USING CONCEPTS DRAWN FROM COGNITIVE THEORY, SETTING THEORY, AND ACTIVITY THEORY TO DEVELOP STUDENT THINKING IN TECHNOLOGY EDUCATION CLASSES.

By

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DECLARATION

This thesis presents work which is to the best of my knowledge and understanding, original except as acknowledged in the text of this document. This thesis does not contain material which has been submitted previously for a degree or diploma at this or any other institution.

Bradley Walmsley.

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TABLE OF CONTENTS

DECLARATION .......................................................................................................................... II

ACKNOWLEDGMENTS ............................................................................................................. III

TABLE OF CONTENTS ........................................................................................................... IV

LIST OF FIGURES .................................................................................................................. VII

LIST OF TABLES ..................................................................................................................... IX

LIST OF APPENDICES ........................................................................................................... XI

ABSTRACT .............................................................................................................................. XIII

CHAPTER 1 ............................................................................................................................ 1

INTRODUCTION .................................................................................................................... 1
  1.1 Technology Education: A Subject Area in Transition ..................................................... 1
  1.2 Conceptualising Higher-Order Thinking ...................................................................... 2
  1.2.1 Cognitive Theory ........................................................................................................ 3
  1.2.2 Behaviour Setting Theory ......................................................................................... 4
  1.2.3 Activity Theory .......................................................................................................... 4
  1.3 Technology Education: Teaching Strategies and Tactics ............................................. 5
  1.4 Technology Education: Classroom Program ............................................................... 5
  1.5 Technology Education: Teaching and Learning .......................................................... 7
  1.6 Statement of the Problem ............................................................................................. 9
  1.7 Contribution of the Thesis .......................................................................................... 10
  1.8 Thesis Structure ........................................................................................................... 10

CHAPTER 2 ............................................................................................................................ 14

HIGHER-ORDERS OF THINKING ......................................................................................... 14
  2.1 Introduction .................................................................................................................... 14
  2.1.1 Chapter Structure ..................................................................................................... 14
  2.2 Higher-Order Thinking: Towards a Definition ............................................................ 15
  2.2.1 Critical thinking and defining higher-order thinking ............................................. 16
  2.2.2 Bloom’s taxonomy and conceptualising higher-order thinking ......................... 18
  2.2.3 Contemporary definitions for higher-order thinking ............................................ 20
  2.3 Hierarchy of Cognitive Structures .............................................................................. 23
  2.4 Self-Regulation and Higher-Order Thinking ............................................................... 29
  2.5 The Learning Environment and Higher-Order Thinking .......................................... 33
  2.6 Activity Theory and Higher-Order Thinking ............................................................... 39
  2.7 Conclusion ................................................................................................................... 47
  2.8 Chapter Summary ......................................................................................................... 50

CHAPTER 3 ............................................................................................................................ 52

TEACHING, LEARNING AND HIGHER-ORDER THINKING IN TECHNOLOGY EDUCATION ..... 52
  3.1 Introduction .................................................................................................................... 52
  3.2 Teaching Strategies and Tactics: Defined ..................................................................... 53
  3.2.1 Classifying Strategies and Tactics .......................................................................... 55
  3.3 Teaching and Learning in Technology Education ....................................................... 58
  3.3.1 Introduction ............................................................................................................. 58
  3.3.2 The Role of Classroom Program in Technology Education Instruction ................ 65
  3.3.3 Modular Technology Education: Teaching and Learning .................................... 73
  3.4 Conclusion and Predictions ......................................................................................... 79
LIST OF FIGURES

CHAPTER 1 ........................................................................................................................................1

CHAPTER 2 ........................................................................................................................................14
  FIGURE 2.1 ........................................................................................................................................45
  VYGOTSKY’S MODEL OF A MEDIATED ACT
  FIGURE 2.2 ........................................................................................................................................46
  THE STRUCTURE OF A HUMAN ACTIVITY SYSTEM
  FIGURE 2.3 ........................................................................................................................................49
  A VISUAL CONCEPTUALISATION OF HIGHER-ORDER THINKING
  DRAWING ON COGNITIVE, BEHAVIOUR SETTING AND ACTIVITY THEORIES

CHAPTER 3 ..........................................................................................................................................52
  FIGURE 3.1 ........................................................................................................................................63
  CYCLIC MODEL OF A DESIGN PROCESS

CHAPTER 4 ..........................................................................................................................................83
  FIGURE 4.1 ........................................................................................................................................88
  RESEARCH DESIGN: STUDY 1 (AUSTRALIA)
  FIGURE 4.2 ........................................................................................................................................89
  RESEARCH DESIGN: STUDY 2 (AMERICA)
  FIGURE 4.3 ........................................................................................................................................93
  STUDY 1 TIMELINE
  2003 SCHOOL YEAR (S1 - AUSTRALIA)
  FIGURE 4.4 ........................................................................................................................................93
  STUDY 2 TIMELINE
  2004/2005 SCHOOL YEAR (S2 - AMERICA)
  FIGURE 4.5 ........................................................................................................................................137
  EXAMPLE LEXIMANCER TEXT EXTRACT
  FIGURE 4.6 ........................................................................................................................................138
  EXAMPLE LEXIMANCER CONCEPT MAP

CHAPTER 5 ........................................................................................................................................145
  FIGURE 5.1 ........................................................................................................................................147
  RESEARCH STUDY DESIGN (STUDY 1)
  FIGURE 5.2 .........................................................................................................................................153
  COMPARISON OF FOCHP AND SOCHP MEANS
  STUDY 1-PHASE 1 PRE-TEST AND STUDY 1-PHASE 3 POST-TEST
  FIGURE 5.3 .........................................................................................................................................175
  TEACHER 21 CONCEPT MAP
  FIGURE 5.4 .........................................................................................................................................179
  TEACHER 91 CONCEPT MAP
  FIGURE 5.5 .........................................................................................................................................187
  STUDENTS CLASS 21 CONCEPT MAP
  FIGURE 5.6 .........................................................................................................................................189
  STUDENTS CLASS 91 CONCEPT MAP
  FIGURE 5.7 .........................................................................................................................................194
  AUSTRALIAN TECHNOLOGY EDUCATION CLASSROOM ACTIVITY SYSTEM
  ASSOCIATED WITH HIGHER-ORDER THINKING

CHAPTER 6 ........................................................................................................................................197
FIGURE 6.1 ................................................................................................................................. 209
AMERICAN TECHNOLOGY EDUCATION CLASSROOM ACTIVITY SYSTEM
ASSOCIATED WITH HIGHER-ORDER THINKING
FIGURE 6.2 ................................................................................................................................. 213
TECHNOLOGY EDUCATION ACTIVITY SYSTEM
ASSOCIATED WITH PROMOTING HIGHER-ORDER THINKING

CHAPTER 7 .................................................................................................................................. 216
FIGURE 7.1 .................................................................................................................................. 222
A VISUAL CONCEPTUALISATION OF HIGHER-ORDER THINKING
DRAWING ON COGNITIVE, BEHAVIOUR SETTING AND ACTIVITY THEORIES
LIST OF TABLES

CHAPTER 1 ................................................................................................................................. 1

CHAPTER 2 ................................................................................................................................ 14

Table 2.1 ................................................................................................................................. 19

Ten Micro-Thinking Skills by Degree of Abstraction

CHAPTER 3 ................................................................................................................................ 52

Table 3.1 ................................................................................................................................. 57

Instructional Strategies and Tactics

CHAPTER 4 ................................................................................................................................ 83

Table 4.1 ................................................................................................................................. 102

Study 1 Australia
Case Study Technology Class & School Characteristics
Table 4.2 ................................................................................................................................. 106

Study 2 America
Case Study Technology Class & School Characteristics
Table 4.3 ................................................................................................................................. 107

CHPQ Numbers Supplied and Completed by Study and Phase.
Table 4.4 ................................................................................................................................. 109

Alpha Reliabilities of FOCHP and SOCHP from Various Studies
Table 4.5 ................................................................................................................................. 110

Alpha Reliabilities for FOCHP and SOCHP
Table 4.6 ................................................................................................................................. 111

Current Study
Alpha Reliabilities for FOCHP and SOCHP
Table 4.7 ................................................................................................................................. 126

Video Code Letter Descriptions
Table 4.8 ................................................................................................................................. 131

Excerpt from an Example of the Technology Education Lesson Coding Table
Table 4.9 ................................................................................................................................. 131

Excerpt from an Example Code and Code Descriptions Table
Table 4.10 ................................................................................................................................. 135

Video-Stimulated Interview Themes
Segregated into Activity Theory Components

CHAPTER 5 ................................................................................................................................ 145

Table 5.1 ................................................................................................................................. 150

Study 1-Phase 1 Pre-test FOCHP & SOCHP Means
Technology Class & Gender
Table 5.2 ................................................................................................................................. 152

Study 1-Phase 3 Post-test FOCHP & SOCHP Means
Technology Class & Gender
Table 5.3 .................................................................................................................................. 156

Comparison of FOCHP and SOCHP Means
Study 1-Phase 1 Pre-test and Study 1-Phase 3 Post-test: Case Study Classes Only
Table 5.4 .................................................................................................................................. 158

Comparison of FOCHP and SOCHP Means
Study 1-Phase 1 Pre-test and Study 1-Phase 3 Post-test: Class 21 Only
Table 5.5 .................................................................................................................................. 159
APPENDIX 1 ...........................................................238
SCHOOL INFORMATION DOCUMENT
TECHNOLOGY EDUCATION / IT&D / MANUAL ARTS AND STUDENT THINKING

APPENDIX 2 ...........................................................241
PARENT AND STUDENT INFORMATION DOCUMENT
TECHNOLOGY EDUCATION / MANUAL ARTS AND STUDENT THINKING

APPENDIX 3 ...........................................................244
TECHNOLOGY EDUCATION AND STUDENT THINKING
SURVEY CONSENT FORM

APPENDIX 4 ...........................................................245
TECHNOLOGY EDUCATION / MANUAL ARTS AND STUDENT THINKING
OBSERVATION AND INTERVIEW CONSENT FORM

APPENDIX 5 ...........................................................246
COGNITIVE HOLDING POWER QUESTIONNAIRE

APPENDIX 6 ...........................................................248
CHPQ INTRODUCTION

APPENDIX 7 ...........................................................249
SCORING THE CHPQ

APPENDIX 8 ...........................................................250
VIDEO RESEARCH PACKAGE

APPENDIX 9 ...........................................................251
VIDEO STIMULATED RECALL INTERVIEW PROCEDURE
TEACHER

APPENDIX 10 ..........................................................252
VIDEO STIMULATED RECALL INTERVIEW PROCEDURE
STUDENTS

APPENDIX 11 ..........................................................253
RESEARCHER OBSERVATION SHEET STUDY1-PHASE 2

APPENDIX 12 ..........................................................254
LESSON CODING OF TEACHER AND STUDENT ACTIVITIES

APPENDIX 13 ..........................................................256
VIDEO MASTER CODE DESCRIPTIONS

APPENDIX 14 ..........................................................258
COGNITIVE HOLDING POWER QUESTIONNAIRE VALIDATION CURRENT STUDY

APPENDIX 15 ..........................................................265
SHAPIRO-WILK TESTS OF NORMALITY
STUDY 1-PHASE 1 PRE-TEST
TECHNOLOGY CLASS MEANS FOCHP & SOCHP

APPENDIX 16 ..............................................................266

STUDY 2-PHASE 2 RESEARCHER CLASSROOM OBSERVATION SHEET
ABSTRACT

The problem addressed in this thesis is the nature of the technology education classroom teaching and learning environments that promote students’ use of higher-order thinking. The problem is addressed firstly, by examining higher-order thinking in terms of theories of cognitive structures, behaviour settings and learning activity. It is argued that contemporary empirical research is limited in its ability to provide a conceptualisation of higher-order thinking. Therefore, this literature is examined to conceptualise higher-order thinking in terms of a relationship between the internal cognitive structures of a person and their activities within a behaviour setting. Secondly, this thesis examines instructional design in contemporary technology education classrooms to ascertain what is understood regarding teaching, learning, and the promotion of higher-order thinking in technology education classes. It was found that little is known and understood through empirical research regarding the conditions that promote higher-order thinking within technology education classrooms.

It is prescribed through curriculum documentation that students’ participation in technology education learning activities should support their use and development of higher-order thinking. However, it is argued in this thesis that current theories inadequately define higher-order thinking, resulting in technology education teaching and learning that is fashioned by teacher intuition rather than by knowledge gained through empirical research results. Hence, a better understanding of the classroom activities of teachers and students that support students’ use of higher-order thinking is required to inform curriculum development in technology education. Additionally, the knowledge generated through this research may support teaching and learning and the promotion of higher-order thinking in other similar subject areas.

This thesis reports on two studies that investigated technology education classrooms in Australia (Study 1) and America (Study 2) with the aim of interpreting classroom conditions that appeared to be associated with students’ use of higher-order thinking. In both studies, a
research approach was adopted that combined quantitative and qualitative methods of investigation. Studies 1 and 2 surveyed introductory technology education classes to assess the extent to which the technology education learning environment promoted different types of student thinking. Subsequent qualitative methods of investigation, comprising video analyses and video-stimulated interviews, were used to interpret the classroom activities that encouraged students to think in particular ways. In Study 1, technology education classes in South East Queensland, Australia were video-recorded and teachers and students were interviewed using a video-stimulated technique to interpret the factors that caused students to think differently. In Study 2, technology classes in North Carolina, America were observed using a researcher-generated checklist to interpret the factors that caused students to think differently. The results of these studies across two countries have facilitated the formulation of classroom programs that are advanced as promoting student higher-order thinking in technology education classes.

It is argued in this thesis that the findings of Studies 1 and 2 supports the concept of higher-order thinking as conceptualised in this thesis. Additionally, it is argued that teachers create a classroom program through strategy selection and implementation. The classroom program influences the learning actions of students, which in turn promotes different types of student thinking. Therefore, it is argued in this thesis that teachers influence the thinking of students through strategy selection and implementation. In addition, the results of Study 1 and 2 are interpreted to indicate that technology education classes have significant potential to provide students with learning experiences that promote their use of higher-order thinking.
Chapter 1

INTRODUCTION

This thesis examines the relationship between teacher and student activity and the different types of thinking students use in technology education classes. The nature of higher-order thinking is examined in terms of the literature associated with theories of cognition, behaviour settings and activity. It is argued in this thesis that contemporary definitions for higher-order thinking are inadequate to capture its nature, or to infer the conditions necessary for its promotion in technology education classrooms. This study is significant because it is the first to examine theories of cognition, behaviour settings and activity in order to interpret the technology education learning environment in terms of its capacity to promote student higher-order thinking. In this chapter an overview of what follows in later chapters is provided. The following sections of this chapter identify gaps in the literature that are addressed by the thesis, summarise the main arguments and provide the thesis structure. Section 1.1 is concerned with establishing technology education as a subject area in transformation as the context for this thesis.

1.1 Technology Education: A Subject Area in Transition

Technology education is advanced in the literature as a subject area that has the potential to support student higher-order thinking (DeMiranda, 2004). However, also acknowledged is the lack of empirical research that provides support for this potential (Cajas, 2002; DeMiranda, 2004; DeMiranda & Folkestad, 2000; Johnson, 1997; McCormick, 1996; Zuga, 2004). Additionally, the literature provides evidence of the transition of technology education from some form of industrial arts-based subject focused on industrial hand and machine skills, to a subject more concerned with problem-solving and technological literacy (Eggleston, 1992; Fritz, 1996; Hansen, 1995; Herschbach, 1998; Lauda, 1988; McCormick, 1997; Newberry, 1997; ...
Herschbach (1998) argues that the teaching strategies traditionally employed within the industrial arts’ workshops of the past arose from behaviourist traditions and that these strategies were primarily concerned with the passing of content didactically from teacher to student using a show and follow, step by step strategy (Fritz, 1996; Williams, 2000). Additionally, these strategies are argued to display little regard for the process of learning as experienced by the individual learner (Hansen, 1995; Herschbach, 1998). That is, rather than being concerned with constructing knowledge based on student understanding and cognitive development, these show and follow strategies were more concerned with students displaying appropriate behaviours as demonstrated by teachers using a step by step process (Fritz, 1996; Hansen, 1995; Herschbach, 1998; Williams, 2000). There is evidence that technology education has changed in terms of content through stipulated curriculum documentation at a systemic level [e.g. standards statements (ITEA 2000), curriculum documents (QCA, 1999), and technology syllabi (QSA, 2002)]. However, there is little empirical research examining the effect of different teaching strategies on students’ use of higher-order thinking in technology education classes. Therefore, this research has been designed to address these gaps in knowledge.

1.2 Conceptualising Higher-Order Thinking

Various authors posit that a robust definition of higher-order thinking is yet to be formulated (e.g. Cuban, 1984; Beyer, 1985; Cruikshank & Olander, 2002; Lewis & Smith, 1993; O’Tuel & Bullard, 1993; Newmann, 1990; Resnick, 1990, 1987; Smith, 2001) and that often various different theoretical perspectives give rise to diverse interpretations of higher-order thinking (e.g. Resnick, 1990, 1987) (See Section 2.2). For example, often critical thinking is advanced as an alternative to a higher-order thinking construct (Smith, 2001) (See Section 2.2.1). However, critical thinking is equally as often discredited as an alternative within the literature.
Beyer, 1985; O’Tuel & Bullard, 1993; Smith, 2001; Tsui, 1998). The levels of analysis, synthesis, and evaluation within Bloom’s taxonomy are argued to provide a conceptualisation of higher-order thinking (O’Tuel and Bullard, 1993) (See Section 2.2.2). Alternately, it is argued that Bloom’s taxonomy is not a useful tool for representing and teaching higher-order thinking (Challenor, 1991; Ennis, 1987; Ivie, 1998; Raudenbush, 1992). However, Geertsen (2003) argues that Bloom’s taxonomy provides the basis for distinguishing between abstract thought at various levels and that abstract thinking denotes the extent that an individual must alter, manipulate, interpret or apply information.

Chapter 2 (See Section 2.2.3) provides support for the argument that within the literature similarities between the definitions, criteria, and characteristics of higher-order thinking may be identified. Higher-order thinking is often argued to require self-regulation, self-management or a disposition of thoughtfulness within a system that investigates, acquires, analyses and evaluates information in order to resolve problem situations (Boekaerts, 2002; Ivie, 1998; Newman, 1990). However, O’Tuel and Bullard, 1993 and Resnick, 1987 appear to focus on the characteristics of higher-order thinking, rather than attending to its structure or the environmental conditions that support or hinder its use. Thus, a conceptualisation of higher-order thinking is required that identifies the process of higher-order thought, and what personal, social, and environmental factors influence its use. One aim of this thesis is to examine the theories of cognition, behaviour settings and activity in terms of advancing a conceptualisation of higher-order thinking.

