline specific ways of dealing with problematic situations that emerged from the real work design project. These were used by the mentors in the manner of "tricks of the trade" (Collins, et al., 1989, p. 478) that had been tacitly acquired by them through professional experience in the domain. For example, one mentor coached students under his direction in the use of CAD based pre-drawn design elements to rapidly develop multiple design solutions without regard for closure of the geometry, in order to explore broadly before defining the final form of the design. Heuristic design strategies like this were used by all of the mentors, but in individualist ways.

Much of what was observed as mentor use of heuristic design strategies here pertained to managing problem solving in building design. This occurred through reflective work practices and the sequencing of design tasks as scheduled by the mentors. This approach gave structure and formality to the development of cognitive processes by setting the strategies in the context of the domain, thus making them purposeful through student application, which enhanced their understanding of their role (Choi & Hannafin, 1996).

Each of the six key teaching strategies of the cognitive apprenticeship learning approach used for the conceptual framework of the study are now discussed with reference to findings and pertinent literature.

Modelling.

Modelling in this study involved mentor demonstration of design strategies and procedures used by them in their everyday culture of practice activities, as applied to the authentic tasks of the students' design projects. The approach taken by most of the mentors when modelling their usual work practices provided highly visible representations of their tacit and procedural knowledge of building design. This method of presenting information, processes and procedures in the context and domain of expert practice is fundamental to the Collins et al., (1989) cognitive apprenticeship learning model. Brandt, et al., (1993) contend that cognitive apprenticeship can only be successful when someone can perform ways of dealing with tasks to be learned in real life, this being clearly evident in emergent findings here also. During Phase Three of this research the mentors were observed interacting with the students by modelling their manner of dealing with complex cognitive problems that emergent from the authentic situations being resolved in the context and culture of their usual practices (Casey, 1996).

Findings from this study indicated that the mentors, when working with students individually or in collaborative teams, used modelling to demonstrate a structured approach to design. When modelling their design methods, the mentors often gave explanations for using particular practices by verbalising their reasons for working in the manner that they did. This enabled the mentors to introduce and demonstrate ways for resolving tasks using typical design office practices such as the "office set" approach to design.

In addition to modelling practices that externalised cognitive processes and activities (Collins, et al., 1989), the mentors also incorporated modelling into almost every aspect of their collaborative activities with the students. From the study outset, the mentors modelled elements such as appropriate behaviours, language, dress standards, technical vocabulary, professional attitudes and respect for others within the hierarchical structure of their organisation and the broader design industry. Findings that emerged concerning all of these aspects of the study indicated that this helped students to acquire knowledge and skills and gave them entry to the building design office culture of practice. Much of this learning took place as a process of "enculturation" (Brown et al., 1989) as the students observed how the mentors behaved and talked with others in their professional working culture.

While observing and working collaboratively with a mentor, many students in this study also worked in the design office as part of larger design teams and had experience of the working practices of consultant experts from associated disciples. Through such experiences, the students were provided with many examples of work practices, explicit knowledge and problem solving strategies, as modelled by experts from other discipline contexts and having multiple design models and perspectives. Interaction with consultants from disciplines associated with the mentor's building design practice provided models of the links to other professions that exist in the wider community of practice of design and construction. Although the students were often only informally involved in much of what took place with consultants in the design office, the social interaction taking place around the students allowed them to acquire knowledge through situated opportunity (Brown, et al., 1989) brought about by their proximity to others interacting in the domain (Duncan, 1996).

Three elements of modelling emerged as being highly effective in knowledge transfer in the design office situations in which the students worked with the mentors.

The first aspect is that of mentors (and later the students) explaining their thought processes and reasons behind design practices or decisions by verbalising their thoughts about how and why they work in the manner that they do. Verbal exchanges between designers consultants and clients, when discussing the reasons behind design decisions were for many students a source of valuable information applicable to their own design tasks. It also provided them with information, domain specific expressions and common practices that assisted their communication with others and supported their entry to the design office culture of practice as they were drawn into such exchanges or discussed them with their mentor later.

The practice of verbalising while modelling their design practices was observed to be an effective means used by the mentors and the students to reify their tacit knowledge, problem solving strategies and personalised design style preferences. Mentor use of highly descriptive language when discussing real design situations and when articulating their views and problem solving strategies also emerged as a vital element in student learning. The use of this approach allowed mentors to reify for students the reasons underpinning how they solved complex problems in the context of their usual culture of practice activities as described by Jarvela, (1995).

The second vital element of modelling used by mentors was sketching. Freehand sketching and over-sketching of hard-line or CAD drawings was extensively used in every student/mentor design office collaboration studied here. Sketching emerged as the principal tool used by building designers for the creation, exploration, development and communication of design concepts, emergent problems and possible solutions. Whenever sketching was used, it was always in concert with rich descriptive explanations of the reasons underlying design decisions or problem solving strategies, as well as personal points of view or design preferences articulated by the mentors and later also by the students. Sketching made visible aspects of abstract concepts or ideas and allowed rapid exploration of multiple perspectives or design solutions for a given situation, thus allowing the study participants to "criss-cross the knowledge in numerous ways" (Casey, 1996, p. 76).

The highly interactive nature of the student/mentor collaborative work sessions was characterised by the use of verbal/visual communication methods for the rapid demonstration and exploration of ideas. Throughout the study the mentors' use of modelling constantly shifted to coaching and back to modelling as they introduced ideas and strategies used by them in authentic design commissions. The mentors then acted to coach students in the application of those ideas or strategies in the context and culture of the tasks at hand. This approach I regarded as facilitating the students' conceptualisation of new design forms and their exploring new aspects of these. This approach is in keeping with a cognitive apprenticeship (Collins, et al., 1989) learning style because it incorporates concrete experience, reflective observation, conceptualisation and active experimentation (Dinmore, 1997; Kolb, 1984).

Articulation and sketching were used together as communication tools in modelling of heuristic design strategies, concepts and problem solving methods typical of the mentors' everyday culture of practice activities. They provided the means for transfer of explicit declarative knowledge and procedural knowledge from mentors to students as they worked collaboratively on a real work design project. As the students acquired design and communication skills during their collaboration with the mentors, the work sessions became more interactive with less modelling by the mentor and greater input from the students. The communication facilitated by all of the participants using articulation, discussion and sketching as an integrated tool for the expression and exploration of ideas enhanced interaction between the parties and allowed negotiation of meaning and a frame of reference for the context of the work domain. This interaction indicated a growth of reciprocal understanding between the students and the mentors and self-directedness by the students in their development of metacognitive skills in ways similar to those reported by Jarvela, (1995).

The third aspect of modelling to emerge, as a key learning element was the use of authentic task examples, practices and procedures in all modelled aspects of design practice presented by the mentors. Authentic activities were said by Collins et al., (1989), to develop understanding through social interaction and collaboration in the culture of authentic domain activity. They contended that student learning is enhanced through observation with guided and supported practice along with feedback for the development of cognitive and metacognitive skills (Collins, et al., 1989). Findings from this study support the Collins et al. (1989) approach to learning. The six key teaching strategies of the cognitive apprenticeship approach used for the framework in this research are well supported by the evidence that emerged from analysis of the study data.

In every student/mentor collaborative situation investigated here, the mentors made extensive use of past authentic design office commissions to provide exemplars of their usual practices in design, problem solving and presentation. All of the tasks required of the student/mentor collaborative teams were authentic real work design project based and evaluated by practicing design experts to industry established standards.

Findings here have suggested that student performance was enhanced when they explored multiple solutions by applying real work based design and problem solving strategies they had seen successfully used by the mentors when modelling their own authentic design commissions, an approach supported by Jarvela, (1995). Student acquisition of explicit knowledge and heuristic design strategies modelled by mentors using exemplar design office commissions was expedited by the links made visible by mentors reifying their work practices when addressing problems emerging from the students' authentic design project (Baird & Fetherston, 1999).

Another aspect of using authentic design office commissions as exemplars when modelling usual practices was the mentors' inclusion of students in visits to works under construction, which they had discussed earlier with the students during work sessions. In some instances, consultant discipline experts, builders, or other designers also accompanied mentors and students on site visits. During these visits the mentors provided detailed explanations about the design and construction detailing. These site sessions provided concrete evidence of outcomes from design decisions made and discussed in the office, with the advantage of having the real form there to see successes and failures. The immediacy of feedback from the mentor and others on site provided ready transfer of knowledge and strategies used in the development of a design and encouraged discussion and exploration of ideas.

Coaching.

Coaching, in the cognitive apprenticeship approach to learning proposed by Collins et al. (1989, p. 481), is considered to be about:

> "...observing students while they carry out a task and offering hints, scaffolding, feedback, modelling, reminders and new tasks aimed at bringing their performance close to expert performance."

In the student/mentor collaborative situations studied here, coaching mostly took place as part of the work sessions in which the students and the mentors together resolved the real work design projects. Coaching also took place in the design office as part of the everyday practices of the mentor and other design staff when working with students in an incidental manner or when addressing minor issues arising from the students' design development. In situations such as this, the mentors provided the students with coaching and advice to assist them to learn by building on what they already knew, using tips and tricks and new knowledge or techniques (Choi & Hannafin, 1996). In this study, the methods used to coach students through their design and development of a real work design project were focussed on guiding and advising them so as to maximise their use of cognitive skills and resources and to develop decision making processes and problem solving strategies. This approach is similar to that proposed by Tobin & Dawson (1992) and that of Casey (1996) who contended that coaching needs to occur in highly cooperative, interactive learning environments in order to be effective.

The extensive use of discussion and articulation by mentors in the design office situations examined here mostly centred on explaining the reasons why and how the mentors make decisions when resolving authentic complex tasks. This approach parallels findings by Casey (1996, p. 78) who said:

> "...the only way to get learners to verbalise and thoroughly surface internal processes seems to be through a cooperative learning environment in which they talk with their peers".

In this study, the students were afforded designer status by most of the mentors and others in the design office who often treated them as peers in the team-based work situations there. This provided the students with opportunities to verbalise their thoughts about problems that emerged from the design tasks and strategies they had used to resolve them.

The student/mentor collaborative work sessions were characterised by an ever shifting balance between modelling and coaching, as the students' needs changed according to the information, skills and strategies needed at any one time. When coaching took place, it mostly took the form of mentors assisting students to apply heuristic design strategies and problem solving methods to their own design problems, but shaped by the context and culture of the mentor's usual practices. In this way, the mentors were able to clarify, describe, compare, negotiate and reach consensus on the meaning of various experiences they shared with the students (Hooper, 1992) pertaining to the tasks at hand, while operating as they normally would with another designer.

A key feature of the coaching methods used by all of the mentors studied here was their thinking aloud (Dinmore, 1997) when articulating personal thoughts concerning multiple perspectives, problem solving strategies, or solutions to the tasks at hand. This was often done in tandem with sketching to illustrate the ideas being discussed and questioning the students to involve them in the works.

The very focussed nature of the working collaborations formed in the student/mentor teams created a highly interactive environment for the exchange of ideas and for learning design practices. The building design discipline brings together creative skills and technical processes each with its own cognitive demands and discipline specific elements such as style in design and CAD practices for technical aspects.

Some aspects of coaching used by the mentors studied here were shaped by parts of the design discipline or other unique aspects of the study situation that required particular coaching practices. Coaching was observed to almost always involve some modelling by the mentors and the use of detailed explanations to reify the reasons for working in particular ways. Often when coaching, the mentors used explanation building to detail the reasons underlying design processes and decisions they made as influenced by their professional design experiences. This usually took the form of verbalisation to articulate personal thoughts about the tasks being addressed while using sketching to provide visual explanations for the verbal images being presented.

This approach to coaching promoted visualisation and communication of ideas or concepts. When using this approach, most of the mentors also used a broad range of design office resource materials to stimulate a lateral approach to thinking about design. In this way, the mentors guided students through difficult design elements and procedures using a structured approach to apply heuristic design strategies and methods. During coaching sessions, the mentors encouraged the students to reflect on the development path taken and the design ideas that had emerged. This process led to student exploration of new design ideas that stemmed from earlier concepts, as documented in the "office set" which provided and audit-trail of design development.

Although much of what took place in the student/mentor collaborative work sessions involved intense one-on-one activities, coaching was not just restricted to that situation. Other designers or consultants from associated disciplines, provided as-needed and often informal coaching that was also important to student learning. Most of the materials used b the study mentors to coach students were based on authentic design office commissions, professional practice experiences and current real work projects.

Throughout the development of the students' authentic design project, most of the mentors emphasised in their coaching the vital role of exploration and reflection in design, for the development of multiple solutions and multiple perspectives for any given design situation. In this way, the students were encouraged to evaluate their own works and to model for the mentors the ideas created and their thoughts in exploring all possible variations on those ideas at a metacognitive level. The highly interactive exchanges observed during work sessions between the mentors and the students indicated the development of reciprocal understanding between the participants as the students increased their use of metacognitive ways to resolve problems that emerged from the real work design project. Optimal social interaction in the student/mentor collaborative working situations observed here was enhanced by mentor use of progressive scaffolding that enhanced student self directed learning, an approach similar to that proposed by Jarvela (1995).

The complex, multi-faceted nature of building design demands a broad understanding and declarative knowledge of many interrelated facts about situations, regulations and construction details. McInerney & McInerney (1994, p. 210) consider declarative knowledge to be what we know about the world and "hypothesised to be structured as an interrelated network of facts that exist as propositions". When considering the diversity of information and the complex relationships that determine how some elements of a design situation affect others, the interactive nature of coaching becomes more important as new situations constantly evolve during the design processes. In addition, the transfer of procedural knowledge, "knowing how to perform various cognitive activities" (McInerney & McInerney, 1994, p. 211) becomes more complex as usual practices are modelled by mentors, then implemented by students with coaching by the mentors until independent interpretation/application is achieved.

The success of the coaching methods used by the study mentors was partly due to the sequencing of design activities introduced by them with materials that facilitated the students' gradual progression through the real work design project. This coincided with the students' development of metacognitive skills as needed to resolve problems as they emerged from the ongoing design process. As the students developed their knowledge and skills, the mentors introduced new design tasks of increased number and complexity to address all of the issues found in the real work design project. Throughout this process, the mentors coached the students in ways to resolve emergent problems and to implement strategies enabling them to operate on metacognitive levels, free from the contextual bindings of the tools level individual elements of the design situation (Collins, et al., 1989).

Scaffolding and Fading.

Prior to the development of the Collins et al., (1989) cognitive apprenticeship model for learning, the use of scaffolding to assist learning had been explored by many other researchers. For example, Scardamalia & Bereiter, (1985) and Scardamalia, Bereiter & Steinbach (1984) investigated the use of physical supports in what they described as Procedural Facilitation. Palinscar & Brown (1984) reported on the use of suggestions or help in reciprocal teaching. In an earlier study, Scardamalia & Bereiter (1983) discussed the use of scaffolding to assist learning as part of a technique called co-investigation. Scaffolding in the Collins et al. (1989) model is considered to be one of the three (*modelling, coaching, scaffolding*) core teaching strategies of a cognitive apprenticeship approach to learning. Collins et al. (1989, p.482) proposed that scaffolding "refers to the supports that the teacher provides to help the student carry out the tasks".

Findings that emerged from this study have suggested that scaffolding mostly took place concurrently with modelling and coaching activities and was observed to take many forms including:

- physical materials to expedite resolution of design elements or to stimulate metacognitive design visualisation and resolution; and
- verbal assistance from mentors, from consultant discipline experts, or other design office staff, in the form of "tips and tricks" to boost understanding and visualisation of problem situations and potential solutions or strategies for resolving them.

The content, nature and timing of the many different scaffolding methods observed in use here was governed by mentor perceptions of student needs as seen by their progress with the real work design project and the level of cognitive skills they were using to resolve emergent problems. This aspect of scaffolding is closely linked to the sequencing (Collins, et al., 1989) of learning events so as to make available to students information and procedures to keep their cognitive development ahead of elements in the learning situation that represent barriers to their progress.