1.2.1 Cognitive Theory
Stevenson’s (1986a, 1986b) and Barkley’s (2001) theories of cognitive adaptation argue that cognition involves a hierarchy of cognitive structures that facilitates thinking at higher and lower-order levels (See Section 2.3). Additionally, it is argued in this thesis that self-regulated learning is analogous to a hierarchical adaptive cognitive system and that higher-order
thinking be conceptualised to acknowledge the significant role of self-regulation within the person-to-environment adaptive system (See Section 2.4).

1.2.2 Behaviour Setting Theory
Stevenson’s (1984) conceptualisation of cognitive holding power was derived from setting theories including that of Barker (1968, 1978) (See Section 2.4). The influence of the learning environment on higher-order thinking is examined in this thesis in terms of Barker’s (1968, 1978) theory of behaviour settings (See Section 2.5). Barker argues that behaviour settings have an ordered and socially maintained program that impacts, both negatively and positively, upon various individuals’ personal goal attainment within that setting, and thus exhibits an influence on the types of activities a person engages with during routine or non-routine situations in pursuit of their goals. It is argued that realising goals, or attaining desirable hypothetical futures is an important factor within the self-regulation of higher-order thinking. Therefore, this thesis aims to establish the significance of the role played by the behaviour setting in facilitating goal attainment and thus in supporting higher-order thinking.

1.2.3 Activity Theory
This thesis examines the literature on activity theory in order to interpret the influence of individual and collective activity during cognitive adaptation within a setting (See Section 2.6). The literature associates activity theory with goal orientated behaviours (i.e. actions and operations). Culturally determined tools mediate these behaviours or actions and these tools both constrain and support activity within a dynamic relationship (Wertsch, 1998). That is, over time, activities are transformed because of the transformations that evolve in the relationship between tools and actions. The interaction of tools (i.e. psychological tools and technical tools) and actions indicates that cognition exists and interrelates on two planes, one internal to the person and one external to the person (Susi & Ziemke, 2001; Hacker, 2001; Jonassen & Rohrer-Murphy, 1999; Wertsch, 1998). This thesis examines the role played by activity (i.e. teacher and student actions during tool use) in supporting students’ use of higher-order thinking in technology education classes (See Section 2.6).
It is argued in this thesis that the cognitive, behaviour setting and activity theory literatures provide the basis for a conceptualisation of higher-order thinking. This thesis aims to advance a model of teaching and learning in technology education classes that establishes the framework for support of the conceptualisation of higher-order thinking advanced in this thesis. The conceptualisation advanced in this thesis combines aspects of theories of cognition, behaviour settings and activity to establish a theory for higher-order thinking. This thesis advances this theory by examining technology education classes in terms of the teaching strategies and tactics (i.e. classroom program, See Sections 1.3.1 and 3.3.2) that promote different types of student thinking (i.e. higher and lower-order thinking). The following sections are concerned with the nature of teaching and learning in technology education classrooms.

1.3 Technology Education: Teaching Strategies and Tactics
Contemporary technology education teachers are required to formulate their curriculum from syllabus documents and standards statements that emphasise the development of students’ higher-order thinking skills (See section 2.1). Teaching strategies are formulated in response to these documents and should be reflective of the need to promote or support student higher-order thinking. This process of strategy formulation is defined as: front-end analysis (Jonassen, et al, 1990) (See Section 3.2). This is an important process in the context of this thesis because teachers make these decisions based on their interpretation of the curriculum documentation and on their beliefs about what is important in terms of teaching and learning in their technology education classrooms. Therefore, an aim of this thesis is to identify the various teaching strategies of technology education teachers and to understand how these different strategies influence the thinking of students in their classrooms.

1.4 Technology Education: Classroom Program
McCormick (2004) argues that through strategy selection (i.e. using a process of front-end analysis) teachers create a classroom culture and it is this culture that promotes particular
types of student and teacher classroom activity and inhibits others (See Section 3.3.2). In this thesis McCormick’s concept of classroom culture is interpreted in terms of Barker’s (1968, 1978) concept of behaviour setting program (See Section 2.5). That is, technology education classrooms (i.e. the behaviour setting), exhibit ongoing patterns of behaviour, or programs that govern how teachers and students engage with their activities (interactions between people and inanimate artefacts).

It is argued that teachers employ specific tactics during strategy implementation (See Section 3.2.1) and these tactics are defined as what teachers do during their interactions with students (Jonassen, et al, 1990; Leshin, et al, 1992; Rothwell & Kazanas, 1992) (See Section 3.2). Teaching tactics are rarely mentioned in the instructional design literature (Rothwell & Kazanas, 1992). However, it is argued in this thesis that the concept of teaching tactic is significant because it establishes a relationship between teaching strategies and what teachers do (teachers’ activities) to support the implementation of strategies. That is, the concept of teaching tactics supports an interpretation of teacher-student interaction based on strategy selection and implementation. In other words, an analysis of the strategies teachers select and the tactics used in their implementation provides evidence of the program of the technology education classroom. Therefore, an aim of this thesis is to explore classroom programs in terms of their influence on the promotion of different types of student thinking (i.e. higher and lower-order thinking) in technology education classes.

Therefore, this study is designed to address the lack of research focused on the activities of teachers and students in technology education classrooms and how these activities influence the types of thinking students use (McCormick, 1996). This research project is the first to combine theories of cognition (Anderson, 1982; Fischer, 1980; Jones & Anderson, 1987; Newell & Simon, 1972; Scandura, 1981; Stevenson, 1984), behaviour settings (Barker, 1968, 1978; Stevenson, 1984, 1986a, 1986b; Wicker, 2002, 1991, 1984) and activity (Engeström, 2000; Engeström & Cole, 1997; Jonassen & Rohrer-Murphy, 1999; Virkkunen & Kuutti,
2000) in order to identify classroom activities (teaching strategies and tactics) that promote students’ use of higher-order thinking in technology education classes.

1.5 Technology Education: Teaching and Learning
It is argued in this thesis that teaching and learning in technology education is influenced by the legacy of the subject’s industrial arts past (Fritz, 1996; Sanders, 2001; Walmsley 2001, 2003; Williams, 2000). The literature argues that this situation: influences teachers’ perceptions of curriculum documentation (Sanders, 2001); the relative importance of technological content and problem-solving (Sanders, 2001); the relative importance of hand and machine skills (Walmsley, 2001, 2003); and the types of teaching strategies used to implement curriculum (Fritz, 1996; Sanders, 2001; Walmsley, 2001, 2003; Williams, 2000) (See Section 3.3.1). Sanders (2001) studied the transition from industrial arts to technology education within a number of American education districts. Sander’s study concluded that considerable change was evident in technology education program labels, delivery methods and emphasis (i.e. from hand and machine skills to technological problem-solving), however, the legacy of the industrial arts past was still present. That is, while substantial change was evident within Sanders’ data, from within each category, the data still reflected the influence of technology education’s industrial arts heritage (See Section 3.3.1).

Of particular interest to this thesis is the change in delivery methods or instructional strategies that contemporary technology teachers employ. It is concluded from the literature reviewed in this thesis, that contemporary technology educators acknowledge problem-solving development as the primary focus of students’ participation in technology education classes (Sanders, 2001) (See Section 3.3.1). Given that problem-solving is seen as an important consequence of students’ engagement in technology education learning experiences, what then are the teaching strategies that support student problem-solving (i.e. higher-order thinking) and what are the teaching strategies that do not? The answer to these questions is the primary focus of this thesis.
It is argued in this thesis that the literature appears to be divided on the issue of how to promote student higher-order thinking in technology education classrooms. The literature reviewed in this thesis is interpreted as supporting opposing viewpoints based on assumptions drawn from other disciplines, rather than from empirical research results related to teaching and learning that promotes student higher-order thinking in technology education classrooms. For example, Schultz (1999) argues that project-based instruction supports student higher-order thinking, while DeMiranda (2004) argues that contemporary technology education classrooms (i.e. modular technology education, MTE (See Section 3.3.3) and technological problem-solving based instruction) have the potential to promote student higher-order thinking (See Section 3.3.1). However, these claims need to be tested in terms of the types of thinking that actually occur within technology education classrooms.

The design-process has become the strategy of choice for many technology educators to facilitate the promotion of student higher-order thinking in their classrooms (Mioduser, 1998; Rowel, 2004). However, Mawson, (2003), McCormick, et al, (1994) and McCormick, (2004) discredit the design-process for characterizing problem-solving as a generally applicable skill because it is often applied in a ritualistic and prescriptive manner (Mawson, 2003; McCormick, 2004). The design, make and appraise model (DMA) (Mawson, 2003) is often portrayed as a cyclic or linear series of steps (See Figure 3.1) that McCormick (2004) argues is often ritualistically applied and does not accurately represent the actual thinking of students (See Section 3.3.1). This thesis reports on a study that examines the teaching and learning activities of design-process based technology education classes in Australia and modular technology education (MTE) classes in America. This examination of the capacity of the learning environments to promote particular types of student thinking, allows for an interpretation of technology education classroom programs and their effect on students’ use of higher and lower-order thinking.
There is little publicised empirical research into teaching and learning and the promotion of higher-order thinking in technology education classes (Cajas, 2002; DeMiranda, 2004; DeMiranda & Folkestad, 2000; Johnson, 1997; Lewis, 1999; McCormick, 1996; Zuga, 2004). Recognising this gap in knowledge, this study investigates technology education classes in Australia and America to examine what teacher and student activities (i.e. classroom programs) support different types of student thinking (i.e. higher and lower order thinking).

1.6 Statement of the Problem
This thesis addresses two related questions. What is the nature of higher-order thinking and the technology education classroom conditions that support students’ use of higher-order thinking? The two related areas are examined in this thesis through the following research questions:

- How can higher-order thinking be conceptualised?
- In what ways can higher-order thinking be promoted in technology education classes?

To further focus the study, a series of more specific research questions are posed:

1. What differences exist between Australian technology education classes regarding the press for higher-order and lower-order thinking?
2. What factors appear to press for higher-order and lower-order thinking within Australian technology education classes?
3. What differences exist between American technology education classes regarding the press for higher-order and lower-order thinking?
4. What factors appear to press for higher-order and lower-order thinking within American technology education classes?
5. Do factors that appear to promote a press for student higher-order and lower-order thinking in technology education vary across Australian and American technology education classrooms?

An interpretation of the results obtained from these research questions is used to propose a conceptualisation of the technology education classroom conditions necessary for the promotion of student higher-order thinking. Questions 1 and 3 examine what is happening in technology education classes in terms of the types of thinking in use. Questions 2 and 4 seek
to understand why technology education classes support the types of thinking encountered. Question 5 addresses the similarities and differences across countries, in terms of factors that promote or inhibit different types of student thinking in technology education classes.

1.7 Contribution of the Thesis
This thesis is concerned with understanding the nature of higher-order thinking and the conditions supportive of its promotion in technology education classrooms. The thesis contributes to knowledge in four related areas. Firstly, the thesis contributes towards an understanding of the nature of higher-order thinking in terms of the relationship among a person’s cognitive structures (i.e. a person’s internal cognitive processes), the behaviour setting (i.e. the environment in which the person is situated) and activity (i.e. a person’s interaction between the environment and their internal cognitive processes). Secondly, this thesis provides a contribution to knowledge of instructional design and the factors that contribute to the promotion of a relationship between classroom program and support of higher-order thinking in technology education classes. Thirdly, the thesis contributes to knowledge of teaching and learning and the promotion of higher-order thinking in two different countries. Fourthly, this thesis contributes in a practical way towards the prescribed requirement that teachers strategically implement curricula that promote students’ use of higher-order thinking in technology education classes. Furthermore, while technology education is the primary focus of this thesis, it is possible that the conclusions reached may contribute to teaching, learning and the promotion of higher-order thinking in other subject areas. In addition, this thesis contributes to knowledge of the utility of the various research methods as applied to technology education classes in this study: the cognitive holding power questionnaire and analyses, video data capture and classroom observation techniques and analyses, and stimulated-recall interview techniques and analyses.

1.8 Thesis Structure
The thesis is structured in the following way. Chapter 1 outlines the nature of the problems examined in the thesis, provides an overview of the literature and identifies gaps in knowledge
of technology education in terms of cognition, behaviour settings, activity, instructional design and higher-order thinking. Chapter 2 reviews the literature in relation to higher-order thinking, cognition, behaviour settings and activity, and advances a conceptualisation of higher-order thinking as a construct within this framework. Chapter 3 reviews literature associated with instructional design, technology education and higher-order thinking. Chapter 4 presents the methods used to investigate the research questions posed in this thesis. Chapters 5 and 6 present the results and analyses of Studies 1 and 2 respectively. Chapter 7 discusses the theoretical and practical implication of the results and conclusions drawn from Studies 1 and 2, and outlines suggestions for further research. The following paragraphs outline the contribution of each chapter to the thesis.

Chapter 2 examines literature concerned with higher-order thinking. It examines existing definitions of higher-order thinking and the literature on structures associated with thinking. Self regulation, the learning environment and activity are examined in the literature to advance a conceptualisation of higher-order thinking that draws on these constructs. On the basis of this examination, it is argued that thinking is hierarchically constructed with reference to the physical, the social, and the contextual environments experienced by an individual.

Chapter 3 examines literature concerned with instructional design in technology education. Technology education’s transition from industrial arts is examined in terms of contemporary pedagogy. Teaching strategies and tactics are outlined. Literature concerned with contemporary technology education teaching and learning environments is examined. The Chapter concludes by predicting particular types of activities that are argued to promote students’ use of higher-order thinking in technology education classes. These predictions are synthesised from the literature reviewed in Chapters 2 and 3.

Chapter 4 presents and justifies the research methodology employed to address the research questions posed in this thesis. The study combines quantitative (surveys) and qualitative
(video, observation and video-stimulated interviews) research methods to examine factors that appeared to promote students’ use of higher-order thinking in technology education classes.

The study consists of two related studies (i.e. Study 1 and Study 2). Study 1 was conducted in Southeast Queensland, Australia and Study 2 was conducted in North Carolina, America. Both studies combined quantitative and qualitative methods of investigation to understand the activities of teachers and students in terms of their influence on the types of thinking students used in technology education classes. Quantitative analyses were used to interpret what was happening in the classrooms (i.e. what types of student thinking were in use) and qualitative analyses were used to interpret why this appeared to occur.

Chapter 5 presents the results and analyses of Study 1. On the basis of these results and analyses, an Australian technology education classroom program that is interpreted to support students’ use of higher-order thinking is advanced.

Similarly, Chapter 6 presents the results and analyses of Study 2. On the basis of these results and analyses, an American technology education classroom program that is interpreted to support students’ use of higher-order thinking is advanced.

Chapter 7 reports on the conclusions drawn from the study and recommends areas for further research. It is concluded that technology education teachers can promote students’ use of higher-order thinking by adopting a classroom program that emphasises certain teacher and student activities over others. For example, higher-order thinking is argued to be promoted by activities that support single student-to-teacher interactions and limit those that promote whole class or group-to-teacher interactions and by learning activity that occurs independent of the teacher that is undertaken by individual students rather than by students acting within groups.

The conclusions drawn from this study support and extend those from previous studies (e.g. Stevenson, 1998; Stevenson & McKavanagh, 1991; Stevenson & Evans, 1994; Stevenson & McKavanagh, 1994) and provide support for the literature that proposes technology education
learning experiences as having the capacity to support student higher-order thinking (e.g. DeMiranda, 2004; Johnson, 1992; Schultz, 1999).

The implications of the study are discussed in terms of areas that require further investigation. The cross-country nature of the study provides opportunities to examine the differences and similarities across two countries in regard to classroom programs that promote different types of student thinking. The research methodologies employed in this study are suggested as a possible direction for future research examining teaching and learning and the promotion of students’ use of higher-order thinking in technology education classes.
Chapter 2

HIGHER-ORDERS OF THINKING

2.1 Introduction
This chapter reviews literature concerned with two aspects of higher-order thinking. It examines existing definitions of higher-order thinking and concludes that a conceptualisation of higher-order thinking is required that captures its nature. Also examined is the literature on cognitive structures associated with thinking. On the basis of this examination, it is argued that thinking is hierarchically constructed with reference to the physical, the social, and the contextual environments experienced by an individual.

Contemporary curriculum documentation and related literature commonly refer to the desirability of students acquiring and using higher-order thinking skills (Hobson, 1997; Ivie, 1998; O’Tuel & Bullard, 1993; Raudenbush, 1992; Sparapani, 1999; Zohar, 1999). However, these arguments are often made without an accompanying definition of higher-order thinking or any indication of how these skills might be identified and taught in educational contexts (Ivie, 1998; Lewis & Smith, 1993; O’Tuel & Bullard, 1993; Resnick, 1987; Sparapani, 1999; Smith, 2001). This thesis aims to reconcile the apparent disparity between knowledge and understanding of how higher-order thinking might be conceptualised and the teaching strategies and tactics (See Section 3.2 for literature that defines teaching strategies and tactics) that might be employed in the pursuit of improved higher-order thinking outcomes in technology education classrooms.

2.1.1 Chapter Structure
Section 2.2 examines contemporary definitions for higher-order thinking. Section 2.3 examines cognitive structures and advances the incorporation of a theory of cognitive adaptation when conceptualising higher-order thinking. Section 2.4 reviews the literature
associated with self-regulation and the importance of this concept in its relation to higher-order thinking. Section 2.5 reviews the literature associated with behaviour settings and examines the significance of this construct for higher-order thinking. Section 2.6 reviews the literature associated with activity theory and examines the significance of activity in relation to the support of higher-order thinking. Section 2.7 summarises the literature reviewed in the previous sections of the chapter to synthesise a conceptualisation for higher-order thinking. This conceptualisation is examined further in Chapter 3 in its relation to teaching and learning in technology education classes.