Findings to emerge here suggest that as students acquired knowledge and skills that allowed them to work with greater autonomy at each level of design practice, scaffolding was gradually withdrawn by the mentors and others. Progressive fading (or withdrawal) of scaffolding is an important aspect of learning in a cognitive apprenticeship situation.

In this study, scaffolding took many forms, was introduced by the mentors from the outset of the first student/mentor collaborative work sessions and continued throughout the entire study as an integral part of the culture of practice through social interaction and defined work practices. This approach to using scaffolding to support learning was reported by Casey, (1996), Carver, (1995), Jarvela, (1995), Berryman, (1991) and Collins, et al., (1989), as being successfully applied in studies conducted by them involving cognitive apprenticeship methods.

Greenfield (1984) contended that scaffolding closes the gap between task requirements and skill levels by creating the match between the cognitive level of the learner and the characteristics of the instruction. He also reported that observed guided instruction using timely scaffolding elements was enhanced by the teacher/mentor being cognisant of the student's cognitive skill levels in order to provide appropriate support. An extensive range of materials and techniques was used by the mentors who participated in this research, to scaffold student learning. Findings here have suggested that mentor use of scaffolding in the design office situation mostly occurred when students encountered difficultly with specific aspects of design and when they needed new design strategies or problem solving methods in order to progress beyond the level of design skills that they had already attained. This use of scaffolding has its roots in the concept of the zone of proximal development proposed by Vygotsky (1962).

The very nature of the building design discipline demands multi-faceted skills in creative, artistic contexts and in technical contexts. Scaffolding methods and materials used by mentors to assist students to overcome problems that emerged during their resolution of a real work design project were in some instances global stimulants to encourage imaginative creativity and in others, specific task focussed methods for dealing with details, design processes or replicable procedures. Numerous scaffolding elements were geared to the usual culture of practice activities of the design office and occasionally methods/items of a non-contextual nature, like fashion magazines were used to encourage innovative ways of solving emergent problems.

As the students' skills improved and they were regarded by the mentors to be able to work with greater autonomy, scaffolding was faded or withdrawn (as discussed on page 108 of this thesis) as reported in other studies using cognitive apprenticeship (Choi & Hannafin, 1996; Rogoff & Gardner, 1984). Careful monitoring of this process by the mentors ensured that the students remained on track with their design work. This was achieved through frequent design evaluation meetings organised as per the usual practices of a design office and through questioning. The mentors used questioning with students to ensure that they could defend their design decisions and could demonstrate exhaustive exploration and evaluation of all design elements they had incorporated in their works. Where students were not able to justify their design decisions, the mentors used coaching and scaffolding to introduce information and procedures with which the students could diversify their design approach to include other perspectives, heuristic design strategies, or solutions. This approach is similar to findings reported by Hennessy (1993, p. 31) who contends that the teacher should "assist the students to access and use their prior knowledge appropriately in solving problems in the new domain under mastery".

One aspect of undertaking authentic design tasks involves accountability to design process time-lines. Part of the mentor sequencing (Casey, 1996) of tasks to have increasing complexity, increasing diversity and the development of global before local knowledge and skills (Collins, et al., 1989) involved the use of design office schedules. These were used by mentors to scaffold student learning by bringing to the design process, structure, time frames, tasks and goals. Using schedules enabled the students and the mentors to keep track of the design process, quickly identify problems presenting barriers to student progress and to put in place scaffolding appropriate to the problems encountered. Schedules used in this manner assisted the mentors to maintain awareness of student progress and to match their development level in the design to new stages of the work to be done, in a manner that aligned learning experiences with intended outcomes (Hennessy, 1993; Simpson, 1988). For many students, the schedules often provided a concept map of their progress and tasks to be addressed and as such became an advance organiser for their learning.

The different methods used by the mentors in this study to assist student learning formed I believe part of a cycle of learning in which modelling, coaching and scaffolding became an integrated vehicle for knowledge transfer and the acquisition of metacognitive skills. Figure 44 (p.299), below, shows the interdependence of these three teaching strategies to knowledge transfer in the authentic situations used in this research.

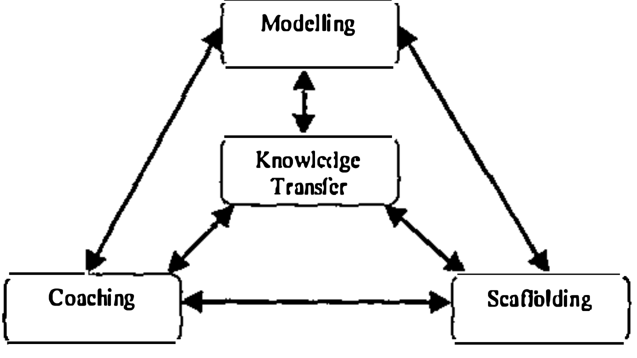


Figure 44. Knowledge transfer using Modelling, Coaching and Scaffolding.

The learning environment developed in the mentor supported design office situations studied here assisted the students in having control over their own learning processes and the confidence to engage in critical analysis of their own works. Student development of higher cognitive processes in building design in this study was born out of cognitive activities experienced by them in the social context of an authentic design office situation and extended by their shared cognitive experiences with experts in the domain. This has its roots in the learning theories of Vygotsky (1978) and echoes the model of cognitive apprenticeship presented by Collins et al., (1989).

Articulation.

Articulation and reflection are paired by Collins, et al., (1989, p. 481) as teaching methods designed to help students to "focus their observations of expert problem solving and conscious access to (and control of) their own problem solving strategies". In the situations studied here, the very focussed nature of the one-on-one student/mentor collaborative work sessions provided excellent opportunities for the articulation of personal views and problem solving strategies. Observation of student/mentor collaborative work sessions revealed extensive use of articulation by the mentors and the students, usually supported by sketching and often in conjunction with the use of "office set" documents to confirm ideas aired, or demonstrate application of strategies proposed. As the students gained confidence and acquired knowledge and skills to develop their own building designs, the balance of articulation used in the work sessions shifted from mostly mentor based to mostly student based. This took place in response to mentor questioning of students to encourage them to externalise their thought processes as they implemented problem solving strategies using metacognitive design processes (see comments by Student 13, p. 160). Solving emergent problems in this way encouraged student learning through knowledge transfer and problem solving strategies embedded in one context, then applying them in multiple contexts that emerged from authentic situations embedded in complex projects rather than isolated elementary situations. This approach is founded on the elements of situated cognition (Brown et al.,1989) and as incorporated by them in their cognitive apprenticeship model.

Articulation during problem solving and debriefing sessions was reported in a study by Cash et al. (1997). In that study, the researchers noted the importance of student articulation of their thought processes when using problem solving strategies and diagnostic skills to resolve problems emergent from authentic tasks. Evidence of this emerged also in this research study. In a different study that has parallels with this one, Scardamalin & Bereiter (1983) reported that student use of articulation and reflective practices prompted by mentor scaffolding assisted learning during co-investigation. They found that students reflected on their own knowledge and constructed new meanings in the context of the domain after reflecting on design practices articulated by the mentor. This study also supports their findings. Here the students were observed exploring new approaches to design after reflecting on design elements introduced and explained by the mentors as part of their current design office commissions.

Casey (1996) reported that student use of articulation supports students in demonstrating their mastery of new tools and knowledge. Evidence of this emerged in data from observed work sessions in Phase Three where open discussions with the mentors and others in the design office provided a forum for the expression of personal views and design strategies. Debate and personal contributions from others in such a forum provided students with multiple perspectives for reflective evaluation of their own works in the context of the domain. This also enabled the students to compare problem solving strategies or solutions offered by experts with their own methods and to focus on differences at a finite level (Casey, 1996).

The mentors studied here modelled many heuristic design strategies for the students to use in resolving problems that emerged from the real work design project. The mentors backed up their use of such strategies by articulating their reasons for using them as they did. This approach is similar to that articulated by Schoenfeld (1987) when using rules of thumb to deal with frequently occurring problem situations, or tricks of the trade.

The use of articulation emerged as a feature common to all the student/mentor collaborative work partnerships observed in the design office situations studied here. Articulation was used to convey individual interpretation of information and procedures used in design. It was also used for the expression of personal thoughts or points of view pertaining to work practices and design style when reflecting on decisions taken and pathways followed in the creation and development of authentic design solutions. Articulation was used by the mentors and students to reify personal knowledge and procedures, derived from authentic design experience in the physical and social context of the domain.

Findings from this study have suggested that student learning was enhanced by mentor articulation of personal strategies used to resolve design problems, thus making visible their experience based tacit knowledge that provided a means for knowledge transfer to students in the context of application in the mentors' culture of practice.

Reflection.

Reflection as a teaching strategy is described by Collins et al. (1989, p. 456) as the process that "underlies the ability of learners to compare their own performance at both micro and macro levels, to that of an expert". They also contended that by using reflective practices, students can develop a conceptual model of their learning that can be continually updated through further observation and feedback which encourages learning autonomy. Through ongoing exploration and reflection on learning experiences and methods modelled by mentors, students diagnose difficulties and "incrementally adjust their performance" until they reach competence (Collins, et al., 1989, p. 456). Collins, et al. (1989, p 473) also contended that student use of reflective practices enhances their "self monitoring and self diagnosis skills" and this enhances their ability to articulate their reasons for working in the manner that they do. Through this process the students gain control over their reflective and metacognitive processes in their problem solving.

Findings from this study support these contentions and showed that reflective practices were used by the students and the mentors throughout all phases of the design process. Student use of reflective practices assisted their focus on emerging design solutions and the strategies they had applied to resolve them. This use of reflective practices throughout the entire design process is similar to that reported by Carver (1995, p 208) who contends that "the key is to focus student reflection on all phases of the process, not just the final presentation". Reflective practices used by students and mentors led students to investigate fully, emergent aspects of the design solutions being developed and to reflect on practices modelling by the mentors when dealing with similar problem situations emergent from authentic design projects. Collins et al. (1989) advocated two strategies to promote reflection. They are the comparison of expert and novice performances on problem solving processes and students' self-analysis of the process. Both of these practices occurred during the work sessions when the mentors monitored the students' design performance by comparing the students' works with exemplar design solutions of the mentor's own projects. The mentors then provided explicit instructions to the students about how to apply heuristic design strategies used in design solutions presented in exemplar drawings, to the students own emerging design solutions by reflecting on pathways followed and ideas explored. Findings here show that student use of reflection, supported by explicit instruction by the mentor to address emergent problems assisted student learning by helping them to resolve design solutions. This learning outcome is similar to findings reported by Carver (2000, p. 5) who contends that "short-term explicit instruction can promote student learning, transfer and retention". In this study, the mentors encouraged the students to constantly reflect on the design pathways and solutions they had explored and to self-assess the suitability of the solutions being developed for inclusion in a final design proposal. They also provided the students with explicit instructions about using heuristic design strategies to resolve problems that emerged from their reflection on different aspects of the designs being developed. The combination of student reflection on the design process and mentor instruction in ways to address emergent problems led to student acquisition of problems solving strategies and tacit knowledge based on their own design experiences when applying the mentor's strategies. This aspect of their learning I regard as a vital part of the student's development of metacognitive design skills and the main means by which they progressively refined their design solutions while working with greater independence from the mentor.

The common design tool used by most of the students and the mentors in the design office situations of this research for reflecting on pathways followed in the development of design solutions, was the "office set" of drawings. These drawings provided rich sources of information and visual representation of heuristic design strategies implemented with problem solving procedures applied by mentors in the context and culture of their usual design practices. The use of the "office set" by students when reflecting on their own work and when articulating the reasons for design decisions made or practices adopted, situated their learning firmly in the context of practice. It also facilitated reflective exploration of design elements which led to their development of multiple perspectives of authentic situations from which domain specific knowledge was transferred into other settings or design applications (Choi & Hannafin, 1996).

Findings here have suggested that use of the "office set" enhanced the students' higher order thinking skills and the development of metacognitive design methods thus facilitating their transition from novice to skilled designer, in a manner similar to that reported by Choi & Hannafin (1996). Student development of their own "office set" drawings allowed them to reflect on and compare their design ideas and solutions with those modelled by mentors in authentic commission "office set" documents. This enabled them to evaluate their own works and to focus on differences at a finite level (Casey, 1996). The use of "office set" drawings to demonstrate outcomes from the students' cognitive design processes also facilitated student reflection on their own performance when using problem solving processes. This was observed to occur when students compared their design solutions with those modelled by the mentors. Mostly this took the form of "replaying the performance of both expert and novice" in the design work sessions in which the students defended their design solutions (Collins, Hawkins, & Carver, 1991, p. 224). In those sessions, the students demonstrated for the mentor their use of heuristic design strategies and, in reply, the mentors modelled their ways for applying those methods to the same problems. I regard the use of reflective practices in this way to have assisted students to acquire enhanced visualisation skills and to acquire metacognitive ways to conceptualise and resolve design problems. This was possible because it provided a means for students to "compare their performance with that of others" in the context of expert building design practice applied to authentic tasks (Collins et al., 1991, p. 228).

Findings that emerged here about the use of reflective practices by students and mentors suggest that this helped in facilitating student transition from simple application of the vocabulary and tools of design, to using metacognitive ways for exploring and refining design solutions. Student use of advanced sketching methods and rich description of their thought processes when reflecting on their application of heuristic design strategies in work sessions with the mentors towards the end of their design project was said by some of the mentors to signify their use of advanced design methods. It also provided evidence of their use of reflective practices as part of their development of creative, innovative design practices methods typical of the culture of practice activities used by expert building designers.

Exploration.

In the Collins et al. (1989, p. 481) cognitive apprenticeship learning model, exploration is regarded as a teaching strategy "aimed at encouraging learner autonomy". Students, learning in a cognitive apprenticeship situation as proposed by Collins, et al. (1989, p. 483), are "pushed into a mode of problem solving of their own", forcing them to explore. This, they proposed, is the natural culmination of the fading of supports (modelling and scaffolding) thus forcing the students to go it alone after having first acquired the basic skills to explore in the domain and act on what they find.

From the outset of this study, the mentors encouraged the students to explore multiple design ideas in their quest to develop solutions to problems that emerged from their authentic design projects. This, the mentors did by first modelling ways for assembling and evaluating a diverse range of materials and techniques that they used in their everyday culture of practice activities. Then the mentors coached the students in the application of those resources and design methods to their design project. Having established the resources and the tools necessary for the students to develop design solutions, the mentors then encouraged the students to work in more independent ways to explore multiple variations of potential design solutions before accepting any elements as part of a final design presentation. This approach was mostly implemented using overlaid sketches to progressively build on ideas and explore alternatives using the "office set" as the basis for reflecting on different pathways explored and ideas accepted or rejected along the way. The "office set" drawings provided a context for learning and facilitated knowledge transfer by making available concrete examples of multiple interrelated design situations (Choi & Hannafin, 1996). By using exploration in this way, the students in this study were regarded to construct understanding rather than being taught specific knowledge (Winn, 1993) because their learning was situated in the context of its application to authentic tasks.

Finding here show that the mentors encouraged the students to explore design ideas beyond their first solutions by utilising resource materials and problem solving strategies to address tasks of increasing levels of difficulty. In this way, the students were able to "stretch their ability to an appropriate degree" in order to meet the challenges of the authentic design project (Brandt, et al., 1993, p. 77). It also encouraged students to explore multiple design variations and design elements in the search for the best solution to their real work design project and thereby "explore what strategies work for given situations and what strategies don't work in a real world context" (Casey, 1996, p. 79). This led students to be reflective in exploring and evaluating their design ideas and to then explore other design concepts they visualised and refined in metacognitive ways (Collins, et al., 1989).

Phases of learning activities observed in this study.

Findings from this study have suggested that student learning in this authentic design office situation is characterised by three phases that revolve around activities and experiences that provided students with entry to the culture of practice, knowledge of the discipline domain and ways for using design strategies. The three phases are as follows:

- Phase One - Entry to the design office situation

  Involved bonding with the mentor and establishing links with others operating in the domain.