2.2 Higher-Order Thinking: Towards a Definition
Resnick (1990, 1987) argues that across educational stakeholders there are various definitions of higher-order thinking. Resnick argues further that the various thinking skills (e.g. critical thinking, metacognition, cognitive strategies, heuristics etc.) advanced by those who appear to hold different theoretical orientations are in fact related. O’Tuel and Bullard (1993) and Smith (2001) argue that attempts to define higher-order thinking in terms of these aforementioned skills have proven untenable. Lewis and Smith conclude that philosophers lean towards critical thinking as a focus for instruction: while psychologists prefer the term thinking skills (Lewis & Smith, 1993, p. 136). Smith (2001) argues that many theorists provide critical thinking as an alternative to higher-order thinking. Additionally, Smith argues that too often, critical thinking is defined as broadly encompassing all the thinking skills, rather than only those of: reasoning and argumentation (Smith, 2001, p.349). O’Tuel and Bullard agree that critical thinking as a term is sometimes regarded as including all forms of thinking: hard or deeply (O’Tuel & Bullard, 1993, p.1). Bloom, Englehart, Furst, Hill and Krathwohl (1956) conceptualise a taxonomy of educational objectives. These objectives include knowledge, comprehension, application, analysis, synthesis, and evaluation. Postlethwaite, (1993) argues that Bloom et al’s, (1956) taxonomy (i.e. Bloom’s Taxonomy) is able to distinguish between cognitive demand at the lower and higher levels, with knowledge or recall being at the lower and evaluation being at the higher end of the continuum. The levels of analysis, synthesis and
evaluation are often represented in the literature as being indicative of thinking at the higher-order levels (Cruikshank & Olander, 2002; O’Tuel & Bullard, 1993). Thus, there appears to be a view that thinking is hierarchical, but different views about how thinking at the higher end of the hierarchy is conceptualised.

2.2.1 Critical thinking and defining higher-order thinking.
Ennis argues that the term higher-order thinking is vague and serves only to remind us that schools have a purpose that is greater than merely providing students with: banks of memorised and soon to be forgotten facts (Ennis, 1987, p.10). In addition, Ennis argues that critical thinking appears to provide a more valuable contribution to the establishment of effective student thinking in the school curriculum than does higher-order thinking, because as a construct it can be more effectively defined and developed. Smith (2001) argues that Ennis’s definition of critical thinking as being: reasonable reflective thinking that is focused on what to believe or do (Ennis, 1987, p.10) is not indicative of the true nature of critical thinking. That is, Smith (2001) views critical thinking as argument-centred and as such, concludes that it is chiefly about belief rather than about action (doing). In addition, Smith argues that critical thinking research, texts, and instructional programs: lack the breadth needed to produce fully effective thinkers (Smith, 2001, p. 350). Smith’s (2001) argument is supported by Tsui (1998) who reviewed sixty-two critical thinking studies involving American college students. Despite the similar nature of the research questions and the use of similar research instruments (i.e. standardised tests of critical thinking), Tsui discovered very little evidence of consistency across the empirical results of these studies. Tsui argues that: Although the virtue and imperative of critical thinking is widely espoused, there is surprisingly little known through empirical research about the development of critical thinking in college (Tsui, 1998, p. 20).

Ennis (1987) argues that because the skills defined as higher-order thinking are necessarily vague they should not be associated with critical thinking. However, Ennis also argues that the practice of critical thinking includes the skills of practical higher-order thinking. Alternatively,
Ten Dam and Volman argue that the literature associated with critical thinking tends to define it as a higher-order thinking skill, rather than as a competency for: *critical participation in modern society* (Ten Dam & Volman, 2004, p. 360). A lack of agreement would appear to exist in terms of the role of critical thinking within the broader context of what constitutes higher-order thinking. Beyer argues that:

> ...critical thinking is not problem solving. It is not decision making. It is not Bloom’s taxonomy. It is not a cover-all term for all thinking skills. Critical thinking is instead, the process of determining the authenticity, accuracy and worth of information or knowledge claims. It consists of a number of discrete skills, which one can use and is inclined to use, to determine such authenticity, accuracy and worth.

(Beyer, 1985, p.276)

Ten Dam and Volman (2004) argue that it is necessary to move beyond critical thinking in defining higher-order thinking because: *A problem that is connected with the characterization of critical thinking as a higher-order thinking skill is the unclear distinction between critical thinking on the one hand, and other kinds of higher-order thinking on the other* (Ten Dam & Volman, 2004, p.363). However, critical thinking should be and is recognised as being an important skill for students to possess as they learn to evaluate the information and the knowledge claims that they encounter during their various learning activities (Beyer, 1985).

Ten Dam and Volman (2004) argue that Bloom’s taxonomy (Bloom et al, 1956) is used to contrast higher and lower-order thinking skills. That is, lower-order thinking is represented by knowledge, comprehension and/or application, and critical thinking (i.e. higher-order thinking) is represented by analysis, synthesis and/or evaluation within Bloom’s taxonomy of educational objectives. Bloom’s taxonomy and defining of higher-order thinking is examined in the following section.
2.2.2 Bloom’s taxonomy and conceptualising higher-order thinking

O’Tuel and Bullard (1993) argue that the levels of analysis, synthesis, and evaluation within Bloom’s taxonomy provide a definition for higher-order thinking. Alternately, Ivie (1998) and Ennis (1987) argue that Bloom’s taxonomy is not a useful tool for representing and teaching higher-order thinking, arguing for the importance of focusing on instruction that teaches students how to think clearly and logically. Similarly, Challenor (1991) argues that the widespread misinterpretation of Bloom’s taxonomy has resulted in students, perceived as being academically weaker, being taught almost exclusively at the lower levels of the taxonomy (i.e. knowledge, comprehension and application). Raudenbush (1992) supports this view by arguing that empirical evidence (i.e. classroom observations) indicates that students perceived as being lower achievers rarely experience instruction aimed at promoting higher-order thinking, while high achieving students are more likely to experience instruction that actively promotes higher-order thinking.

Geertsen (2003) argues that Bloom’s taxonomy provides the basis for distinguishing between abstract thought at various levels. According to Geertsen (2003), the more concrete thinking skills are located at the lower end of Bloom’s taxonomy (i.e. knowledge or memory recall) and the most abstract thinking is located at the higher end of the taxonomy (i.e. evaluation). For example, recalling information that was previously acquired requires the use of the most concrete of thought processes, while applying, analysing, or evaluating this same information requires the use of more abstract forms of thought (Geertsen, 2003). In this context, abstract thinking denotes the extent that the individual must alter, manipulate, interpret or apply information. Geertsen (2003) expands on Bloom et al’s six levels of educational objectives as displayed in Table 2.1 below.
Table 2.1
Ten Micro-Thinking Skills by Degree of Abstraction

<table>
<thead>
<tr>
<th>Highest Degree of Abstraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extrapolation (high transfer) – to discover how what applies to known situations/data might apply to less familiar situations/data</td>
</tr>
<tr>
<td>Evaluation – to determine the value of something</td>
</tr>
<tr>
<td>Explanation – to deduce/show how something logically follows</td>
</tr>
<tr>
<td>Synthesis – to put together to form some coherent whole</td>
</tr>
<tr>
<td>Analysis – to break down into various parts (compare and contrast)</td>
</tr>
<tr>
<td>Application (low transfer) – to use with familiar situations/data</td>
</tr>
<tr>
<td>Classification – to arrange according to common characteristics</td>
</tr>
<tr>
<td>Interpretation – to give the essential meaning of something</td>
</tr>
<tr>
<td>Translation/paraphrase – to restate the same thing in different words</td>
</tr>
<tr>
<td>Recall – to recollect or remember something</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lowest Degree of Abstraction</th>
</tr>
</thead>
</table>

(Geertsen, 2003, p.3)

In the context of this thesis, Geertsen’s (2003) reasoning for such an extension of Bloom’s taxonomy (as displayed in Table 2.1) is less important than the structure of his taxonomy, which identifies thinking at various degrees of abstraction. As a result, it is not examined, other than by acknowledging Geertsen’s argument for higher-order (higher-level) thinking to be regarded as analogous to the degree of abstract thought required during an individual’s use of various types of thinking skills. That is, Geertsen defines higher-level thinking as: a disciplined, systematic way of using the mind to confirm existing information or to search for new information using various degrees of abstraction (Geertsen, 2003, p.4). In terms of this thesis, this definition is significant because it recognises the conditions of use of higher-order thinking (i.e. whilst using thinking skills at various degrees of abstraction) and additionally, acknowledges the role of cognition (the mind) during this process. However, Geertsen’s (2003) definition does not describe the processes involved in higher-order cognition, or consider whether or not other factors may have an influence over higher-order thought. The following section examines literature that provides contemporary definitions for higher-order thinking.
2.2.3 Contemporary definitions for higher-order thinking

Cuban argues that attempts to define different forms of thinking (e.g. critical thinking, problem-solving, creative thinking, metacognition etc.) have proven to be a *conceptual swamp* (Cuban, 1984, p.676). That is, difficulties with defining different forms of thinking have arisen because of the inherent desire of researchers and stakeholders to segregate philosophical and psychological constructs. Lewis and Smith argue that:

*...the field of philosophy has grown through discourse and argumentation, the field of psychology has evolved from a tradition of experimentation and research. While philosophers are basically interested in the use of logical reasoning and perfections of thinking to decide what to believe and do, psychologists are more concerned with the thinking process and how this process can help people make sense out of their experience by constructing meaning and imposing structure.*

*(Lewis & Smith 1993 p.132)*

In other words, the sciences (i.e. psychology) most often utilise a scientific problem-solving approach, while the humanities (i.e. philosophy) consistently utilise a critical evaluative approach to the solving of problems (Lewis & Smith, 1993). However, Lewis and Smith (1993), Newmann (1990) and Smith (2001) argue that a more general framework is required to interpret the processes of thinking. Lewis and Smith (1993) and Smith (2001) argue that current approaches to the study of thinking have been defined in terms of an overly narrow focus on specific thinking skills, such as critical thinking.

Lewis and Smith define higher-order thinking as occurring: *when a person takes new information and information stored in memory and interrelates and/or rearranges and extends this information to achieve a purpose or find possible answers in perplexing situations* (Lewis & Smith, 1993, p.136). Young argues that higher-order thinking can be defined: *as a function of the interaction between cognitive strategies, metacognition (metacognitive knowledge and strategies) and domain specific knowledge (including schema and mental models) during problem solving* (Young, 1997, p. 40). Newmann (1990) argues that students should be involved in non-routine situations that require the solving of problems using previously unknown knowledge. Newmann argues that students must possess: *...in-depth knowledge,*
skills and dispositions of thoughtfulness (Newmann, 1990, p. 53) to engage effectively in higher-order thinking. Underbakke, et al, (1993) argue that higher-order thinking involves students in: manipulate[ing] information in order to produce certain outcomes (Underbakke, et al, 1993, p. 139) and for students to become better higher-order thinkers they must learn to deal with information more effectively. Dealing more effectively means that students learn to select and sequence procedures (i.e. information about how to do things) for dealing with novel situations (i.e. problems) in order that they achieve effective problem solutions (Underbakke, et al, 1993).

Rather than define higher-order thinking directly, some academics advance characteristics or criteria that might be used to conceptualise higher-order thinking. For example, O”Tuel and Bullard argue that higher-order thinking includes the following dimensions:

1. Skills, strategies and processes.
2. Selection, organisation, and use of the skills, strategies and processes.
3. Application within and across subject areas and real world tasks.
4. An inquisitive and positive “can do” attitude.
5. Managing and regulating one’s own thinking processes.

(O”Tuel & Bullard, 1993, p. 4)

Resnick characterises higher-order thinking as:

1. ...non-algorithmic. That is, the path of action is not fully specified in advance.
2. ...complex. The total path is not “visible” (mentally speaking) from any single vantage point.
3. ...often yield[ing] multiple solutions, each with costs and benefits, rather than unique solutions.
4. ...involv[ing] nuanced judgement and interpretation.
5. ...involv[ing] the application of multiple criteria, which sometimes conflict with each other.
6. ...often involv[ing] uncertainty. Not everything that bears on the task at hand is known.
7. ...involv[ing] self-regulation of the thinking process. We do not recognise higher-order thinking in an individual when someone else “calls the plays” at every step.
8. ...involv[ing] imposing meaning, finding structure in apparent disorder.
9. ...effortful. There is considerable mental work involved in the kinds of elaborations and judgements required.  
(Resnick, 1987, p.3)

Newmann (1990) argues that situations that demand student higher-order thinking may not necessarily exhibit all of Resnick’s higher-order thinking characteristics. Ivie posits that higher-order thinking tends to reflect three related criteria: (A) The utilisation of abstract structures for thinking... (B) The organisation of information into an integrated system...(C)The application of sound rules of logic and judgement (Ivie, 1998, p. 36).

Similarities among the definitions, criteria, and characteristics of higher-order thinking are evident within the literature. For example, most argue that an increased level of abstraction is indicative of higher-order thinking. Resnick (1987) uses the terms imposing meaning and finding structure in apparent disorder to highlight the abstract nature of higher-order thought. Higher-order thinking is often argued to require self-regulation, self-management or a disposition of thoughtfulness within a system that investigates, acquires, analyses and evaluates information in order to resolve problematic situations (Boekaerts, 2002; Ivie, 1998; Newman, 1990). Like Geertsen (2003), O’Tuel & Bullard, (1993) and Resnick, (1987) focus on the conditions of use of higher-order thinking, rather than attending to the specific nature of higher-order thinking in relation to the environmental conditions that support or hinder its use. That is, the question of conceptualising higher-order thinking and understanding how it can be promoted in educational contexts remains substantively unanswered.

In summary, the literature examined in this chapter to this point provides the basis for synthesising a conceptualisation of higher-order thinking. However, the literature continues to emphasise narrower concepts, such as critical thinking, when striving to design research, instruction, and texts to improve student thinking. Critical thinking and the higher levels of Bloom’s taxonomy are often provided as a model for the recognition and instruction of higher-order thinking skills. However, Resnick argues that: thinking skills resist the precise forms of
definition we have come to associate with the setting of specified objectives for schooling (Resnick, 1987, p.2). The emphasis on particular thinking skills (e.g. critical thinking) has been unable to provide a consistent flow of empirical evidence that indicates a potential for sustainable and widespread development of instruction that promotes these skills. On this basis, Cuban (1984), Lewis and Smith (1993), Newmann (1990) and Smith (2001) argue for a definition of higher-order thinking in its broadest sense. That is, they argue that there is need for a definition of higher-order thinking that transcends disciplinary boundaries.

In order to conceptualise the nature of higher-order thinking, the following sections of this chapter examine the literature concerned with the concept of thinking as being hierarchically structured and actively constructed by the learner in response to the learning environment. In this thesis the learning environment is defined as being a dynamic system that incorporates the physical (inanimate physical objects), the social (inhabitants) and the context (rules and routines that govern behaviour) in which learning takes place (Barker, 1968, 1978; Cambourne, 2002; Wicker, 1984, 1991, 2002).

2.3 Hierarchy of Cognitive Structures
Schrag (1989) argues that the idea that hierarchical orders of thinking exist is not conclusive and as yet open to debate. This argument stems from Schrag’s assertion that thinking is conditional upon the intellectual challenge faced by the individual, and that in Schrag’s opinion, efforts to assign scientific status to this concept, in terms of levels or orders of thinking, have largely proved to be unsuccessful. Alternately, Lewis and Smith argue that there exists a: _general agreement that lower and higher order thinking skills can be distinguished_ (Lewis & Smith, 1993, p.132). Lewis and Smith qualify their argument by indicating that higher and lower order thinking skills are necessarily linked to an individual’s learning history and in much the same way as Schrag (1989) argues that thinking is conditional upon the intellectual challenge faced by the individual.
Stevenson (1984) advances a theory of cognitive adaptation that conceives of the cognitive system as consisting of cognitive items (facts or conceptual knowledge) and procedures (procedural knowledge) at varying levels or orders. Stevenson combines aspects of Anderson’s (1982) theory of skill acquisition, Scandura’s (1981) hierarchy of rules and Fischer’s (1980) skill theory to formulate a theory of adaptive cognitive processes which traces the acquisition and development of cognitive skills through a hierarchy of transformations (Stevenson, 1986a, 1986b; Stevenson & Evans, 1994; Stevenson, 1998). That is, cognitive items are transformed by higher-order procedures into specific lower-order procedures during initial learning. These lower-order procedures are then combined or restructured by general-purpose (higher-order) procedures during subsequent learning situations. Anderson argues that: *the basic control architecture across these situations is hierarchical, goal structured, and basically organized for problem solving* (Anderson, 1982, p.403).

Lower or first-order specific procedures (Stevenson, 1986a) enable the person to interact with situations that are familiar. Information (cognitive items) and the ways of structuring the information (lower-order specific procedures) already exist within the person’s cognitive repertoire of person-environment experiences. Under circumstances where the person is confronted by unfamiliar or non-routine situations (i.e. problem situations where no lower-order procedures for dealing with the situation already exist), the person seeks either to combine already existing specific lower-order procedures or to create new lower-order procedures by seeking new cognitive items relevant to characteristics of the new situation. Anderson (1982) describes the process of combining cognitive structures as compilation. Compilation consists of the: *subprocesses of composition, which collapses sequences of productions [lower-order procedures] into single productions, and proceduralization, which embeds factual knowledge into productions* (Anderson, 1982, p.369).
Compilation is controlled by general-purpose higher-order procedures within the cognitive system (Stevenson, 1986a). Stevenson (1986a) argues that higher-order procedures exist at the second and third-order levels. Second-order procedures combine first-order procedures to create new first-order procedures as a means for dealing with novel or non-routine situations. That is, the person seeks access to memories that are created through prior experiences (first-order procedures) and that appear to have similarities with the current situation. These memories are represented as specific procedures which contain referents that may link to aspects of the current situation. The cognitive system (i.e. the person) uses these referents to locate applicable lower-order procedures (Stevenson, 1986a). If the person discovers that a new combination of lower-order procedures consistently allow for the correct performance of a skill in dealing with the new situation, then the sequence may be compiled into the system as a new lower-order procedure applicable and useful in the new specific situation (Anderson, 1982; Stevenson, 1986a). Therefore, second-order procedures (i.e. higher-orders of thinking) are responsible for establishing and monitoring the performance of lower-order procedures. Third-order procedures are argued to execute control over all other levels of the system (Stevenson, 1986a). Stevenson argues that: Third order general purpose procedures can commence new learning altogether (Stevenson, 1984, p.64). Third-order procedures switch control between the various cognitive levels in order to attain satisfactory skill accomplishment and goal attainment. Essentially this can be defined as a: system that learns by doing (Anderson, 1982, p.404).

Technology education’s emphasis on design and problem solving provides students with problem situations where their existing knowledge, and specific (lower-order) procedures for applying this knowledge, are likely to be inadequate. For Example, Zubrowski (2002) studied a group of fourth grade students as they designed and constructed a model windmill. These students had limited, if any previous knowledge of wind generated movement and as such required additional support. Zubrowski (2002) provided this support in the form of a standard model of the design process. The design process is examined in Section 3.3. During the design
process, the students’ continually sourced information about the problem (in this case to design and construct a suitably efficient windmill) and applied the knowledge until the problem had become satisfactorily resolved. Anderson (1982) argues that it is a feature of this adaptive process that it prohibits the person from readily accepting changed conditions. That is, the learner must first filter any newly acquired knowledge and procedures through his or her own interpretive system. This interpretive system has evolved as a result of the student’s past experiences and any new information must first pass successfully through this scrutiny before the student’s perception or behaviour is permanently altered. Literature concerned with the influence of the technology learning environment and the promotion of student thinking is reviewed in Chapter 3.

Barkley (2001) provides support for Stevenson’s (1986a) conceptualisation of a hierarchy of adaptive cognitive processes. Barkley argues that Executive Functions (EFs) (i.e. likened here to Stevenson’s hierarchy of cognitive processes) serve to support adaptation through self-regulation which is interpreted as being covertly governed by the individual through a combination of five interrelated processes or EFs.

Barkley’s Executive Functions (EFs) comprise:

1. **Response inhibition** which is defined as a process that delays an initial response to a situation in order to limit the potential negative impact of impulsive behaviours. Response inhibition interrupts a response to a situation that is proving to be ineffectual and it provides stability when competing events and responses cause distraction. Barkley argues that: *response inhibition is a prerequisite to self-regulation* (Barkley, 2001, p.5).

2. **Self-sensing** which is defined as: *covert seeing and hearing to the self* (Barkley, 2001, p.7). Self-sensing provides a person with a covert reference system (using visual imagery and covert dialogue) that bridges the experiences of the past with possible hypothetical futures.

3. **Self-speech** which is defined as internalised speech that permits self-description and reflection, self-instruction, self-questioning and problem-solving, as well as the invention of rules and meta-rules to be applied to oneself (Barkley, 2001, p.8).
4. **Self-emotion/motivation** is defined as: *feeling (emoting/motivating) to the self* (Barkley, 2001, p.8). This emotion is activated by private sensing and speech and serves to motivate the person to act on the basis of an event that is represented mentally to the self.

5. **Self-play** is defined as a means for dealing with situations that obstruct goal attainment. That is, self-play reconstitutes patterns of behaviour (i.e. behaviour units) that have proven ineffective in regards to solving problems en route to future goal attainment.

These Executive Functions have as their purpose:

...to “internalize” or make private certain self-directed behavior so as to anticipate and prepare for change (time) and the future, especially the social future...the ultimate utility function of this EF system is to maximize the net long-term versus short-term social outcomes for the individual.

(Barkley, 2001, p.6)

Barkley (2001) provides a model of covert adaptive cognitive processes which is hierarchically organised in a similar fashion to Stevenson’s (1984) theory of cognitive adaptation. That is, the system is controlled by response inhibition (a self-directed behaviour) that has as its purpose to control the application of other Executive Functions so as to redirect behaviour (actions) towards desirable hypothetical futures. Importantly, Barkley’s model acknowledges self-directed play as a process for reconstituting behaviour units (lower-order specific procedures). Behaviour units are transformed through a two-stage process that is argued in this thesis to mirror Anderson’s (1982) process of compilation. This process involves breaking down the behaviour units into smaller sub-units that are subsequently reassembled to meet the requirements of the current situation. This process becomes operational when successful goal attainment appears to be problematic because of the novelty or non-routine nature of the current situation.

For example, a technology education student may be confronted by a design problem that requires an in-depth knowledge of mechanisms (e.g. levers and linkages). Initially the student may seek access to this knowledge (with teacher support) if his or her existing knowledge in
this domain appears to be inadequate. Once this information has been acquired, the system will attempt to break down existing behaviour units in order that this new and relevant knowledge is integrated into the system. The new behaviour units created through this process are utilised in an attempt to solve the original design problem (for technology education examples of student design and problem-solving see; Mahlke, 1993; Sigmon, 1997; Winek & Borchers, 1993; Zubrowski, 2002). If unsuccessful, the system restarts the process of reconstituting behaviour units until the goal (i.e. desirable hypothetical future) of solving the design problem has been successfully attained.

Thus, Stevenson’s (1984) and Barkley’s (2001) theories of cognitive adaptation are congruent to the extent that they identify a broadly applicable hierarchical cognitive system that enables transformations to occur. Transformations to or controlled operations on existing lower-order specific procedures (Stevenson, 1986a) or behaviour units (Barkley, 2001) within the cognitive system allow the person to adapt to situations that appear to be novel or non-routine. The activation and regulation of these transformations are controlled by cognitive structures that exist at higher, more general levels [i.e. general-purpose second and third order procedures (Stevenson, 1986a), and response inhibition and self-play executive functions (Barkley, 2001)]. Despite each theory originating from different perspectives, with Stevenson’s emanating from cognitive psychology and Barkley’s emanating from neuropsychology, it is argued in this thesis that the two theories can be interpreted as being mutually supportive in terms of acknowledging a hierarchically structured cognitive system that has as its purpose for the individual to adapt to new and unusual circumstances.

In summary, Stevenson’s (1984) and Barkley’s (2001) theory of cognitive adaptation advances the concept of a hierarchy of cognitive structures that facilitates a conceptualisation of thinking that occurs at the higher and lower-order levels. Therefore, it is argued in this thesis that Stevenson’s and Barkley’s theories support the formulation of a broadly applicable conceptualisation of higher-order thinking; that is, that higher-order thinking be considered as
used by an adaptive system (person to environment/situation) that administers a hierarchy of cognitive transformations. Higher-orders of thinking within the cognitive system combine existing lower-order procedures (individual historical learning experiences), or introduce new cognitive items, in order to manage non-routine situations. However, understanding the controlling mechanism that helps people to decide when to do what is an issue that arises when higher-order thinking is examined. Therefore, the following section examines literature regarding self-regulation and higher-order thinking.

2.4 Self-Regulation and Higher-Order Thinking
According to Resnick:

Higher-order thinking involves self-regulation of the thinking process. We do not recognize higher-order thinking in an individual when someone else calls the plays at every step. (Resnick, 1987, p.3)

Student self-regulation involves learner autonomy and is widely regarded as a desirable component of contemporary curriculum development and implementation (Boekaerts, 1997; Eshel & Kohavi, 2003; Paris & Paris, 2001; Perry, Phillips, & Dowler, 2004; Ryan, & Deci, 2000; Stefanou, Perencevich, DiCintio, & Turner, 2004; Veugelers, 2004). Unfortunately, contemporary learning environments do not necessarily reflect the requirement for self-regulated student learning (Boekaerts, 1997; Boekaerts & Minnaert, 1999; Eshel & Kohavi, 2003).

Ryan and Deci (2000) argue that in order for students to be self-determined (i.e. self-regulated) the learning environment must fulfil their psychological needs for competence, (i.e. understanding their learning activities), autonomy (i.e. initiation and functional control of their learning activities), and relatedness (i.e. the extent that the learner feels comfortable with and within the learning environment). Stefanou, et al argues that: learning itself has an autonomous nature (Stefanou, et al, 2004, p.98). Perkins argues that: learning is a consequence of thinking (Perkins, 1992, p.8). Hence, an argument may be made that the thinking act is the sole responsibility of the autonomous individual. However, according to
Newmann (1990), Perkins (1992) and Tishman, et al (1993) it is necessary to distinguish between the supportive role of the environment in providing referents that stimulate the retrieval or transformation of lower-order procedures by the hierarchically controlled adaptive cognitive system, and the thinking dispositions or thoughtfulness of the individual learner.

Tishman, et al argues that thinking dispositions are: comprised of a trio of abilities, sensitivities and inclinations (Tishman, et al, 1993, pp.148-149). Newmann argues that thoughtfulness:

...involves attitudes, personality or character traits, general values and beliefs or epistemologies about the nature of knowledge. (e.g., that rationality is desirable; that knowledge itself is socially constructed, subject to revision and often indeterminate; and that thinking can lead to the understanding and solution of problems).

(Newmann, 1990, p.47)

Therefore, the self-regulated learner has a requirement for competence, autonomy and relatedness (Stefanou, et al, 2004) and has personal attributes (thinking dispositions or thoughtfulness) that facilitate meaningful engagement with the learning situation. Ryan and Deci (2000) argue that it is the satisfaction of an individual’s basic need for self-regulation that contributes to a feeling of psychological wellbeing and it is essential for educators, employers, etc. to acknowledge situations that promote the fulfilment of these self-regulatory needs.

Boekaerts defines self-regulation as:

...students’ attempts to attain personal goals by systematically generating thoughts, actions, and feelings at the point of use, taking into account the local conditions. Self-regulation is a “fundamental psychological construct”.

(Boekaerts, 2002, p.602)

Personal goals, in the context of this thesis, are likened to Barkley’s (2001) desirable hypothetical futures and are secured by the regulating mechanisms that determine how and when (i.e. higher-order procedures) lower-order procedures are compiled within the cognitive system. Moreover, according to Boekaerts (2002), adaptation to non-routine situations is governed by a person’s goals (i.e. desirable hypothetical futures) and is regulated by a
person’s theory of self (i.e. a person’s prior learning or life experiences). Both experience and context contribute to SRL [self-regulated learning] (Paris, & Paris, 2001, p.99). Boekaerts argues that self-regulated learning is: a Complex, Demanding, Deliberate, Volitional Activity [i.e. higher-order thinking]: as Well as a Simple, Habitual and Automatic Activity [i.e. lower-order thinking] (Boekaerts, 1997, p.167). The two levels of self-regulated learning identified by Boekaerts (1997) are interpreted here as being thinking at the higher and lower-order procedural levels. That is, higher-order thinking requires effort and intent on behalf of the learner during engagement with non-routine, unusual or complex situations (Resnick, 1987), and lower-order thinking applies previously acquired procedures automatically (e.g. expertise in a knowledge domain) during engagement with routine or previously experienced situations (Stevenson, 1986a, 1986b).

In summary, support for the development of student self-regulated learning requires that a trilogy of psychological needs be met. These needs are described as competence, autonomy and relatedness. In addition, the self-regulated learner should possess a disposition for thinking or thoughtfulness. The individual self-regulates learning with reference to personal goals (desirable hypothetical futures) and these goals emanate from a person’s interpretation of self. Therefore, it is argued in this thesis that higher-order thinking is governed by a process of self-regulation. That is, a person’s goals or hypothetical futures promotes and regulates a person’s higher-order thinking processes towards satisfactory goal attainment. Thus, self-regulated learning is argued to be equivalent to the hierarchical adaptive cognitive system as defined in this thesis. In other words, self regulation and goal attainment (i.e. a person’s perception of a desirable hypothetical future for oneself) drive the process of higher-order thinking by determining when the goal has and has not been achieved.

This section provides support for a broadly applicable conceptualisation of higher-order thinking by acknowledging that an individual’s psychological needs for competence, autonomy and relatedness are important in terms of self-regulated learning (i.e. adaptation or
higher-order thinking). Personal goals are identified as providing a purpose or direction (i.e. a desirable future) for learning (i.e. higher-order thinking). A person’s goals are determined by a theory of self and include a person’s disposition for thinking or state of thoughtfulness. It is these goals and personal attributes that regulate a student’s adaptation to non-routine situations within learning environments.

Additionally, students are influenced by aspects of the learning environment (Stevenson, 1986a). These aspects or factors affect the level of cognitive engagement that students exhibit with their learning tasks (Talbert & McLaughlin, 1993; Tessmer & Richey, 1997). Stevenson (1986a) defines the influence or press on student thinking by particular factors within the learning environment as Cognitive Holding Power. Cognitive Holding Power (CHP) is defined as the press exerted by an educational learning environment, which causes students to execute certain levels of procedural knowledge (Stevenson, 1986a), that is, to engage students in particular kinds of thinking. Press in this context refers to the learning environments’ influence on positive or negative goal attainment and is activated by the tasks students are required to encounter within the educational environment (Stevenson, 1986a, 1998). Students perceive and interpret these tasks based on their own internal cognitive structures and on the proximal influence or Cognitive Holding Power of the task environment (Stevenson & Evans, 1994). In other words, the environment influences the perception of a person in terms of goal attainment and thus has an influence on the processes involved in higher-order thinking.

The concept of Cognitive Holding Power (CHP) finds its origins in theories of cognitive structures and ecological psychology (Stevenson, 1986a; Stevenson & Evans, 1994). Stevenson’s (1986a) orders or hierarchies of knowledge structure are utilized in the concept of CHP (See Section 2.3 for details). Ecology may be defined simply as an organism's interrelationship with its environment. The: ...environment subsumes all external forces to which organisms are actually or potentially responsive… (Stokols, 1977, p.7). A person or groups’ immediate social and physical environment can be described as a behaviour setting.
(Wicker & Kirmeyer, 1977) (See Section 2.5 for details). Behaviour setting theory is an integral component of the conceptualization of CHP (Stevenson, 1986a, 1998). The following section examines the literature concerned with the learning environment and higher-order thinking.

2.5 The Learning Environment and Higher-Order Thinking

This thesis draws on Barker’s (1968, 1978) theory of behaviour settings in order to conceptualise the environment’s influence on an individual’s process of cognitive adaptation. Chiel and Beer argue that: *adaptive behaviour is the result of continuous interaction between the nervous system, the body and the environment, each of which have rich, complicated, highly structured dynamics* (Chiel & Beer, 1997, p.555). The premise of Barker’s theory is that the behaviours of the majority of people within a setting can be predicted because of the influence of the characteristics of that setting. In other words, the setting exhibits a causal effect upon collective individual behaviour and this effect occurs irrespective of the innate differences between individuals within the same setting (Barker, 1968, 1978; Wicker, 1984, 1991, 2002). Behaviour setting theory acknowledges the interaction of person and place, for without people a place cannot be defined as a behaviour setting (Barker, 1978; Wicker, 1984).

For example, university lecture theatres are arranged in such a way as to promote one form of learning activity and constrain most other forms. Lecture theatres are designed to promote lecturing (i.e. knowledge transmission from lecturer to student) of large numbers of students within a restricted time frame. Rows of seats generally face the rostrum at the front of the theatre, and the individuals in this setting understand that expectations are placed upon their behaviours or activities, that is, in the lecture theatre students should sit quietly, listen to the lecturer and take notes. The lecturer understands that he or she is to deliver the content of the lecture to the students from a position at the front of the theatre. Conversely, tutorial rooms are generally smaller and contain moveable chairs and desks. These may be rearranged to allow smaller group discussion regarding the content of a previously attended lecture. The tutor
focuses students on topics of importance and facilitates peer interaction and discussion. In the tutorial, students discuss issues that they may not have understood from a prior lecture. The content is extensively the same in both forms of environment; however the settings are structured differently and influence the same students to act in a different, although appropriate manner for each setting.

Behaviour settings contain human and non-human components and have spatial and temporal boundaries. In the above example, the human component is the students and the lecturer or tutor, the non-human component is the inanimate physical objects (chairs, desks, white-board etc), the spatial boundary is the external walls of the lecture theatre or tutorial room and the temporal boundary is the time at which the lecture or tutorial regularly occurs (Barker, 1968, 1978; Cambourne, 2002; Wicker, 1984). Each setting, the lecture and the tutorial, have ongoing patterns of behaviour, or programs that govern how the majority of human participants engage in their activities (interactions between people and inanimate objects) while they inhabit the setting (Wicker, 1984). A standing pattern of behaviour is an: *extra-individual behaviour phenomenon; it has unique characteristics that persist when the participants change* (Barker, 1968, p.18). For example, lectures and tutorials are conducted in a similar fashion regardless of the students, lecturers and tutors that may or may not be in attendance.

Barker argues that a behaviour setting: *consists of standing patterns of behaviour-and-milieu* (Barker, 1968, p.18). For instance, the milieu of the educational psychology lecture is lecture theatre 1a, Building S12 at 9.30 a.m. Mondays and includes the physical objects within its boundaries. The milieu contains and supports the behaviour and is synomorphic or compatible to it (Barker, 1968). However, a milieu exists apart from the behaviour setting it supports. During those times when lectures are not held, the milieu exists (i.e. the lecture theatre and the chairs, rostrum, specialist lighting and computer facilities etc. that it contains) even though the behaviour setting that is the educational psychology lecture, does not.
The differences that are evident between the lecture theatre and tutorial behaviour settings are a function of the synomorphic (Wicker, 1984) relationship between the objects (milieu) and the inhabitants (behaviour) of each. For example, the seats in the lecture theatre (milieu) contain the listening students (behaviour) who face the rostrum (milieu) where the lecturer lectures (behaviour) the students in aspects of educational psychology. The tutorials contain seats and desks (milieu) that can be moved to form discussion groups (behaviour) and the tutor has freedom to move throughout the room (milieu) to facilitate focused discussions (behaviour). Barker concludes that behaviour settings contain, or consist of various forms of these couplings of milieu and behaviour, which he defines as being synomorphs (Barker, 1968, p.20). In the case of the lecture and the tutorials that follow the lecture, the synomorphs have interdependence. That is, it would seem important that tutorials are held after the corresponding lecture. The synomorphs that occur within the tutorial are dependent on those that occur within the lecture. Hence, behaviour settings are distinct from, yet often connected to and dependent upon, other settings.

Wicker argues that a: *behaviour setting is a bounded, self-regulated and ordered system composed of replaceable human and non-human components that interact in a synchronised fashion to carry out an ordered sequence of events called the setting program* (Wicker, 1984, p.12). Behaviour settings are self-regulating to the extent that they support the desirable hypothetical futures (personal goals) of individuals and these individuals strive to maintain the program in order to realise these goals (Wicker, 1984).

Individuals exclude themselves from behaviour settings because they are not perceived as important with regard to fulfilling their individual goals. For example, very few members of society attend educational psychology lectures, yet for some individuals it is an essential component of their future teaching career. Other individuals are excluded from a behaviour setting because they deviate from the program and therefore interfere with the goal attainment
of other setting inhabitants. For example, if a student or groups of students are talking incessantly during an educational psychology lecture, other students, the lecturer or both may react by asking for silence, or in extreme cases, ejecting the offenders from the lecture.