- Phase Two – Acquisition of knowledge and skills in the domain of practice

  This phase is constructed around a three-part cycle of learning focussed on:

  (a) *Culture of practice* activities with the mentor and other experts in the broad spectre of the design industry;

(b) *Knowledge Acquisition*, including *Declarative knowledge* (explicit), *Procedural knowledge* (design processes and procedures), *Tacit knowledge* (experience based strategies and understanding); and

(c) *Communication:* the use of *Discussion, Articulation and Sketching* to express visualised design concepts using industry language and vocabulary.

- Phase Three - Development and application of metacognitive ways for creating, visualising and resolving design concepts

  This phase is constructed around a three-part cycle of learning focussed on:

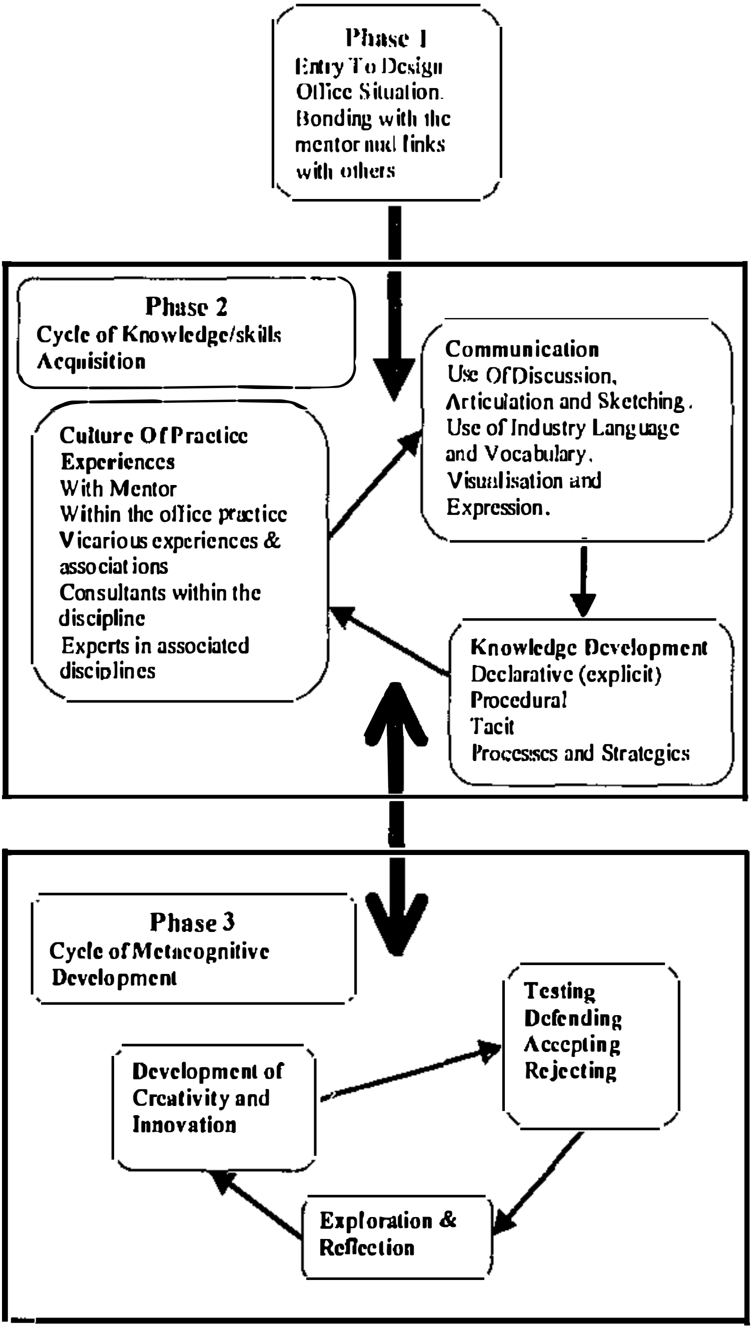
  (a) *Development of Creativity and Innovation* – using knowledge and design tools; and

  (b) *Testing and Defending* design ideas for acceptance or rejection – applying evaluation procedures.

  (c) *Exploration and Reflection* – using metacognitive ways to create, explore and refine design ideas by reflecting on multiple potential solutions

The use of modelling, coaching and scaffolding for knowledge transfer as shown in Figure 44 (see p. 299) applies to Phase Two and Phase Three of this proposed structure. The three phases of student learning to emerge from this study are graphically represented as a theoretical framework in Figure 45 (p. 307) with arrow links being used to represent the interdependence of each of the cycles of learning that took place.

Figure 45. Learning Phases in this study.



Implementation Of Cognitive Apprenticeship Methods In A Classroom

Findings from this study have suggested that mentor use of the teaching strategies proposed by Collins, et al., (1989) in their cognitive apprenticeship approach to learning provided a successful means for teaching building design in the situations studied here. Using authentic activities, the students developed skills during their social interaction and collaboration with expert building designers acting as mentors, in the context and culture of practice of their usual design activities. The combination of the creativity based design domain with the technically based construction and documentation domain makes the learning environment complex, much more so than a TAFE classroom. Many aspects of student learning with the mentors in this situation involved overlapping activities, ongoing activities and metacognitive processes to resolve problems. Students were often required to use creative design skills and technical procedures with construction detailing methods.

Throughout the work sessions, the students were observed to gain confidence in their use of design knowledge and fundamental problem solving procedures, then work in more independent ways to apply heuristic design strategies to resolve design problems and to defend their solutions. Many of the students were also observed to undergo a transition from simply using information and procedures to resolve design problems, to using heuristic design strategies in creative, innovative ways. This is consistent with findings reported in other studies about using a cognitive apprenticeship approach to learning and supports the Collins et al. (1989) contentions about students attaining mastery of knowledge and skills modelled by experts.

Having first attained mastery of the methods used by expert designers, the students then mostly applied their knowledge and design skills in creative and innovative ways to explore and reflect different design ideas as they refined and developed new design solutions, with personal style elements. Findings here have shown that using the six teaching strategies of a cognitive apprenticeship approach to learning provided a successful means for learning building design when implemented with authentic tasks in a design office settings. They have also indicated that student learning was enhanced through having a well defined learning situation and authentic activities structured to address specific aspects of practice.

It is my contention that cognitive apprenticeship methods can be used effectively for classroom-based student learning in the building design discipline. In order for students to operate in the manner used by expert building designers, they need to have mentors who are expert in the building design discipline to assist their learning. They must also have a learning environment that replicates the conditions and practices typical of the commercial design office situations used in this research. The learning tasks used must be based on authentic projects and be implemented using the kinds of resources and methods that emerged from this study as typical of those used by expert building designers in their everyday culture of practice activities.

Findings about the three phases of student learning (see Figure 44, p. 307) that emerged from this study and the manner in which cognitive apprenticeship (Collins, et al., 1989) teaching methods were used by the mentors suggested that a particular structure was needed to optimise student learning opportunities. It is proposed here that student learning in the building design discipline can be facilitated by cognitive apprenticeship teaching methods in conjunction with a four part structure that incorporates teaching activities and authentic tasks that together replicate everyday design office culture of practice operations.

It is also proposed here that for teaching building design students in a TAFE classroom, the six teaching strategies of a cognitive apprenticeship (Collins, et al., 1989) learning approach can be effectively implemented in such a learning environment if structured using the four elements outlined below. A summary list of elements recommended for constructing the learning environment, the learning activities and the learning tasks is also provided in Appendix I.

1. The mentor.

The most vital element in creating a cognitive apprenticeship based learning situation for teaching building design is the mentor. The mentor must be able to model expert practice which includes the knowledge and procedures for resolving problems that emerge from the development of design solutions. In the classroom situation multiple expert mentors may be required to address problems that emerge as part of the many different aspects of design and construction that commonly occur in commercial building design practice. For this reason a team-based approach in which academic staff with expertise in different areas of design might work in collaboration with experts from industry on an as needed or structured occasional basis. In this way, the teaching strategies of a cognitive apprenticeship approach might be implemented by multiple experts, each of whom could contribute specific key knowledge and skills to a collective model for student learning. Having multiple experts, each of whom bring a different perspective and expertise to the learning situation, may enhance student learning by supporting a community of learning as suggested by this study's findings.