Likewise, the milieu of the setting supports this collective goal attainment. For example, a breakdown of the audiovisual system in the lecture theatre is promptly repaired or replaced because it is an important component (milieu-behaviour) in the maintaining of the setting program. Other objects are not essential to the lecture theatre setting and are therefore excluded (e.g. movable chairs and desks). Collectively, inhabitants of behaviour settings support and maintain the setting program in order to realise their collective goals. Therefore, it would appear that as much as collective individual activities are constrained by behaviour settings, so too are behaviour settings constrained by the collective goals of its inhabitants (Wicker, 1984).

The discussion to this point has outlined how behaviour settings exist because of a collective desire to maintain a setting program in order to satisfy particular personal goals. It is not imperative that all members of a behaviour setting have exactly the same goals; however it is imperative that the aggregation of these disparate goals maintains the setting program. For example, the lecturer has as his or her goal to provide educational psychology students with information that is relevant to their goal of learning skills that will facilitate their becoming effective future educators. If the students do not perceive a connection between the content of the lecture and their goal of learning these skills, the students may raise their concerns in an attempt to adjust the content of the lecture and maintain the desired setting program. However, the relative importance of the content would vary for each student and each student would have different goals that motivate their attendance at the educational psychology lectures.

Barker (1968) uses the analogy of a baseball game to highlight the disparity between individual goals within the same behaviour setting. He identifies the pitcher’s enjoyment for
striking out batters, the umpire’s desire to earn 25 dollars for umpiring the game, and the hometown fans love for seeing the team victorious. Barker argues that if members of the setting are not having their desires met then they will self-exclude or be excluded from the setting. For example, many baseball fans will not attend games if the team is performing very poorly. The team may try to improve its on field performances in an attempt to lure the fans back to the stadium. The pitcher will feel less enjoyment from his pitching activities if he is not striking out batters and he may subsequently find that he is dropped from the team. In response, the pitcher may train harder or seek the advice of a mentor in order to re-access the setting and have his goal of enjoyment realised. The umpire may decide not to umpire the game if his fee of 25 dollars is reduced, or if he decides that the fee is not sufficient to compensate him for the time and effort he expends during his umpiring of the game. To alleviate the potential threat to the setting (i.e. the baseball game needs an umpire), other inhabitants of the setting (the officials or team owners) may choose to obtain the services of another umpire, or increase umpiring payments to maintain the services of the existing umpire.

Therefore, behaviour settings may be conceptualised as complex systems of milieu-behaviour synomorphs (i.e. a synomorphic relationship between objects and behaviours) that support and maintain individual goal attainment through a socially maintained setting program. However, personally relevant goals also support the goals of other setting inhabitants by maintaining the mutually beneficial setting program. Thus, goal pathways or goal circuits (Barker, 1968) at the same time maintain and are maintained by the milieu and the social interaction of interrelated goal pathways that support the setting program (orderly patterns of behaviour) (Wicker, 1984).

In summary, this section outlines the role of Barker’s (1968, 1978) theory of behaviour settings in terms of influencing an individual’s use of higher-order thinking. That is, behaviour settings have an ordered and socially maintained program that impacts, both negatively and positively, upon various individuals’ personal goal attainment within that setting, and thus influences the types of activities (milieu-behaviour synomorphs) a person may engage with.
during routine or non-routine situations in pursuit of their goals. Because realising goals, or attaining desirable hypothetical futures is an important factor within the self-regulation of higher-order thinking, it would seem necessary to acknowledge the role played by the behaviour setting in facilitating goal attainment and thus in its support of higher-order thinking.

Wicker (2002, 1991, 1984) has extended Barker’s original conceptualisation of behaviour setting theory, in which settings are considered inherently stable to include a perspective that describes settings in terms of their development. That is, Wicker coined the term: life cycles of behaviour settings (Wicker, 2002, p.119), which conceptualises settings in terms of their development through various stages, preconvergence (before emergence or factors that lead to the establishment of a setting), convergence (beginning), continued existence (intermediate state), and divergence (inevitable ending). In addition, Wicker (2002) argues that setting occupants cause change to the setting program based on their prior and current experiences. In Wicker’s view, behaviour settings are dynamic entities, which change to become combinations of past, present and future settings. That is, as individuals within a setting adapt in order to attain personally relevant goals, so too do settings, as collectives of individuals, adapt to satisfy collective goals. In much the same way interrelated behaviour settings pressure each other to adapt, or modify, in order to realise their own goals. For example, university courses provide instruction in the skills required by graduates to perform successfully within a particular profession. As the personal attributes and skills required within a profession change over time, so too does the content and training methods used to educate university students in the development of these skills and attributes change. In this way, both the immediate setting and other related settings provide support for or inhibit an individual’s use of higher-order thinking during goal attainment. Thus, it may be argued that higher-order thinking is influenced by a confluence of individual and collective behaviours, and that these behaviours are derived from within various interrelated settings.
While behaviour setting theory uses the behaviour setting as its unit of analysis, activity theory uses the: historically evolving collective activity system, seen in its network relations to other activity systems, ...as the prime unit of analysis against which scripted strings of goal-directed actions and automatic operations are interpreted (Engeström, 2000, p.960). Therefore, because of its focus on collective activity as the basis for the meaningfulness of individual actions, the following section of this chapter examines the literature related to the role of activity within settings and its influence on higher-order thinking.

2.6 Activity Theory and Higher-Order Thinking

This thesis examines the literature on activity theory in order to interpret the influence of individual and collective activity during cognitive adaptation (i.e. higher-order thinking). Activity theory is a cultural-historical theory of activity, initiated by ... Vygotsky, and his successors Leont’ev and Luria in the 1920s and 1930s (Susi & Ziemke, 2001, p.277). The central principle of activity theory is that human cognition exists because of the interrelationship between the individual and his or her socially determined material environment (Susi & Ziemke, 2001). The activities of the individual are: motivated and regulated by higher-order goals and are realised through actions that are themselves relatively independent components of each activity (Hacker, 2001, p.58). Jonassen and Rohrer-Murphy argue that: ...activity theory provides us with an alternative way of viewing human thinking and activity (Jonassen & Rohrer-Murphy, 1999, p.62).

Rather than learning occurring as a precursor to activity, activity theory proposes that learning occurs simultaneously within activities (Roth, 2004). Additionally, activity theory acknowledges that the influences of specific practices alone do not totally shape how individuals learn within activity (Jonassen & Rohrer-Murphy, 1999; Engeström & Cole, 1997). That is, activity theory argues that as much as activity shapes learning, so too does that learning shape the activity. It is the dynamics of the relationship between activity and learning, that sets activity theory fundamentally apart from other theories such as situated learning
(Engeström & Cole, 1997), which argue that learning occurs in communities of practice and that these practices are relatively stable (Lave and Wenger, 1991).

Susi and Ziemke (2001), Hacker (2001), Engeström (2000) and Jonassen and Rohrer-Murphy, (1999) argue that within activity theory, activities are considered to have a hierarchical structure. At the highest level, activities are undertaken as a result of a personally significant motivating factor. This motivating factor or overall collective purpose is defined as the object of the activity. *The object of the activity affects the nature of the activity, which affects the object in a dynamic relationship* (Jonassen & Rohrer-Murphy, 1999, p. 65). That is, transformations occur which have a reciprocal influence on the object of the activity and the activity itself (Susi & Ziemke 2001; Jonassen & Rohrer-Murphy, 1999). Subordinate actions are directed at more specific intermediate goals and it is the aggregation of these actions that support the activity and thus overall collective achievement purposes. Operations are sub-units of actions. These operations react automatically to environmental factors and constantly adjust a person’s actions relative to these factors (Susi & Ziemke, 2001).

For example, university students engage with the object of the activity of educational psychology lecture (e.g. to develop psychological concepts) and their motivation for doing so is to attain a passing grade and thus graduate into their chosen profession. In order to engage in the lecture activity successfully, the students must take some actions. That is, they must attend the lecture, sit, and take notes and if need be they might ask questions. Operations exist at the lowest level and automatically adjust the person’s actions in response to local conditions. For instance, the student listens to the culturally embedded verbal language, writes individual words on paper, and carries relevant materials in support of the aforementioned actions. The student attends lectures and tutorials, studies, and sits exams in order to realise his or her goal of passing the educational psychology course and graduating into a teaching career. Therefore, the goal of the actions (attending educational psychology lecture) is to
graduate into a teaching career and this is the personally significant motivating factor for the
students who attend these lectures. Engeström argues that:

*Goal directed actions, as well as automatic operations, are relatively independent but subordinate units of analysis, eventually understandable only when interpreted against the background of entire activity systems. Activity systems realise and reproduce themselves by generating actions and operations.*

(Engeström, 2000, p.964)

However, these individual goals would not make sense without the collective object of the
activity system. This object that all students, lecturers, tutors and others in the university
engage with may be considered to be something akin to the “advancement of knowledge”.
That is, the activity system (i.e. the aggregation of goal-directed actions and automatic
operations) that occurs within the lecture (i.e. the educational psychology lecture activity
system) can only be fully understood when interpreted against the overall object of the activity
(i.e. the advancement of knowledge). Bedny et al argue that:

*Activity captures individuals and engenders individuality as much as individuals create activity. Social and physical environment prescribes the space of possible actions for individuals. To establish effective social interactions, an individual must develop standardized actions. Expectations are formed and predictions made about how different people will act in different situations. Activity includes objects and sign tools, as well as norms and procedures for attaining particular goals. When one studies individual styles of activity, one should compare them with modal, normative activity engendering a complementary frame of individual-psychological and cultural-historical approaches.*

(Bedny et al, 2000, p. 172)

Within the activity system of an educational psychology lecture an array of various cultural
tools support and mediate the activity. These cultural tools, through their very design, place
particular expectations upon individuals and group of individuals. These tools both facilitate
and constrain activity. For example, the students sit within a building that maintains a
comfortable temperature. The students sit in seats that are designed to be relatively comfortable for short periods of time. However, the seats are not so comfortable that they totally relax the students and thus reduce their ability to maintain attention to the lecture in
progress. In these seats, that are often equipped with a fold down writing surface, the students write notes in lecture pads using pencils or pens and using a culturally embedded written language. The students may also record the lecture using MP3 devices. The lecture theatre supports the lecturer’s presentation with various types of audiovisual and computer equipment. It is apparent that without these culturally specific artefacts (tools) the activity of the lecture theatre would be quite different. The available tools have been historically and culturally developed to support the actions of the students and of the lecturer. Over time, the tools that mediate this lecturing activity may change with the result that this type of activity might no longer exist in this form or may not change when needed causing tensions in the activity system. The increasing number of Internet based university courses is a pertinent example of a possible future for this activity.

Wertsch (1998) argues that mediated actions exhibit an historical context. That is, artefacts or tools and the mediated actions that support the use of these evolve over time. As this evolution takes place, it becomes more likely that the original activity changes to the degree that it is no longer representative of its past form. Wertsch (1998) uses the examples of pole vaulting and multiplication to highlight this point. He characterises multiplication as using a psychological tool or sign (i.e. the syntax or spatial organisation of numbers) and pole vaulting as using a technical tool (i.e. a pole). Over time multiplication has evolved from being a purely pencil and paper orientated activity, which involved students in recognising and using cultural tools associated with syntax, to now being one which almost exclusively involves the students’ ability to interact with technological tools (i.e. calculators). In much the same way, pole vaulting has changed as advances in materials technology made it possible to construct more efficient poles. It was not only that the poles were better able to propel a person over a high bar that enabled world records to be bettered, but also the improved ability of the vaulter to use the new poles effectively. Thus, not only did the tool take on a substantively different form (i.e. in terms of its construction), but also the skills involved in using the new tool were substantively modified.
Toomela (2000) cautions about the application of activity theory in human mind studies because of the tendency of researchers to focus on the analysis of activity alone. Toomela argues that:

...the analysis of activity is necessary but not sufficient for understanding the human mind. Analysis of activity alone cannot lead to unequivocal results because external activity and psychological operations supporting that activity are not in one-to-one correspondence. (Toomela, 2000, p.356)

Toomela argues that proponents of activity theory often ignore the need to consider the relationship between mind and activity as being dialectical. That is, Toomela argues that activity theorists often neglect to consider the possibility of conflict between mind and activity, instead opting to focus on unidirectional interpretations of the person (thinking) within socially mediated activities. Toomela uses Ratner’s activity theory analysis of emotions and culture to highlight this point and argues that: Ratner suggests that individual psychological phenomena are passive, individual concepts which only reflect social activities (Toomela, 2000, p.355). In addition, Toomela believes that this tendency to interpret unidirectional relationships within human activity systems pervades research associated with activity theory. Toomela argues that Vygotsky highlighted the dialectical nature of thinking and activity and for him, sign meaning became the prime unit of analysis rather than human activity. Toomela views this point of departure from Vygotsky’s cultural-historical psychology by contemporary activity theorists as significant.

Roth (2004) acknowledges the type of criticism that Toomela makes regarding activity theory. Roth argues that this criticism is often unwarranted and does not recognise the dynamics of the relationships evident within activity theory frameworks. For example: subject and object form a dialectic unit and human praxis and self-change coincide with change in life conditions (Roth, 2004, pp.2-3). For this reason Roth contends that activity theory, as it is represented by contemporary theorists, embodies the very notion of change. Similarly, Baerentsen and Trettvik argue that:
Activities consist of actions that are realised by operations. Concrete activities are always motivated, goal directed and adapted to the conditions of action. The three constituents of activity are not separate entities, but rather systematic relationships, relating it to needs, intentions and conditions. Although a motive and a goal may remain constant, the ways of achieving the results may differ according to circumstances. The attainment of a goal in a specific way may likewise satisfy very different motives etc. The relation between motives, goals and operational constituents are not arbitrary, but they are very flexible and dynamical [sic].

(Baerentsen & Trettvik, 2000, pp. 53-54)

In this way care is taken to acknowledge the dynamic relations between and within activities rather than to highlight any form of static or stable relationship. Activity is a living dynamical [sic] structure (Baerentsen & Trettvik, 2000, p. 54).

Thus far, this section has presented literature that associates activity theory with goal orientated behaviours (i.e. actions and operations) whose meaning resides in object oriented activity. Culturally determined tools mediate these behaviours or actions and these tools both constrain and support activity within a dynamic relationship (Wertsch, 1998). That is, over time, activities are transformed because of the transformations that evolve in the relationship between tools and actions. The interaction of tools (i.e. psychological tools and technical tools) and actions suggests that cognition exists and interrelates on two planes, one internal to the person and one external to the person (Susi & Ziemke, 2001; Hacker, 2001; Jonassen & Rohrer-Murphy, 1999; Wertsch, 1998). Jonassen and Rohrer-Murphy argue that the: Mind and body (mental and physical) are interrelated, so knowing can only be interpreted in the context of doing (Jonassen & Rohrer-Murphy, 1999, p.64). Acknowledging this feature of cognition contributes to understanding how an adaptive cognitive system responds to its surroundings, not only to learn by doing, but also to learn from the past experiences of culturally significant others via cultural-historical tools and mediated actions. In other words, tool use (i.e. cultural-historical tools and mediated actions) by its very nature supports one form of action or activity over another and in so doing promotes or constrains various different types of thinking.
Vygotsky initially represented activity as a mediated act that comprised the individual subject, the object of the activity and the tool or artefact that mediated the subject’s actions (Engeström, 2001; Susi & Ziemke, 2001). This system was represented in graphical form and has become known as Vygotsky’s triangular model (see Fig 2.1 below) of a *complex, mediated act* (Engeström, 2001, p. 134).

![Vygotsky’s Model of a Mediated Act](image)

(Engeström, 2001, p.134)

Vygotsky’s model acknowledged the activity of the individual and the influence of the mediating artefact or tools during this individual activity. It wasn’t until Leont’ev (Leont’ev, 1981) expanded on Vygotsky’s work that a model of collective activity was formulated (Engeström, 2001). This model (see Figure 2.2) (Engeström, 2001, p.135) includes the model first developed by Vygotsky (i.e. the upper triangle). The lower portion of the model acknowledges the influence of the community or collective during activity.
The model depicted in Figure 2.2 below highlights the interrelationship among the subject, the community, and the object of the activity. Tools and signs (i.e. mediating artefacts) mediate between the subject and the object of the activity. The rules (i.e. both the implicit and explicit norms and conventions associated with cultural practices) mediate between the subject and the community. The division of labour mediates the relationship between the object and the community (Susi & Ziemke, 2001).

Figure 2.2
The Structure of a Human Activity System.

(Engeström, 2001, p.135)

Using the example of the educational psychology lecture, with the subject being the students, one would expect the object of the activity to be advancing knowledge and the students’ goals to be obtaining a passing grade and graduation to become a teacher. It would be reasonable to expect that the lecturer would have a similar object for the activity and a variety of goals, such as payment for his services. The mediating artefacts are the books, lecture notes, lecture theatre, pens, pencils, paper, computers, audio-visual equipment and these support the students
and the lecturer in attaining the object of the activity. The explicit rules would relate to things like university policy on lecture attendance, study allocation for the course, plagiarism, course accreditation and what constitutes a passing grade. The implicit rules would relate to things like arriving at the lecture on time, no talking during the lecture, taking notes, audio-recording the lecture, whether questioning is permitted and mobile phones being turned off. These rules (explicit and implicit) are formulated from within both the academic (university) and student communities and are created to maintain successful outcomes relative to the activity’s objective of advancing knowledge. The division of labour assumes that the students will attend the lecture and sit facing the rostrum while they take notes and the lecturer will deliver the content of the lecture via various academic communities endorsed mediating artefacts (i.e. audio-visual displays and lecturing).

Activity theory is not predictive (Susi & Ziemke, 2001), it is however: a powerful socio-cultural and socio-historical lens through which we can analyse most forms of human activity. It focuses on the interaction of human activity and consciousness (the human mind as a whole) within its relevant [collective] environmental context (Jonassen & Rohrer-Murphy, 1999, p. 62). Activity theory contributes to this thesis through its ability to provide a deductive framework that facilitates an analysis of activity systems. However, any analysis of an activity system should acknowledge context, for it is only during activity embedded within: everyday practice in the real world that an understanding of the unity of consciousness and activity can be established (Susi & Ziemke, 2001, p. 278).

2.7 Conclusion
This chapter reviews the literature associated with cognition, behaviour settings and activity systems. Justification is provided for the concept that cognition involves a hierarchical, controlled, adaptive system that facilitates cognitive transformations. These transformations result from engagement with non-routine situations when a person’s memories of previous experiences prove to be inadequate in pursuit of personally relevant goals or possible
hypothetical futures. Stevenson’s (1984) and Barkley’s (2001) theories are mutually supportive in this regard. Self-regulation has been outlined as an important facilitator of higher-orders of thinking. Behaviour setting theory (Barker, 1968, 1978) supports a view of behaviour settings as having an ordered and socially maintained program that impacts, both negatively and positively, upon various individuals’ personal goal attainment from within that setting, and thus influences the types of activities (milieu-behaviour synomorphs) a person may engage in during routine or non-routine situations in pursuit of their goals. Activity theory provides a dynamic framework for analysing actions as part of collective activities in context, and acknowledging the role of culture and history during goal attainment.