The inclusion of expert building designers, who are engaged in commercial operations, in classroom based mentoring teams may facilitate student acquisition of up-to-date knowledge of building design methods and construction practices in the manner experienced by the students studied here. Having other experts contribute to student learning by participating as consultants to the students in support of the classroom lecturer would reflect the kinds of working situations seen to be effective for implementing cognitive apprenticeship teaching strategies as seen in findings that emerged here.

I contend that the use of modelling, coaching, scaffolding, fading, reflection and exploration by classroom lecturers working in ways like those observed being used by the mentors in this study would provide similar learning opportunities for classroom based students to those experienced by the students studied here. To support this approach to learning, the teaching environment, learning activities and tasks that are arranged in ways as described next.

2. The learning environment.

The learning environment should be structured to replicate the authentic environment typically experienced by expert practitioners in the professional discipline targeted. Such a learning environment should include individual student work stations equipped with all of the resources typically found in commercial design office settings, including computing and reprographic equipment for CAD based design practices. Materials such as "office set" drawings, sets of codes and regulations, trade literature and magazines, used by the mentors to inspire innovation and scaffold learning, should also be made readily available in the students' work environment.

To replicate a commercial design office culture of practice situation in a classroom setting, standards of behaviour, dress codes and language used in the classroom should typify those used by building design practitioners in industry. Also, the team-based working situation of a commercial design office setting should be applied by having students working in multi-skill level teams on various authentic projects within the one work-space to promote peer monitoring and incidental assistance.

The learning environment should incorporate the following aspects:

- a classroom situation that replicates the working environment of a typical design office with individual work stations and equipment arranged for one-on-one tutoring, as well as for group interaction;
- have available industry based consultant designers to support the classroom teacher on an as-needed basis to mentor, advise and assess the students according to industry standards of design and presentation;
- provide access to experts in associated disciplines having multiple perspectives, design styles, working practices and alternative approaches to resolving design problems
- provide within the classroom a diverse range of resource materials including archival "office set" documents of authentic commercial projects produced by recognised expert designers, student projects, books, magazines, technical publications, codes and regulations, computer equipment, telephone/fax, photocopier, and other similar items as used in commercial design office settings;
- include in the classroom environment the kinds of dress codes, behaviour, language use, and design office facilities and services such as music and refreshments to replicate the social working situation present in most commercial design offices;
- create a team-based classroom environment in which students from different course levels work in collaborative teams on different projects in the same general work-space, so that peer mentoring and incidental assistance and learning may take place in a environment that presents a broad picture of design endeavour;
- provide "after hours" access to all of the classroom facilities, including access to expert advice and support from rostered staff, or consultant experts, either face-to-face or via the telephone or e-mail; and
- provide ways for students to participate in building site visits involving experts from associated disciplines to introduce multiple perspectives of each design situation, and to explore multiple solutions.

3. The learning activities.

The learning activities should be based on authentic problems and work practices that reflect the typical working methods used by expert practitioners in the target discipline area in their everyday culture of practice activities.

Activities that encourage creative practices and support the anxiety-free expression of innovative ideas by students must be based on authentic situations that require student exploration of multiple design ideas and solutions. Such activities should include mentor modelling of heuristic design strategies for resolving frequently occurring design situations and coaching in the application of those strategies to problems emergent from authentic design tasks. Assessment of student design solutions should be based on industry standards as determined by benchmarks set by expert building designers and assessed by industry based practicing designers.

Projects undertaken by students in the classroom setting should be organised around team-based methods as used in commercial practice and be structured to support collaborative relationships between groups and individuals operating at different levels or on different projects within the same work-space. Design activities used should be planned to encourage interaction between students working in the classroom setting in ways that make learning a journey of discovery in which they communicate ideas using sketching and discussion to articulate design concepts and solutions when defending their design ideas.

The learning activities should include:

- teaching methods that encourage student self confidence and anxiety-free expression of innovative ideas;
- modelling and coaching in the use of sketching and discussion methods typically used by experts in the building design discipline when exploring, debating and defending design ideas;
- support for using collaborative team-based work practices based on exploration, reflection, and evaluation of ideas to resolve complex design tasks in the manner of commercial design office practices;
- support for an inquisitive approach (to design) with a sense of excitement and inspiration;
- modelling of methods used by expert designers to match patterns of design problems and solutions shown to occur frequently in authentic building design situations, to elements of student design projects
- integrate with design practices the use of rich descriptive articulation of personal design ideas and problem solving methods as part of visualisation and exploration of proposed designs, along with sketching and over-sketching of formal or CAD based drawings;
- incorporate the overlaid drawing "office set" approach into all design projects along with detailed notes and explanatory reporting of the methods and rationale behind design decisions and branching of design elements explored, evaluated, and accepted/rejected in the final presentation;
- introduce industry standards to the assessment of design presentations by having industry experts evaluate student works, or contribute to benchmarks for teacher assessment of the students' work;
- create design teams similar to the student mentor collaborative teams, within the classroom each working on different projects, but able to interact with others by contributing to their works as consultants,
- place emphasis on developing collaborative relationships between students within groups, with other groups at different development levels, and with teaching staff;
- encourage a communicative and supportive approach with all class members using rich explanations and highly visual presentation of their design methods and outcomes as developed for the authentic design tasks;
- place the emphasis in design on it being a guided journey of discovery with clear communication by the students of their design development path showing their exploration of all ideas using sketching and notes, backed up by open forum articulation of the reasons why they accepted or rejected the ideas presented; and
- provision of positive reinforcement of student design ideas throughout project development.

4. The learning tasks.

The learning tasks should be based on authentic discipline specific projects, structured for classroom delivery, sequenced to provide small readily achieved units that provide knowledge and skills regarded as necessary for professional practice in the target discipline. The authentic projects used must replicate design situations experiences by expert building designers and provide opportunities for teacher guided application of design methods that represent as completely as possible those used in commercial design office culture of practice commissions.

The learning tasks should be arranged to:

- use authentic projects that replicate broad based design office commissions using design situations where teacher guided analysis of the design brief can readily define key elements as linked to replicable design processes and procedures that can be implemented through small stages of design development;
- implement small staged design procedures of increasing complexity and difficulty typical of design office working practices;
- address particular aspects of design or design situations, for which authentic commercial design "office set" drawings are available that show how similar problems to those in the student projects, were addressed by professional designers. Include multiple design industry disciplines and real links to regulatory bodies and municipal approval agencies; and
- provide sufficient challenge in their diversity and degree of difficulty to promote student striving to achieve excellence in creative, innovative design solutions.

Using cognitive apprenticeship for learning building design

The use of a learning situation that incorporates the working environment, activities and tasks presented in the four-part structure outlined above, in conjunction with the teaching strategies of a cognitive apprenticeship (Collins, et al., 1989) approach to learning can be an effective way to teach building design students. Such an approach is essentially constructivist. Findings to emerge from this research show that the complex demands of the building design profession, with its need for creativity and technical know-how, were successfully addressed using the methods and learning situation described here. I contend that application of a similar structure and teaching methods to a classroom setting can potentially facilitate student learning in ways similar to those observed in the design office settings of this study.

Conclusion to this Chapter

This Chapter began by addressing each of the research questions using summary findings that emerged from analysis of the study data. Following this, the overall study findings were discussed as part of the six teaching strategies of a cognitive apprenticeship approach to learning (Collins, et al., 1989) used in the conceptual framework that underpins this study.

In presenting a global view of how student learning took place in the design office situation, a model showing three phases of development was proposed. In that model, two phases of student development were shown as cycles of knowledge and skills acquisition. The first, at an elementary procedural level and the second being used to represent a cycle of metacognitive ways for creating, visualising and resolving design ideas. The discussion of student learning represented in this model was based on findings that emerged from this study. Findings here have suggested that when students make the transition from application of design procedures to using metacognitive ways for design development, they move from operating at technician level, to operating as a creative designer.

A proposed strategy for structuring the learning environment, activities and tasks appropriate for implementing cognitive apprenticeship learning methods was introduced and discussed in terms of its possible classroom application for teaching building design students.

In the next Chapter, conclusions to this study are presented, along with a discussion of the study limitations and recommendations for further research.

CHAPTER EIGHT

CONCLUSION TO THE STUDY

This research study set out to investigate student learning in a cognitive apprenticeship situation in a building design office. Its main focus was to identify learning outcomes for students working with expert building designers, acting as mentors in a commercial design office setting. The study also sought to determine how students acquired knowledge and how they acquired ways for solving complex problems emergent from tasks integral to authentic design projects, typical of those faced by experts in the context and culture of their everyday practices.

The extensive body of data collected provided information detailing the personal thoughts, experiences and learning outcomes for the study group. The diverse range of data collection methods and multiple sources of data concerning the same events or phenomena studied here provided rigour, reliability and validity to the investigation and interpretation of each element that formed part of the overall study situation.

This research study has revealed many aspects of student learning in design office, mentor supported, situations that I consider as important learning elements appropriate to a cognitive apprenticeship approach. Suggestions have been made here about how findings from each of these research questions might be applied to classroom teaching practices so as to replicate aspects of the design office experiences that enhanced student learning, in ways that could closely resemble authentic practice.

In addition to confirming the suitability of the six main cognitive apprenticeship teaching strategies suggested by Collins et al. (1989) as used in this study, a strategy for organising the mentors, the learning situation, activities and tasks emerged from the study findings. The main purpose of this proposed strategy is to facilitate student learning by linking knowledge and skills acquisition to autonomous application of higher order design and problem solving procedures in ways that replicate those of expert building designers in authentic design office operations. The proposed strategy for organising a learning situation in which to apply cognitive apprenticeship teaching strategies for building design students utilises a group of teaching practices and study situation conditions. When used together in the design office situations studied here, these elements provided a learning environment and support structure that facilitated student learning. They provided ways for students to link context specific domain knowledge and skills with metacognitive ways for solving complex problems, emergent from authentic tasks, in the manner used by experts in their everyday culture of practice activities.

Findings reported in this thesis show how students acquired knowledge and skills used by expert building designers to visualise, create, explore, refine, defend and present complex building design solutions in the context and culture of their everyday practices. The teaching strategies and classroom application conditions recommended as part of the findings presented in this thesis can be readily applied in the classroom setting and for design office in house training methods. All of the conditions and strategies recommended here could facilitate student learning in a cognitive apprenticeship situation based on authentic problem solving experiences, guided by expert practitioners within the discipline domain.

Application of the study findings

Although this study focussed on learning in the building design profession, I regard that findings reported here have wider application in education and training in other discipline areas. Some aspects of what this study has shown have application to any profession where there is a demand for creativity in visualising and resolving problem situations through the use of replicable procedures and heuristic strategies that may be used for dealing with multi-factor influenced situations.

The dual domains of creative design and technical knowledge of construction methods required of a building designer have similarities with other professions such as engineering, surveying, cartography, dental technicians and web-page design, as some examples. The following elements of this study can be applied to any similar discipline using learning situations constructed around a cognitive apprenticeship approach to learning:

- all tasks must be authentic and true to the usual demands of the discipline;
- all of the participants must be willing to contribute to the collaborative activities required by modelling, coaching, scaffolding, articulation, reflection and exploration;
- students need to have at least elementary skills in the discipline in order to commence their collaboration with a mentor at a level that does not require the mentor's total attention at all times;
- mentors are best selected (as volunteers) from expert practitioners who have shown:
    - excellence in their professional practices;
    - have established communication skills;

- have at least elemental experience with teaching or mentoring in the commercial sector or tertiary institution; and
- have an awareness of the teaching strategies and nature of a cognitive apprenticeship approach to learning, either formally acquired or intuitive.

- the mentoring situation needs to be typical of the environment and culture in which the expert practitioner usually operates in order to replicate the context and culture of the domain of practice; and
- the learning situation needs to be fully resourced in the same manner that the students might encounter when entering professional practice in a commercial setting.

Limitations Of The Study

This study was conducted in metropolitan Western Australia where there is only one teaching institution that offers the full range of building design courses as approved by under Australian National Curriculum for building design. These meant that the 29 students in the study sample all came from a single institution population and are not necessarily representative of other groups in other states.

Data collected from the small discreet sample used for this study have indicated many similarities and some differences in the manner that the mentors used cognitive apprenticeship teaching strategies. These data may be interpreted differently when analysed by others not connected with the study situation in the manner of this researcher, who has close links with the study participants and discipline domain. For these reasons, findings that have emerged here may not be regarded as readily generalisable when studying other similar situations.

The tasks undertaken by the students with the mentors were constructed around authentic building design problems for which there were many possible design-solving procedures and suitable solutions. Although this provided flexibility in the student/mentor collaborative work situations, it also demanded a broad view when assessing student learning outcomes and therefore the effectiveness of the cognitive apprenticeship teaching strategies in assisting students to acquire new knowledge and skills.

FURTHER RESEARCH

This research study has used a clearly defined situation to investigate a cognitive apprenticeship approach to learning. Findings reported here are couched in terms of the specific situation used, but have the potential to be applied in many different domain contexts where there is a need for individuals to synthesise creative thinking with discipline specific knowledge and procedures, executed using metacognitive methods.

Any discipline domain that requires high levels of cognitive thought and communication of concepts or solutions using verbal and graphical means is well suited to the use of a cognitive apprenticeship approach to learning for its exponents and should be investigated. In particular, the proposed structure for implementing cognitive apprenticeship in the classroom as suggested in this thesis (see page 308) might well be applied to many such disciplines. This would include any professional discipline where students must take a "leap of faith" from simply acquiring and applying basic knowledge and procedures as might a technician, to synthesising concepts then visualising new ideas then exploring and resolving them in metacognitive ways.

Further study to investigate how findings from this research may be applied to teaching in other disciplines may improve the generalisability of findings from this study. More focussed research could address specific issues such as:

- application of cognitive apprenticeship methods in learning situations created using multimedia and Web-based learning materials utilising verbal and visual exchanges between student and mentor/teacher using electronic means between remote locations;
- computer based coaching in virtual office situations with immediacy of feedback and rapid presentation of ideas being used to replicate the "look and feel" of one-on-one learning with a mentor; and
- training for work-skills intended to address the more flexible contract focussed work settings that have replaced the traditional "job for life" approach and to address training issues about multiple career changes and "on the job" or "in house" training conducted using cognitive apprenticeship methods.

Research to determine how cognitive apprenticeship teaching strategies can be effectively applied along with the strategy proposed here for organising the environment, activities and tasks, may provide new ways to deliver education and training in at least each of the areas suggested here.

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APPENDIX A

INTERVIEW GUIDE QUESTIONS FOR ROUND ONE MENTOR INTERVIEWS

Introduction For Mentors

My aim in conducting this study is to establish how students acquired knowledge and skills when working on authentic projects with a building designer acting as their mentor. Understanding how students acquire the knowledge and skills that expert building designers use when solving complex design problems may assist in the development of TAFE training courses incorporating learning approaches similar to those used in industry, and in on-the-job real work project experiences.

In this interview I am seeking to understand what took place between the students and the mentors in the design office situations of this study and how this assisted the students to acquire design knowledge and skills. Mostly I would like to hear your views about what took place and how you view that as having assisted student learning.

In order to explore some aspects of how information was shared and how the mentors assisted the students to learn to apply design methods, I will ask specific questions that address six key teaching strategies used in a cognitive apprenticeship approach to learning. The teaching strategies are: modelling, coaching, scaffolding (and fading), articulation, reflection, and exploration.

General Themes For Interview Guide Questions

- *What do students learn from working with mentors in a design office situation using a cognitive apprenticeship learning approach?*
- *How is knowledge (declarative, procedural, tacit) transferred?*
- *How are problem solving heuristic strategies used?*

Begin each interview by asking:

Could you tell me about what took place when the student first came to work with you in the design office?