It is therefore argued that the findings in the literature reviewed in this chapter are related in important ways. That is, cognitive theory argues that higher-order thinking has a hierarchical structure and is regulated to support goal attainment. Behaviour setting theory argues that behaviour settings are bounded, self-regulated and maintain a setting program in order to support goal attainment. Activity theory argues that activity (actions and operations) regulates and is regulated by the collective object of the activity, and that the object is the motivating factor for the goals of individual actions. Thus, the attainment of personally important goals provides a point of intersection and focus between and within these theories.

Figure 2.3 below provides a visual representation of the complex nature of the interrelationship across these theories in terms of their support of goal attainment. The complex nature of the relationship is highlighted by the conceptualised interdependence of the theories. Displayed is the nesting of the explanatory power of one theory within part of the other, with each focused towards the realisation of individual goal attainment. Stevenson’s (1986a) concept of cognitive holding power supports this interpretation and the argument that a relationship exists between individual cognition and the collective environment that encourages certain activities over others (see Section 2.4 for details).
Therefore, on the basis of the literature reviewed in this chapter, higher-order thinking may be conceptualised as a relationship between the socially maintained and mutually beneficial behaviour setting (i.e. the program and various milieu-behaviour synomorphs), the activities of an individual or group of individuals engaging with objects in pursuit of culturally significant goals and the self-regulated adaptive system that incorporates a hierarchy of cognitive transformations. That is, higher-orders of thinking within the cognitive system combine existing lower-order procedures derived from individual historical learning experiences, or
engage in controlled cognition to introduce new cognitive items, in order to resolve non-routine situations satisfactorily and consistently. This process aims at satisfying personally relevant goals and maintains the system of activity that perpetuates and modifies the behaviour setting program, albeit with tensions and contradictions occurring over time. The system (i.e. the person within the behaviour setting utilising culturally and historically embedded tools and signs) accomplishes these tasks by utilising thinking skills at various levels of abstraction. The person’s activities (setting program) are mediated by inanimate historical-cultural evolving objects or artefacts (milieu-behaviour synomorphs) using a prescribed and socially valued dynamic system of activity. This system transforms over time as it seeks to resolve tensions that develop among the elements.

The depiction in Figure 2.3 provides an indication of the degree of difficulty faced by technology education teachers as they strive to support students to think at higher-order levels. That is, the theoretical basis for the model, as argued in this chapter, supports the conceptualisation of a multi-dimensional interdependent construct. In other words, higher-order thinking is reliant on factors that emanate from within and from outside of the behaviour setting. Barker, (1968, 1978) and Wicker, (1984, 1991, 2002) argue that behaviour settings are influenced by and, in turn, influence other related settings. These factors relate to personal satisfaction gained through goal attainment and are regulated by the types of activities encouraged within the behaviour setting (i.e. the setting program), by the individual’s theory of self and prior knowledge, and by the extent of self-regulation experienced by the individual with reference to the intrinsic value of goal attainment.

2.8 Chapter Summary
It is argued in this chapter that higher-order thinking has proven difficult to conceptualise and understand (e.g. Cuban, 1984; Beyer, 1985; Cruikshank & Olander, 2002; Lewis & Smith, 1993; O’Tuel & Bullard, 1993; Newmann, 1990; Resnick, 1990, 1987; Smith, 2001). Attempts to define higher-order thinking using concepts such as critical thinking and Bloom’s
taxonomy have found criticism from within the literature (e.g. Beyer, 1985; Challenor, 1991; Ennis, 1987; Ivie, 1998; Raudenbush, 1992; Smith, 2001; Ten Dam & Volman, 2004). This chapter outlines the gap in the literature in terms of our understanding of and provides a robust conceptualisation for higher-order thinking. The chapter reviews literature that associates goal attainment with factors external to the person and internal to the person. Cognitive theory, behaviour setting theory and activity theory are examined with the aim of understanding the relationship across factors that influence people to think at higher-order levels. The conclusions drawn from the examination of the cognitive, behaviour setting and activity theory literature facilitates the formulation of an interrelated depiction (see Figure 2.3) that supports an understanding of and a conceptualisation for higher-order thinking.

Chapter 3 explores the implications of the conceptualisation for teaching and learning and the promotion of higher-order thinking in technology education classrooms. In addition, Chapter 3 examines literature on the role of teachers’ actions in the context of instruction. In particular, Chapter 3 argues that instruction is hierarchically structured and that student learning outcomes are directly influenced by the tactics teachers employ during instruction. As outlined in Chapter 3 in this thesis, teaching tactics are defined as what teachers’ actually do when interacting with students during instruction (Jonassen, Grabinger & Harris, 1990; Leshin, Pollock & Reigeluth, 1992; Rothwell & Kazanas, 1992).
Chapter 3

TEACHING, LEARNING AND HIGHER-ORDER THINKING IN TECHNOLOGY EDUCATION

3.1 Introduction

Chapter 2 examines the literature associated with cognition, behaviour settings and activity in terms of their relationship to the development and support of higher-order thinking. As a result of this examination, this thesis advances a conceptualisation of higher-order thinking that is suggestive of a relationship between the socially maintained and mutually beneficial behaviour setting (i.e. the program and various milieu-behaviour synomorphs), the self-regulated adaptive system that incorporates a hierarchy of cognitive transformations and the activities of an individual or group of individuals acting in pursuit of culturally significant goals. In other words, higher-order thinking is considered to be hierarchically constructed with reference to the physical, the social, and the contextual environments experienced by an individual.

This chapter examines the research literature associated with instructional design in technology education with reference to how teaching strategies might provide support for student higher-order thinking. Section 3.2 examines literature that identifies and defines teaching strategies and tactics. Section 3.3 examines literature concerning contemporary technology education teaching and learning environments. Section 3.4 draws together the conclusions reached regarding teaching, learning and the promotion of higher-order thinking in technology education classes. Predictions are posited regarding classroom factors that promote higher-order thinking in technology education, given the literature reviewed in Chapters 2 and 3. Section 3.5 provides a summary of the chapter.
3.2 Teaching Strategies and Tactics: Defined

Elshout-Mohr, et al (1999, p.68) refer to three: *fundamental knowledge systems* that provide the basis for teaching: *lesson structure, subject matter and learning goal* (Elshout-Mohr, et al, 1999, p.68). Learning goals are sought using instructional strategies. Jonassen, et al (1990, p.31) define instructional strategies as *a set of decisions that result in a plan, method, or series of activities aimed at obtaining a specific goal*. Teachers formulate instructional strategies in response to requisite subject specific learning objectives or a process of: *front-end analysis* (Jonassen, et al, 1990, p.30). Jonassen, et al define front-end analysis as the act of identifying the central focus of the instruction in terms of meeting the specific needs of the learner in a particular content area. In technology education, documented learning outcomes or standard statements generally provide support for teachers as they engage with this front-end analysis during the instructional design process. In response to the: *needs, task, learner, and environmental analysis* (Jonassen, et al, 1990, p. 29) provided by the front-end analysis of instruction, a technology teacher will select a series of possible instructional strategies. In use, these strategies provide support for the intended outcomes or objectives of the instruction.

Instructional strategies that facilitate learning goals are argued to be evident at three levels. Rothwell and Kazanas (1992) and Jonassen, et al, (1990) identify two distinct levels; the macro-level and micro-level instructional strategy. Leshin, et al, (1992) identify a third intermediate-level instructional strategy that lies between the macro-level and micro-level strategies.

The macro-level instructional strategy is a general plan that defines a yearly program, unit, module or lesson of instruction and sequences a series of learning outcomes or objectives into an integrated instructional entity (Jonassen, et al, 1990; Rothwell & Kazanas, 1992). An example of a macro-level instructional strategy in technology education would be a yearly program, unit, module or lesson of student learning activity focused on the technological
systems of manufacturing, transportation, information, or the appropriateness of a new technology for a particular culture.

The intermediate-level instructional strategy links several areas of instruction through particular instructional approaches (e.g. discovery approach, expository approach). In technology education for example, a teacher may decide to structure a unit, lesson or mini-lesson to allow students to discover material properties (e.g. wood, metal, plastic, etc.) through experimentation (e.g. destructive testing). The intermediate-level instructional strategy provides cohesion and significance for a series of micro-level instructional strategies, which when combined with other intermediate-level strategies, supports the intended instructional strategy at the macro-level (Leshin, et al, 1992).

The micro-level instructional strategy is more specific and occurs within the level of an individual lesson or mini-lesson. It defines what students are to experience during a discrete learning event in respect to their demonstrating a specific learning outcome or objective (Jonassen, et al, 1990). That is, a technology education syllabus document or standards statement identifies a set of desirable learning outcomes or objectives in a particular field (e.g. manufacturing technologies, transportation technologies, etc.). From these outcomes or objectives, a course of instruction is conceptualised at the macro level. Once conceptualised, instruction is refined into increasingly discrete units, consisting of various instructional strategies, until each student is engaged in a series of activities that supports their displaying of an intended outcome or objective. It is during student learning activity that teachers facilitate particular outcomes or objectives using: simple instructional tactics (Rothwell & Kazanas, 1992, p.178). An instructional tactic is defined as what teachers do, (i.e. an activity or series of activities), and they are the component parts that facilitate implementation of a particular instructional strategy (Jonassen, et al, 1990; Leshin, et al, 1992; Rothwell & Kazanas, 1992).
Instructional tactics are afforded little recognition in the instructional design literature (Rothwell & Kazanas, 1992). On the other hand, instructional strategies are overtly considered the central focus for many instructional designers, however, their interpretations of various instructional strategies commonly differ (Jonassen, et al, 1990). Jonassen, et al argues that:

A strategy is like a blueprint; it shows what must be done, but does not prescribe how to do it. Instructional strategies describe a general approach to instruction but do not prescribe how to organise, sequence, or present instruction.... Strategies provide useful advice about how to present and cue content, but they do not prescribe how they should be implemented. Implementations of instructional strategies are instructional tactics.

(Jonassen, et al, 1990, p.32)

These instructional aspects (strategies and tactics) formulate the instructional design framework of the technology education learning environment. Therefore, drawing on Chapter 2, it is argued in this thesis that it is these instructional strategies and tactics that determine and define teacher and student activities (division of labour, tools: activity theory), the behaviour setting (program, physical layout of the setting: setting theory and activity theory) and how these influence student thinking (cognitive theory) in technology education classes. That is, through a process of front-end analysis of the mandatory curriculum documentation, it is the decisions that teachers ultimately make regarding the format of instruction (i.e. the selection of teaching strategies and the tactics that support them) that influences the types of learning that students experience within technology education learning environments. Therefore, to promote student higher-order thinking, it is necessary to understand the decisions teachers make (i.e. strategy selection and implementation), the influence these decisions have on student learning activity and the influence these activities have on the types of thinking students use in technology education classrooms.

3.2.1 Classifying Strategies and Tactics
Jonassen, et al (1990) identify five main classes of instructional strategies:
(a) contextualising instruction, (b) activating learner processing, (c) presenting and cueing content, (d) activating and assessing learning outcomes, and (e) synthesising and sequencing instructional tactics (Jonassen, et al, 1990, p. 33). While these main classes of strategies provide an overarching description of each strategy, they do not identify the learning activities that would necessarily be associated within each (Jonassen, et al, 1990). Jonassen, et al, (1990) argue that each main class of instructional strategy contains a subset of strategies that defines the class through its connection to an instructional activity.

The implementation of these activities is supported by instructional tactics applicable to each instructional strategy. For example, the class of contextualising instruction incorporates six sub-strategies and, within each of these strategies, a number of tactics are argued to support their implementation (See Table 3.1). Within the six, one such strategy is: gaining the attention of the learner (Jonassen, et al, 1990, p.34). In order to implement this strategy Jonassen, et al suggests a teacher should use tactics such as, arouse the learner with novelty and surprise, pose a question to the learner or the learner poses questions to be answered by the lesson. In this way, the teacher can identify what it is he or she should do to support implementation of the strategy class of contextualising instruction. That is, in order to contextualise instruction a teacher should gain the attention of the learner (as well as other strategies) using a number of instructional tactics. These instructional strategies and the tactics that support them are shown in Table 3.1 below. The format of Table 3.1 is modified slightly from that of Jonassen, et al’s, (1990) original to provide clarity to the reader because the content is an extract from the original larger table.
Table 3.1
Instructional Strategies and Tactics
Contextualising Instruction

Instructional Strategies are displayed in **Bold**. Instructional Tactics are displayed in plain text.

1.1 **Gaining the Attention of the Learner**
1.1.1 Arouse learner with novelty, uncertainty, surprise
1.1.2 Pose question to learner
1.1.3 Learner poses question to be answered by lesson

1.2 **Relate the goals of instruction to the learners needs**
1.2.1 Explain purpose or relevance of content
1.2.2 Present goals for learner to select
1.2.3 Ask learner to select own goals
1.2.4 Have learner pose questions to answer

1.3 **State the outcomes of instruction**
1.3.1 Describe required performance
1.3.2 Describe criteria for standard performance
1.3.3 Learner establishes criteria for standard performance

1.4 **Present advance organisers**
1.4.1 Verbal expository: establish context for content
1.4.2 Verbal comparative: relate to content familiar to learner
1.4.3 Oral expository: establish context for instruction
1.4.4 Oral comparative:

1.5 **Present structured overviews and organisers**
1.5.1 outlines of content: verbal (see also 1.4.1, 1.4.2)
1.5.2 outlines of content: oral (see also 1.4.3, 1.4.4)
1.5.3 graphic organisers/overviews
1.5.4 combinations of verbal, oral, and pictorial overviews

1.6 **Adapt context of instruction**
1.6.1 content adapted to learner preferences (different situations)
1.6.2 content adapted to prior knowledge

(Adapted from Jonassen, Grabinger & Harris, 1990, pp. 34-35)

It is not the intention of this thesis to elaborate on the extensive list of strategies and tactics as proposed by Jonassen, et al, (1990, pp. 34-38). However, it is important in the context of this thesis to acknowledge the arguments of Jonassen, et al, (1990), Leshin, et al, (1992) and Rothwell and Kazanas, (1992) that instruction incorporates a hierarchical structure and that strategies include those at the macro, intermediate, and micro levels. Equally important is to recognise that strategy implementation is supported by teachers using instructional tactics and that these tactics are defined as what teachers actually do during instruction (Jonassen, et al,
1990; Leshin, et al, 1992; Rothwell & Kazanas, 1992). This is important in the context of the study reported in this thesis, because the classroom investigations examined what teachers and students did during instructional activity. These investigations examined particular teaching strategies and the tactics in terms of whether they supported or hindered student’s use of higher-order thinking in technology education. The following section examines the literature associated with teaching and learning in technology education.

3.3 Teaching and Learning in Technology Education

3.3.1 Introduction

Technology education is argued within the literature to be a subject area in transition (Eggleston, 1992; Fritz, 1996; Hansen, 1995; Herschbach, 1998; Lauda, 1988; McCormick, 1997; Newberry, 2001; Sanders, 2001; Walmsley, 2001, 2003; Wicklein, 1993). This transition has centred on a movement away from the workshop based industrial arts’ focus on developing industrial hand and machine skills (Young-Hawkins & Mouzes, 1991), to a focus more concerned with developing problem-solving and critical and creative higher-order thinking skills (Lee, 1996; Sanders, 2001). The teaching strategies traditionally employed within the industrial arts’ workshops of the past arose from behaviourist traditions (Herschbach, 1998). These strategies were primarily concerned with the passing of content didactically from teacher to student using a show and follow, step by step strategy (Fritz, 1996; Williams, 2000), rather than having concern for the internal processes of learning as experienced by the individual learner (Hansen, 1995; Herschbach, 1998).

Sanders (2001) studied the transition from industrial arts to technology education within a number of American education districts. His collection of survey responses from 418 teachers within these various districts indicated that a transition towards technology education was evident. Sanders found that programs labelled as technology education (58.6%) outnumbered industrial arts’ labelled programs (9.1%). Approximately 20 % of districts used industrial technology as their program descriptor and a small number of schools used various other labels to describe their programs. Sanders’ study found that contemporary technology teachers
consider student problem-solving development as being the primary purpose for technology education, with hand and machine skill development taking on a lesser importance.

Sanders (2001) discovered that a significant shift had occurred in the area of curriculum delivery. That is, Sanders found that 75% of programs in the surveyed districts were using either a modular or technological problem-solving based technology education curriculum. Only 25% of programs utilised the more traditionally based, “project-from-plans” method of curriculum design. In addition, Sanders discovered that more female students, more gifted and talented students and more students with disabilities were engaging with the technology education curriculum than did so in the past. Additionally, Sanders’ study indicated that curriculum content is changing to incorporate areas such as communication, manufacturing, construction, and transportation technologies. In summary, Sanders argued that:

Considerable change has been taking place over the past few decades, but the legacy of industrial arts is also evident throughout the data. The dynamic between change and legacy seems to characterize the field at this point in time; technology education is a work-in-progress.

(Sanders, 2001, p. 53)

While technology education has been modifying its content through stipulated curriculum documentation at a systemic level [e.g. standards statements, (ITEA 2000); curriculum documents, (QCA, 1999); and technology syllabi, (QSA, 2002)], the legacy that Sanders (2001) identifies is regularly evident in the teaching strategies employed by contemporary technology educators. That is, often teachers of technology education remain fixed in the “show-and-follow” practices of the industrial arts past (Fritz, 1996; Walmsley 2001, 2003; Williams, 2000). In the past, Zuga and Bjorkquist (1989) argued that a primary focus on the curricular content for technology education had resulted in insufficient attention being given to instructional methods that supported such learning objectives as problem-solving, innovation and higher-order thinking. Conversely, Zuga (2004) argues that contemporary research on cognition and instruction in technology education is being restricted because of the reduction of curricular content in the field. Zuga argues that:
Clearly, the new standards can be seen as an attempt to make contemporary visions of technology education teachable and to provide direction for classroom change, a possible compensation for the over reliance on content structures generated in the past. This is not, in itself, a bad idea, but now there are fewer concepts identified, 20 standards and 288 benchmarks related to those 20 standards and spread over four levels of schooling (International Technology Education Association 2000), to be studied and learned. This is a stark reduction of content generated by the curriculum projects of the nineteen sixties, seventies, and eighties. This reduction of content can inhibit research on cognition. (Zuga, 2004, p.82)

Curriculum change, as highlighted by Sanders’ (2001) study, indicates that research is required to examine the content and pedagogy (i.e. instructional design or strategy selection) of contemporary technology education classrooms. In response, Herschbach argues that:

> It is not sufficient to identify curricular components without also addressing the specific pedagogical strategies required to engage students in the acquisition and use of higher-order learning. Largely absent from the discussion on reforming technical education is systematic attention to structuring an effective learning environment through which higher order skills can be acquired. It is an erroneous assumption that integration can be achieved through content selection alone, when probably the most important consideration is how content is taught. Integration and higher-order skill development is primarily a problem of instructional design, not content selection.  
> (Herschbach, 1998, p.36)

Schultz (1999) argues that the traditional project-based curriculum and instruction in technology education is supportive of student thinking through its focus on tool and material use. Schultz argues that: *As we create technology through tool use, technology shapes our thinking. There is a beautiful and symbiotic relationship between technology and our ability to think* (Schultz, 1999, p.84). Johnson (1992) argues that it is important for technology education curriculum to incorporate instruction that recognises the importance of developing the intellectual processes (i.e. higher-order thinking) of students. Johnson argues that:

> As the field of technology education evolves, its unique mission to provide relevant and experiential learning opportunities for students is becoming clear. Through well developed curricula, technology education programs are able to reinforce academic content, enhance higher order thinking skills, and promote active involvement with technology.
Additionally, Johnson (1992, p.26) argues that: \textit{the development of intellectual processes should be the primary goal of education}. However, there exists a lack of empirical research that focuses on cognition and the classroom activities of teachers and students in technology education (Cajas, 2002; DeMiranda, 2004; DeMiranda & Folkestad, 2000; Johnson, 1997; Lewis, 1999; McCormick, 1996; Zuga, 2004). Zohar, Degani and Vaaknin (2001) argue that:

\begin{quote}
As the drive for teaching for understanding and higher order thinking gains momentum in our schools, there is a need for a deeper investigation into the conditions necessary for its success.
\end{quote}


DeMiranda (2004) argues that contemporary technology education curriculum and pedagogy has the potential to exemplify in practice contemporary cognitive theories of learning such as constructivism. However, he argues that many technology educators are using strategies that support teaching and learning for intellectual development based on intuitive beliefs and trial and error methods rather than on the basis of the findings of empirical research. DeMiranda observes that:

\begin{quote}
Through experience in classroom teaching and refining instructional methods by trial and error, technology educators have witnessed the success of hands-on, lab-based design and problem solving instruction. However, they have lacked a powerful connection or grounding between well researched theories on learning and instruction that could help validate their experiences and support their instructional methods. Research grounded in theory from the cognitive sciences may perhaps provide technology educators with a strong understanding and foundation in support of their experiences.
\end{quote}

(De Miranda, 2004, pp. 64-65)

Further, De Miranda argues that exemplary technology education classrooms typify instruction that supports teaching and learning methods that reflect research drawn from the cognitive sciences. That is, students are active participants in the learning process (i.e. self-regulation during design and problem solving). Students have the opportunity to reflect on
their activities and to modify their thinking in the pursuit of personally relevant goals (project-based activity that connects student thinking with the production of artefacts). Students engage within technology education classrooms that value interaction with peers, the teacher, and external sources of information (i.e. learning is socially based and connected to the real world context outside the classroom). De Miranda (2004) argues that collaborative learning, socially distributed expertise, design/engineering and project-based learning or: *learning in doing* (De Miranda, 2004, p. 71) are pertinent aspects of cognitive theory that align closely to exemplary practice in technology education classrooms.

Technological problem-solving within technology education classrooms has generally become analogous with some form of design-process based instruction (Mioduser, 1998; Rowel, 2004; Stevenson, 2004). The design process is principally a heuristic for solving problems and has received criticism for characterising problem-solving as a generally applicable skill (Mawson, 2003; McCormick, et al, 1994; McCormick, 2004). Mawson argues that despite critique of the validity of the design process: *The concept of the design process is now well established as a dominant discursive regime within technology education* (Mawson, 2003, p.119).

It has been argued that the design process teaching strategy is often implemented by technology educators in a ritualistic and prescriptive manner (Mawson, 2003; McCormick, 2004). The design, make and appraise model (DMA) has been and continues to be supported by technology teachers as an instructional strategy in an effort to facilitate instruction and assessment of what is an inherently complex process (Mawson, 2003). Often the design process is portrayed as a linear or cyclic series of steps (See Figure 3.1) that facilitate the solving of technological problems (Mawson, 2003; McCormick, 2004) through: *working technologically* (QSA, 2003, p.14). However, this set process often becomes ritualistically applied and is argued not to best represent the actual thinking of students as they engage with technological problems (McCormick, 2004).
De Miranda (2004, pp. 72-73) draws on the work of Sternberg (1998) and Bransford and Vye (1989) to argue that technology education teachers require skills that facilitate their implementation of curriculum that supports instructional methods formulated to develop students' use of cognitive skills. Teaching skills that De Miranda argues are applicable to technology education are:

1. *Technology teachers must assume the role of teacher as coach. This requires teachers to monitor and regulate student attempts at problem solving so they don’t go too far into the wrong solution yet allow students to have the opportunity to experience the complex process and emotions of authentic problem solving and design practice.*

2. *Technology teachers help students learn to reflect on the processes used while designing, constructing, testing, and solving problems.*
(learning by doing), and contrast their approaches with those used by others in the class.

3. The role of the technology teacher as computer-based instructional tutor with students working in structured groups of two is not being a facilitator or coach. Technology teachers must learn to use a classroom resource that is often underused – other students. By learning to create climates that foster cooperative learning, it becomes possible to help students engage in active problem solving and reflection even though there is only one teacher and many students.

(De Miranda, 2004, p.73)

This section concludes that technology education is a subject area in transition. This transition has centred on both curriculum content and delivery. That is, project-based instruction of the industrial arts’ past is being superseded by either modular or technological problem-solving orientated curriculum designs (Sanders, 2001). Additionally, this section argues that the pedagogy associated with the traditional project-based instruction of the industrial arts’ past has been the use of systematic show-and-follow strategies. The legacy of these methods is argued to persist within contemporary technology education classrooms regardless of curriculum type and structure, however, empirical research is limited in this area (Cajas, 2002; DeMiranda, 2004; DeMiranda & Folkestad, 2000; Johnson, 1997; Lewis, 1999; McCormick, 1996; Zuga & Bjorkquist, 1989; Zuga, 1995; Zuga, 2004).

DeMiranda (2004) argues that exemplary contemporary technology education classrooms display teaching strategies that reflect cognitive or intellectual theories of learning and that the learning environments in these classrooms support student higher-order thinking. Conversely, Schultz, (1999) argues that technology education classrooms that base their curriculum on the more traditional project work have the potential to support student higher-order thinking. It is argued in this thesis that De Miranda (2004) and Schultz (1999) find minimal support through empirical research results into teaching and learning in technology education. Despite the lack of research that focuses on teaching, learning and higher-order thinking in technology education (Cajas, 2002; DeMiranda, 2004; DeMiranda & Folkestad, 2000; Johnson, 1997; Lewis, 1999; McCormick, 1996; Zuga, 2004), DeMiranda (2004) theorises that teachers may
provide support for student higher-order thinking by acting as a coach or facilitator to monitor and support student activity without diminishing student responsibility for learning outcomes. Additionally, DeMiranda argues that the teacher should focus students on the processes of design and problem-solving, and in particular, that support for this learning can be drawn from peers as well as from the teacher or classroom computers. However, De Miranda finds little supporting empirical evidence within technology education literature. The following section examines the classroom context in technology education.

3.3.2 The Role of Classroom Program in Technology Education Instruction
Chapter 2 reviews literature that supports a relationship between a person’s cognition, and activities within a particular setting. McCormick (2004) acknowledges that the concept of such a relationship has important implications for technology education. In particular: *knowing and doing* (McCormick, 2004, p.23) are argued to be best linked together within authentic contexts. This belief is congruent with aspects of activity theory (Jonassen & Rohrer-Murphy, 1999) as presented in Section 2.6. Activity theory argues that learning (i.e. problem-solving / cognitive adaptation towards higher-order goals or possible hypothetical futures) occurs simultaneously during activity and that such an interrelationship is socially determined within the material environment (Susi & Ziemke, 2001).

In the context of this analysis, it is important that McCormick (2004, pp.27-29) has drawn from technology education classroom observations to examine the role of instruction during student problem-solving (i.e. learning / cognitive adaptation). McCormick identifies a number of characteristics of technology education learning environments that influence the types of activities that engage students during technological problem-solving. These characteristics are summarised below as:

1. The classroom culture (i.e. how students perceive the classroom rules for engagement with problems).
2. Students being given or finding problem solutions (i.e. the teacher taking responsibility for problem-solving or supporting student problem-solving).
3. A problem-solving culture (i.e. the teacher supports student problem-solving).
4. Student collaboration (i.e. students work together during problem-solving).

Each of McCormick’s (2004) technology education classroom characteristics is now discussed in turn. The classroom culture is determined, to a large extent, by how students’ perceive the rules of the classroom. These rules determine how students engage with technological problems and may serve to inhibit student creativity by teachers predetermining possible solutions. In terms of the theories presented in this thesis, McCormick’s concept of classroom culture is interpreted as being analogous to the program of the technology education classroom setting. Chapter 2 outlines the setting program as encouraging certain activities over others, in much the same way as McCormick argues that the technology education classroom culture influences the types of thinking used by students. McCormick (2004, p.27) uses the example of a teacher providing a set range of different materials for students to solve a predetermined problem. These materials often constrain student solutions and may cause students to use less appropriate materials to solve a design problem than they otherwise might if provided with additional materials or information about material properties generally. In other words, the technology education setting program, as fashioned by teachers through a process of front-end analysis of the relevant curricula documentation, supports particular patterns of student learning behaviours and inhibits others. That is, the setting program governs how the majority of human participants (the students and the teacher in this case) engage in their activities. In the context of this thesis, McCormick’s concept of classroom culture is significant because it supports the conceptualisation of higher-order thinking and an integral setting program outlined in Chapter 2.

During technological problem-solving activity, a range of emergent problems can be experienced by students. McCormick (2004) uses the example of a student wanting to manufacture a sock-shaped container to hold a moisture sensor. The teacher expected the students to design and make rectangular boxes for this purpose, given that this was the method demonstrated. However, one student decided that a moisture sensor for a clothesline (her
context for the moisture sensor) should have a sock shape. This shape created a series of dilemmas for the student and these problems required solutions. The student asked the teacher for assistance as each problem arose. The student was shown or told by the teacher how to mark out the sock shape, what material to use, how to cut out the curved shape and how the shape could be glued together effectively. The teacher established a classroom program that emphasised teacher problem-solving that provided solutions to students, rather than students establishing ownership of the problem and trying to find their own problem solutions. Given that Chapter 2 outlines self-regulation as an important facilitator of higher-orders of thinking, it would seem problematic to consider that this form of technology education setting program would support student higher-order thinking because of the reduced emphasis on student self-regulation evident in the teacher’s strategy selection.

It would seem more appropriate for teachers to value student self-regulation and problem-solving (i.e. higher-order thinking). In this way, the setting program may be fashioned by teaching strategies that support students as they solve their own problems by posing questions, suggesting multiple alternative solutions or modelling their own problem-solving techniques. McCormick (2004) argues that this type of classroom program aims to engage students with problems within a supportive learning environment: *It takes longer, and it is harder to do, but it is crucial to foster problem solving* (McCormick, 2004, p.29).

Rather than teachers alone supporting or inhibiting student problem-solving, McCormick’s (2004) study found that student collaboration exists in technology education at three levels. The first level occurs, as students are often required to work side by side on individual projects. Students have the opportunity to discuss each others’ activity and to talk about problems and successes. Students may provide advice to each other in contexts where difficulties arise. DeMiranda (2004) argues that often technology teachers tend not to use peer tutoring as an instructional strategy during student problem-solving, and suggests that it is a resource that should be used to take some responsibility for supporting problem-solving away
from the teacher. The second level is evident when students divide activities into sections and each student is allotted an individual task to perform. Students collaborate during the allocation of tasks and during the bringing together of the components to create the problem solution. According to McCormick, the third level of collaboration occurs when students are grouped together and are required to jointly design and manufacture a product or solve a technological problem. McCormick (2004) and McCormick and Davidson (1996) argue that this type of instruction is problematic because of the requirement for individual assessment within group contexts and for each student to have a product outcome to take home. McCormick argues that:

*Designed correctly tasks should require solutions to a problem to be considered by all students through discussion and decision making. In the real world of industry, individuals may work on their own but that work contributes to the overall task. They share the products of their work, but not necessarily the process, whereas in the learning situation we want both.*

(McCormick, 2004, p.30)

In other words, the collective activity of the technology education classroom is important in terms of support for student higher-order thinking and often this support is overlooked because of the nature of prescribed assessment requirements. That is, the object of the technological activity within the technology education classroom behaviour setting may be to advance knowledge of the underlying technological concepts, however, tensions arise as students and teachers strive towards individual goals that emphasise success through individual accomplishment (i.e. positive assessment results). Chapter 2 outlines successful learning (i.e. higher-order thinking) as being regulated as much by what is not known and understood as by what is, and therefore, it would seem that the goal of successful accomplishment alone may not be conducive to the support of student higher-order thinking.

Sanders found that teachers’ considered that the major purposes for technology education are: *Developing problem-solving skills* and: *Use technology (knowledge, resources, and processes) to solve problems and satisfy human wants and needs* (Sanders, 2001, p.45). Given that problem-solving and the skills that support these activities are perceived as important by
technology teachers, it is therefore necessary to understand more about the classroom contexts that support this type of student learning activity (McCormick, 2004; Zuga, 2004).

It is argued in Chapter 2 that higher-order thinking should be conceptualised to acknowledge the influential nature of individual cognition, the behaviour setting and collective activity during individual goal attainment. It is argued in this thesis that the behaviour setting supports activity through a program that incorporates various milieu-behaviour synomorphs (i.e. the coupling of behaviours in their relation to artefacts) that, in turn, support and encourage particular types of activities over others. According to activity theory, activities are, in turn, supported by cultural expectations and this is often manifested in the types of technical and psychological tools, and the actions mediated in terms of their use, which support and encourage different types of thinking. Individual cognition is argued to be hierarchically structured and self-regulated to satisfy individual goal attainment with overall collective purposes that confer meaning on activity. During occasions when a person encounters unusual circumstances (i.e. problems) during goal attainment, the hierarchical cognitive system analyses, manipulates and synthesises information in order that the impediment to goal attainment be overcome. The complexity of this process is evident in its juxtaposition within the bounds of the behaviour setting and of the activities that are therefore encouraged. Further, complexity is evident when other related behaviour settings influence the activities of individuals acting towards goal attainment.

The concept of classroom culture as proposed by McCormick (2004) is argued in this thesis to reflect the interdependent nature of higher-order thinking as conceptualised in this thesis and displayed in Figure 2.3. Classroom culture is argued to be influenced by rules which govern student and teacher behaviours or actions and is therefore represented in this thesis as being analogous with the behaviour setting program. It is also argued in this thesis that different types of activities promote different types of thinking. In much the same way, Figure 2.3 indicates that, the rules or program of the setting, which is created by the teacher using a
process of front-end analysis of the stipulated curriculum documentation and implemented using tactics that support particular strategies at the intermediate and micro-levels, dictates the types of actions students engage in. Additionally, the physical characteristics of the behaviour setting exhibit an effect on how setting inhabitants (i.e. students and teachers) act. That is, the synomorhic relationship between the milieu and the activities of setting occupants restrict or encourage one form of activity and or actions over others, and thus impacts on the types of thinking used by students during individual goal attainment.

For example, design-based technology education classes may be structured to include the more traditional workshop type facilities that support student manipulation of wood, metal or plastic materials during their various designing activities. Harris, (2005) and Schwaller, (2002) argue that modular technology education classrooms and the more traditional workshop-based technology education classrooms consist of very different facilities (see Section 3.3.3), however, modular technology education too can support design-based learning, although through a different series of activities than would be evident in the more traditional workshop setting (Harris, 2005). Thus, it is argued in this thesis that setting structure, or its physical design and layout, impacts on the technology education curriculum, on the strategies teachers select and on the tactics teachers use during strategy implementation.

Wicker (2002) argues that behaviour settings are influenced by and exhibit an influence over other related settings. For example, the technology education class setting may be influenced by the administrative setting of the school in terms of the available time, monetary support and equipment. The technology teacher training behaviour setting (e.g. university) may impact on the beliefs and professional qualities of the teacher that supports and promotes learning activity within the technology education class setting. Additionally, the personal characteristics of the students are governed, in part, by their relation to other behaviour settings, such as family, school, neighbourhood, district and city. That is, a person’s understanding of self and their prior experiences (i.e. memories) are important aspects of the
behaviour setting and these are influenced in important ways by other related settings (Wicker, 2002).

The conceptualisation of higher-order thinking, as advanced in this thesis, emphasises higher-order thinking in its relation to an individual’s goal attainment in collective activity (see Figure 2.3). It is argued in behaviour settings theory that it is not important that all setting inhabitants have the same goals (Barker, 1968; Wicker, 1984, 2002), however, it is important that the setting program is maintained by setting inhabitants because the desire to realise individual goals is mutually supported (Barker, 1968; Wicker, 1984, 2002) (see Section 2.5). In activity theory, an individual’s goals derive their meaning from the object of the collective activity. An individual’s hierarchical cognitive processes are argued to be structured for problem-solving and goal attainment (Anderson, 1982). Therefore, the inherent nature of the cognitive processes of an individual are required to be directed towards personally meaningful goals. It is argued in this thesis that self-regulation is an essential component of higher-order thinking. In other words, it is problematic to consider that higher-order thinking is being used by students if they are not involved in activities that have as their fruition the realisation of a personally meaningful goal. It is therefore argued also, that a classroom program that supports higher-order thinking would require student self-regulation towards goals that are meaningful for the students, both individually and at times, how they contribute to collective purpose.