Using questions that stem from the mentor's response to the opening question, to explore the mentor's views of what took place and how this may have affected student learning. Focus questions on the six key teaching strategies of a cognitive apprenticeship approach to learning as set out below.

Question themes based on Cognitive Apprenticeship Teaching Strategies

Modelling

Please explain for me how you showed students your approach to design?
What did you do to facilitate student learning about your approach to design?

Coaching

How did you go about guiding students to use your design methods to resolve problems that they encountered in their design project?
Could you explain how sketching and discussion was used in work sessions to explore design ideas and to develop design solutions?
How did you go about assisting students to work through design problems?

Scaffolding (and fading)

How did you keep the students on track with a design task and boost their performance to the next level of difficulty as they progressed through the design process?
Can you tell me about any processes or procedures that you used to enhance the students' performance or to streamline their resolution of design problems?
Are there tips and tricks that you used to keep the students going?
What kinds of resource materials, like drawing sets or CAD elements, did you use to help the students to overcome difficulties that may have blocked their progress?
How did the student react when you reduced your involvement in their work, and let them go it alone on the tasks?

Articulation

Could you explain for me how you went about explaining to students your approach to design and decision making in the design process?
To what extent did you use detailed explanations of your thoughts and actions when working on a project with students?
In what ways did you encourage students to discuss their approach to problem solving and their design decisions?
What role did hand sketching and drawing play in your interaction with the students?

Reflection

Can you tell me about the role of reflection in learning design. In what ways did the students use reflection to revise and refine their design solutions?
In what ways did you encourage students to reflect on their experiences and learn from them?

Exploration

In what ways did you guide the students to explore innovative or radical approaches to design while working on authentic projects?
Can you tell me about situations where you saw students developing creative, original, or innovative approaches to design projects, based on their experiences in the design office?

APPENDIX B

INTERVIEW GUIDE QUESTIONS FOR ROUND ONE STUDENT INTERVIEWS

Introduction

My aim in conducting this study is to establish how students acquired knowledge and skills when working on authentic projects with a building designer acting as their mentor Understanding how students acquire the knowledge and skills that expert building designers use when solving complex design problems may assist in the development of TAFE training courses incorporating learning approaches similar to those used in industry, and in on-the-job real work project experiences.

In this interview I am seeking to understand what took place between the students and the mentors in the design office situations of this study and how that assisted the students to acquire design knowledge and skills. Mostly I would like to hear your views about what took place and how you view that assisted your learning.

In order to explore some aspects of how information was shared and how the mentors assisted the students to learn to apply design methods, I will ask specific questions that address six key teaching strategies used in a cognitive apprenticeship approach to learning. The teaching strategies are: modelling, coaching, scaffolding (and fading), articulation, reflection, and exploration.

General Themes For Interview Questions

- *What do students learn from working with mentors in a design office situation using a cognitive apprenticeship learning approach?*
- *How is knowledge (declarative, procedural, tacit) transferred?*
- *How are problem solving heuristic strategies used?*

Begin each interview by asking:

Could you tell me about what happened first when you went to work with your mentor in the design office?

Using questions that stem from the student's response to the opening question, explore their learning experiences using other questions based on the following cognitive apprenticeship teaching strategies.

Question themes based on Cognitive Apprenticeship Teaching Strategies

Modelling

In what ways did your mentor demonstrate for you the knowledge and skills that you needed to acquire to do the tasks required of you in the design office?

Can you describe for me the manner in which your mentor used these to resolve problems that emerged from your design project.

Coaching

Which aspects of working with your mentor were most useful to you in understanding and resolving design problems?
Can you tell me about ways used by your mentor to help you to understand and apply design strategies and problems solving methods?
Are there problem solving strategies that you have seen your mentor using that you now incorporate into your design work?

Scaffolding (and fading)

Can you tell me about ways in which you mentor provided you with assistance in problem solving at times when you were struggling to resolve you designs? For example, tips and tricks or other materials that were useful in sorting out problems that emerged during design.
As you became more confident and competent with the work you were doing, did you have less need to consult your mentor in resolving design difficulties?

Articulation

Can you tell me about the sorts of discussions that took place between you and your mentor during the sessions where you worked together in resolving design problems?
In what ways did your mentor explain the reasons for his approach to resolving design problems?
To what extent do you think that your learning was enhanced by the hearing others in the design office talking about their design methods?

Reflection

Looking back at your experiences working with your mentor, what do you think were the most useful aspects of the collaboration?
Can you tell me about problem solving strategies that you now use for design that have resulted from your experiences with your mentor?
Are there aspects of your working with a mentor that you feel were not of value?

Exploration

In what ways have you been able to build upon the knowledge and skills gained through your experiences working with a mentor?
Can you tell me what you might now do differently in your approach to design as a result of your design office experiences?

APPENDIX C

INTERVIEW GUIDE SUPPLEMENT FOR ROUND TWO INTERVIEWS WITH MENTORS AND STUDENTS

General Themes For Interview Questions

- *What do students learn from working with mentors in a design office situation using a cognitive apprenticeship learning approach?*
- *How is knowledge (declarative, procedural, tacit) transferred?*
- *How are problem solving heuristic strategies used?*

Emergent Themes To Explore

Eight themes that emerged from analysis of data collected through the first round of interviews are presented here as guides for questioning mentors and students in second round interviews.

1 Entry to the culture of practice: acceptance by others in the office culture

- How does the mentor relate to the students;
- What status do the mentors extent to the students: apprentice designer or student; and
- Confirming evidence of student status e.g. language, access to mentor, access to the office facilities, access to other staff., access to office archives, social interaction with others in the office.

2 Expectations of the collaboration by both parties

- What does the student look for in the mentor, a solution or guidance;
- What does the student expect of themselves; and
- What does the mentor expect of the student, and of themselves.

3 Value afforded to the collaboration by both parties

- Preparation by the student and by the mentor prior to their first meeting as an indication of the commitment that each has to the collaboration;
- What does the student go away with following a session with the mentor?; and
- Explore confidence building through activities and mutual respect earned by each party seeing the commitment made by the other to the common goal.

4 Making knowledge visible

- Having the mentors reifying existing substantial knowledge by making it accessible to the students through articulation, discussion, sketching, explanation building, notes, site visits;
- Observing how the mentors communicate their knowledge using such tools; and
- Role played by articulation and sketching when used by students to explore and communicate their design ideas.

5 Heuristic design strategies and design procedures used in their implementation

- Use of the "office set" approach by the mentor;
- Use of sketching, discussion, and articulation as communication and design tools;
- Use of nominated usual approaches for the type of design problems associated with the particular type of design project used in this study; and
- Preparation and research methods suggested by the mentors as tools for the students to use in the assembling of resources and the implementation of processes and procedures for the resolution of the design.

6 Problem solving: becoming an expert and working forwards

- Using questioning techniques (both mentors and students) to reveal, discover, and develop knowledge, ideas, concepts, and strategies for resolving designs;
- Pattern matching experiences and solutions to the problems of the project at hand;
- Multiple perspectives – presented by the mentor, by the situation, through investigation and discovery by the students; and
- Scaffolding– exemplars and numerous other materials, resources and expert persons (3 levels).

7 Building metacognition

- Having to justify ideas and have them confirmed by practising designers;
- Defending ideas, concepts, solutions, methods and strategies using sketching, discussion, articulation, and explanatory notes; and
- Evaluation practices and strategies for testing, accepting and rejecting of ideas against industry standards or practices;

8 Style development

- As a synthesis and development of that of the mentor and personal views;
- Reflective practices used in evolving a design and branching to alternative lines of inquiry; and
- Exploration of new and diverse design ideas from the stem of design concepts emerging form the project brief.

APPENDIX D

INDEX TREE ONE

Categories used to code data collected in Phase One of this study were arranged as follows:

Primary Category	Secondary Categories
1. Activities	1.1 Group activities
	1.2 Design exercises
	1.3 Site visits
2. Affect	2.1 Stimulation
	2.2 Freedom in design
3. Learning	3.1 Situational factors
	3.2 Mentor influence
	3.3 Input by others
4. Application	4.1 Evaluating ideas
	4.2 Self development