Thus, higher-order thinking in technology education classes is conceptualised in this thesis as an individual cognitive activity that is supported by the program of the classroom. This program is governed by many factors and these factors are argued to both promote and constrain one type of classroom program over another. This study examines the technology education classroom program in terms of teacher and student actions in collective activity, and thus relates the strategy selection and implementation of teachers with the press of the technology education classroom for different types of student thinking.
This section argues that different types of classroom programs in technology education affect the manner of student engagement with their technological problem-solving activities. McCormick (2004) argues that individual technology education classrooms exhibit different programs (i.e. culture) and that these different programs influence how students engage with technological problem-solving. This thesis advances the argument that this difference is influenced by the instructional strategy selection and implementation of technology education teachers, at either the intermediate or the micro-levels (See section 3.2 for further details).

At the macro-level, McCormick’s (2004) study found that technology teachers have a tendency to make similar decisions. That is, preference appears to be given to technological problem-solving based curriculum designs. One might conclude that this curriculum has been developed from prescribed curriculum documentation using a process of: front-end analysis (Jonassen, et al, 1990). However given the results of McCormick’s (2004) study, it could be argued that the manner of student engagement with these problems alters as teachers use different strategies at the lower strategic levels. For example, the teacher choosing to provide problem-solutions for students as a micro-level teaching strategy diminishes student responsibility for their activity/actions as a consequence of this strategy selection and implementation. Teachers make these decisions regarding how students engage with their learning tasks (i.e. technological problem-solving activity) through the strategies they select and the tactics they use to support them. In other words, teachers influence the types of thinking used by students during their collective activity (i.e. learning through technological problem-solving) by choosing teaching strategies and tactics that alter the technology education classroom learning program (McCormick, 2004).

Along with technological problem-solving, Sanders’ (2001) study found that modular technology education classrooms have become a significant outcome of the transition from the more traditional project-based instruction in technology education. Weymer describes modular technology education (MTE) as:
…a curriculum provided by a commercial vendor in which students learn about an area of technology by: (a) participating in interactive media presentations, (b) following instructions in workbooks, (c) writing responses in student journals, and (d) experimenting and building projects. Working in pairs, students complete instructional activities at computerized work stations. Students follow self-directed instructions that introduce and reinforce technological concepts. Many MTE curricula have a strong “hands-on” component in which students use tools to process resources, generally resulting in a completed prototype or experiment.

(Weymer, 2002, p.34)

Additionally, Weymer argues that the computer is replacing the technology educator as the source of both conceptual and procedural knowledge in MTE classrooms. The students involved in Study 2 (i.e. North Carolina, America), reported in this thesis, engaged in MTE learning experiences. The following section examines literature concerned with teaching and learning in MTE classrooms.

3.3.3 Modular Technology Education: Teaching and Learning

Schwaller (2002) and Rogers (2000) found that an increasing number of American technology education curricula programs are delivered using modular technology education (MTE). These MTE programs incorporate the use of computers, multimedia and technological equipment, such as wind tunnels, CAD/CAM equipment and hydraulic and pneumatic equipment (Schwaller, 2002). Modules are often purchased from commercial suppliers (Schwaller, 2002). Both the curriculum that supports the hardware and the hardware that supports the curriculum are commercially available to facilitate student activity in numerous technological areas (e.g. robotics, aeronautics, electronics and biotechnology) (Schwaller, 2002). Technology education teachers may choose to alter or replace the set curriculum of the modules as suits their requirements (Brusic & La Porte, 2000; de Graw & Smallwood, 1997; Harris, 2005; Schwaller, 2002). Harris states that:

A typical modular setting consists of several modules, or stations, arranged throughout the laboratory. Each module contains different subject matter and project assignments. In this format the students move from module to module, learning about different topics at each station. This type of approach is self-directed by the learner, and no two student
groups are necessarily working on the same lesson or project at the same time.

(Harris, 2005, p.54)

Culbertson, Daugherty and Merrill (2004) suggest that an area for further research in technology education is how the MTE learning experiences of students influence their use of higher-order thinking skills. However, there is currently insufficient empirical research associated with teaching and learning in MTE classrooms (Brusic & La Porte, 2000; Culbertson, Daugherty & Merrill, 2004; de Graw & Smallwood, 1997; Harris, 2005; Rogers, 2000; Weymer, 2002). Studies seek to interpret technology teacher perceptions of MTE by surveying teachers who currently use this format of instruction. For example, studies by Brusic and La Porte, (2000), de Graw and Smallwood, (1997) and Harris (2005), focus on the willingness of technology teachers to accept MTE and the perceived advantages and disadvantages of MTE classrooms. Many of the perceived advantages and disadvantages of MTE found through the research conducted by Brusic and La Porte, (2000), de Graw and Smallwood, (1997) and Harris (2005) are included in the list below along with others provided by Schwaller (2002).

1. MTE saves preparation time.
2. MTE allows for teacher curriculum development within the modular structure.
3. MTE is educationally sound.
4. MTE helps alleviate behaviour problems.
5. MTE is well received and supported by students, parents and school administrations.
6. MTE provides students with access to a considerably wider range of technologies than might be the case in conventional technology programs.
7. MTE requires that teachers have a good knowledge of module equipment and activities to provide student support and to maintain the equipment.
8. MTE is most appropriate for use with middle school students.
9. MTE does not increase student motivation to learn.
10. MTE can be inhibited by a lack of financial support from school administrations for ongoing equipment costs and software upgrades.
11. MTE equipment sometimes fails causing significant classroom difficulties because of the heavy reliance on the hardware to support the MTE curriculum.
12. MTE requires significant initial financial support to purchase equipment.
13. MTE is not always easy for teachers to try out and use on a limited basis.
14. MTE is not always easy for teachers to use and understand.

The research in this area has uncovered various advantages and disadvantages of MTE (See Brusic and La Porte, 2000; de Graw and Smallwood, 1997; Harris, 2005; Schwaller, 2002). On balance, it appears that the technology teachers surveyed in these studies generally perceive that MTE benefits themselves and their students. However, as Harris (2005) acknowledges, the results may be skewed because only the opinions of teachers who currently use MTE-based instruction are surveyed. That is, they could not be considered a representative sample of all technology teachers.

Rogers (2000) argues that there is minimal research that compares MTE learning outcomes with that of traditional or contemporary technology education classrooms. Additionally, Rogers argues that school districts are incorporating MTE without fully understanding how this type of instruction supports or inhibits students’ acquisition and use of technological knowledge and skills (Rogers, 2000). Rogers compares MTE with the traditional and the contemporary technology education instruction of seventh grade students and concludes that seventh grade student achievement is best supported by contemporary laboratory industrial technology instruction when compared with traditional instruction and MTE. Additionally, Rogers argues that the results of his study indicate that:

...contemporary laboratory instruction provided significantly better achievement than modular technology education in the areas of general industrial technology education knowledge, drafting technology, manufacturing processes, construction technology, and power/energy.
(Rogers, 2000, p.49)

Despite the differences between MTE and contemporary laboratory instruction, as argued by Rogers (2000), Schwaller (2002) and Harris (2005) argue that similarities exist between MTE
and conventional technology education laboratories. That is, that much of the learning is hands-on, students may work together in groups and students engage in technological problem-solving using various technological content. However, the literature appears to provide minimal evidence regarding the development of modular instruction through a process of front-end analysis, with many MTE programs being delivered using curricula developed by commercial suppliers (Schwaller, 2002). It was found by de Graw and Smallwood, (1997) that almost half of the technology education teachers surveyed in their study, utilised part or all of the commercially supplied MTE curriculum. However, Schwaller (2002) argues that many of the commercially available modules support the requirements of the American Standards for Technological Literacy (ITEA, 2000).

Harris (2005) and Schwaller, (2002) identify the major differences between MTE and conventional technology education classrooms as being that:

- Students in MTE are involved in different technological activities depending on the number of different modules in the classroom. Conventional technology education classrooms are argued to support student activity using similar technologies and as such students would normally be engaged in similar tasks.
- In MTE, it is argued that the teacher provides less support for student learning and that the module packages or packets are designed to provide self-directed learning experiences for students. In conventional technology education classrooms, the teacher is argued to be primary source of support and information.

Harris argues that:

> While a conventional approach to teaching in the technology laboratory allows students, usually working in groups, to learn about technology by creating and solving problems using a hands-on approach, it is the teacher who is the primary source for instruction and guidance in the conventional laboratory. Due to its teacher-based format, in a conventional laboratory most often the entire class works on the same project or lesson at the same time. On the other hand, in a modular technology laboratory environment, while students also work in groups on problem based, hands-on projects, they do so in a self-directed manner with the aid of multi-media and instructional books rather than through direct instruction by the teacher.

(Harris, 2005, p.53)
Harris argues that MTE facilitates a self-directed learning experience for students and that teachers’ decisions regarding instructional strategies at the intermediate and micro-levels would appear to be often made by the modular designer, given that students interact more with multimedia and instructional books rather than with the teacher. Therefore, it could be argued that the tactics designed to support implementation of these strategies might be developed remotely, rather than by classroom teachers. Under these circumstances, the program of the MTE classroom would be predominantly created by the module’s designer and not by the classroom technology education teacher (See Section 3.3.2 for a discussion of classroom program). Given that students in MTE classes are often directed or supported by information technologies (i.e. multimedia and computers), as argued by Harris (2005), it would seem that this situation may result in diminished self-regulated learning (i.e. higher-order thinking). It may be difficult to interpret more or less self-direction (i.e. self-regulation) in terms of a narrow focus on more or less teacher-student interaction, without also considering the possibility of other influences (e.g. a computer software program that guides a student prescriptively through a series of learning activities). Thus, the question of whether MTE supports the higher-order thinking processes involved in creativity and technological problem-solving is yet to be answered and therefore requires further investigation.

In summary, the literature suggests that use of modular technology education (MTE) programs is expanding in America. This expansion is occurring despite the lack of empirical research that examines the nature of teaching and learning in MTE (Rogers, 2000). Current research efforts appear to be concerned with teachers’ perceptions of MTE rather than with empirical research that examines directly the educational value of the MTE approach to instruction. Roger’s (2000) study examined the learning outcomes of the MTE approach in year seven students and raises questions regarding its effectiveness when compared to the outcomes of more contemporary technology education learning environments. Therefore, it would seem important that more empirical research is conducted that examines the nature of teaching and
learning and the promotion of higher-order thinking within MTE classrooms (Culbertson et al, 2004).

This section examines the literature in terms of MTE from the viewpoint of classroom program. That is, the MTE laboratory includes a number of modules. Each module contains a number of learning activities related to a discrete area of technological content that promotes certain types of student learning actions and inhibits others. Usually, pairs of students cycle through each module at set intervals. These intervals are normally set by the teacher and are dependent on the number of modules and number of students in each technology class. Students generally engage with this content using the support of the module software or multimedia. Therefore, Harris (2005) and Schwaller, (2002) argue that the MTE approach provides students with a self-directed learning experience. Harris, (2005) argues that this aspect of the MTE approach sets it apart from contemporary technological problem-solving based laboratories, in which teachers are considered to provide the bulk of support. It is questioned in this section, whether or not this perceived difference between teacher support and technological support, results in the promotion of student self-regulation and thus of students’ use of higher-order thinking in MTE classes. Regardless of this situation, Schwaller (2002) argues that teachers should facilitate creativity or discovery time to provide students with dedicated opportunities to apply the technological concepts learnt during module activity and thus be provided with situations requiring the use of higher-order thinking.

In summary, MTE learning activities are supported by curriculum materials designed commercially. Technology education teachers are able to alter or replace these commercially supplied materials as suits their requirements (Schwaller, 2002). However, little is known through empirical research about the nature of teaching and learning in MTE classrooms (Brusic & La Porte, 2000; Culbertson, Daugherty & Merrill, 2004; de Graw & Smallwood, 1997; Harris, 2005; Rogers, 2000; Weymer, 2002), and therefore about the classroom program of MTE. The results and conclusions of the study reported in Chapter 6 address this gap in
knowledge by examining the MTE classroom activities of Fundamentals of Technology students and teachers in North Carolina, America. In addition, the study examines the relationship between teaching, learning and the promotion of higher-order thinking in these MTE classrooms. This section argues that a technology education classroom program is largely a consequence of the types of intermediate and micro-level strategies and tactics implemented by teachers. Deluca argues that the teacher as classroom manager holds the major influence in respect to strategies that: define the teacher to student and student to student interaction (Deluca, 1992, p.29).

3. 4 Conclusion and Predictions
This chapter concludes that instructional strategies can be understood in terms of a hierarchical structure. That is, instruction is designed at the macro, intermediate and micro-levels. Macro-level strategies are designed using a process of front-end analysis, through which prescribed student learning outcomes are recognised (Jonassen, et al, 1990; Leshin, et al, 1992; Rothwell & Kazanas, 1992), thereby identifying the object of the activity. Intermediate-level strategies support student actions relative to overall activities at the macro-level. Micro-level strategies occur during discrete student learning experiences and are in turn supported by instructional tactics. Instructional tactics are defined as what teachers do (their actions) during their interactions with students that facilitate strategy implementation (Jonassen, et al, 1990; Leshin, et al, 1992; Rothwell & Kazanas, 1992).

This chapter examines the literature concerning the role of the technology education classroom program in supporting student thinking (McCormick, 2004). Teachers support or create a classroom program through instructional strategy selection. Each level of strategy is important in this regard, however, it would seem that strategies at the intermediate and micro-levels impact directly on the type of activities or tasks with which students engage during instruction (Jonassen, et al, 1990). Different tasks or activities require or facilitate different types of student thinking (Stevenson, 1986a, 1986b) (See section 2.3 for details). The tactics teachers
use to implement these strategies directly influence the learning activities/actions of students and therefore have an impact on the types of thinking students’ employ within technology education classrooms (McCormick, 2004). Thus, it is argued in this thesis that the concept of a technology education classroom program, as conceptualised in this thesis, links teaching to learning and the development of higher-order thinking through strategy selection and implementation in technology education classes.

The conceptualisation of higher-order thinking advanced in this thesis incorporates influences from:

- The behaviour setting program (i.e. the technology education classroom program promoted through particular strategy selection and implementation).
- The inanimate artefacts within the activity system (including psychological and technical tools).
- The interaction of artefacts and behaviours within the setting (i.e. the synomorphic relationship between artefacts and setting inhabitants or mediated actions).
- The hierarchical cognitive structures of an individual.
- An individual’s understanding of self and prior knowledge.
- The self-regulation of individual cognitive processes with respect to inherently important personal goals.

Given the nature of higher-order thinking, as conceptualised in this thesis, and the substance of the literature reviewed in Chapters 2 and 3, it is possible to make certain predictions regarding the types of activities that might support student higher-order thinking in technology education classes. These predictions are as follows:

1. Technology education classes, which support students to achieve personally important goals, will help promote student higher-order thinking.
2. Technology education classes, which support students to self-regulate or take responsibility for their classroom activities, will help promote student higher-order thinking.
3. Technology education classes, which support students to construct knowledge based on what they already know and may need to know, so that they might solve problems that
inhibit personally important goal attainment, will help promote student higher-order thinking.

4. Technology education classes, which value the independent nature of student learning (i.e. higher-order thinking), will help promote student higher-order thinking.

The predictions above are mutually supportive in that they interrelate and are posited in recognition that they are necessarily non-specific. That is, it is argued in this thesis that various teaching strategies and the tactics that support their implementation may facilitate student higher-order thinking in technology education classrooms, provided that the accumulation of the strategies and tactics focus on achieving a classroom program that realises the aforementioned predictions. Therefore, it is argued in this thesis that the advancement of these predictions indicates that there is no one right method or classroom program for promoting higher-order thinking in technology education. However, the method or classroom program selected, should in some way involve students in the activities predicted in this thesis as being necessary for the promotion of students’ use of higher-order thinking. It is the aim of this thesis to identify teaching strategies and tactics within technology education classes that facilitate classroom programs that promote students’ use of higher-order thinking. The following section provides a summary of the chapter.

3. 5 Chapter Summary
This chapter examines the idea that technology education is a discipline in transition (Eggleston, 1992; Fritz, 1996; Hansen, 1995; Herschbach, 1998; Lauda, 1988; McCormick, 1997; Newberry, 2001; Sanders, 2001; Walmsley, 2001, 2003; Wicklein, 1993). This transition centres on both content and pedagogy (Fritz, 1996; Hansen, 1995; Herschbach, 1998; Lee, 1996; Sanders, 2001; Williams, 2000; Young-Hawkins & Mouzes, 1991). Instructional strategies favour technological problem-solving and modular technology education (MTE) over traditional project-based approaches (Sanders, 2001). Literature reviewed in this chapter concludes that more research into teaching and learning and student higher-order thinking is required in technology education whether delivered traditionally or
through modules (e.g. Cajas, 2002; DeMiranda, 2004; DeMiranda & Folkestad, 2000; Johnson, 1997; Lewis, 1999; McCormick, 1996; Zuga & Bjorkquist, 1989; Zuga, 1995; Zuga, 2004).

It is argued in this chapter that teachers influence student thinking by strategy selection at the intermediate and micro levels and thus by the creation of a classroom program that either supports or inhibits students’ use of higher-order thinking. This chapter predicts that particular kinds of activities may promote student higher-order thinking and for technology education classroom programs to promote student higher-order thinking they should facilitate these types of activities. The literature reviewed in this chapter outlines how little is understood about teaching and learning and higher-order thinking in technology education classes. That is, little is understood through empirical research regarding technology education classroom programs and the promotion of students’ use of higher-order thinking. This study addresses this gap. Its purpose is to identify differences in thinking and the factors that influence the types of thinking students use during their learning activities within technology education classrooms. Chapter 4 presents and justifies the research method used to investigate teaching and learning in technology education classrooms within Australia and America.
Chapter 4

RESEARCH METHODOLOGY

4.1 Introduction
This thesis examines teacher and student classroom activities and interactions that promote student higher-order and lower-order thinking in a number of Australian and American technology education classes. In doing so, it draws on cognitive theory (e.g. Anderson, 1982; Barkley, 2001; Jones & Anderson, 1987; Newell & Simon, 1972; Stevenson, 1984), setting theory (e.g. Barker, 1968, 1978; Wicker, 2002, 1991, 1984) activity theory (e.g. Engeström, 1999, 1993; Engeström & Cole, 1997; Leont’ev, 1981) and instructional theory (e.g. Jonassen, 1992; Honebein, Duffy & Fishman, 1993; Simons, 1993).

This chapter presents and justifies the research methods used to examine the arguments and predictions advanced in Chapters 2 and 3. The study addresses gaps in current research literature by examining the types of classroom activities of teachers and students that promote students’ use of higher-order thinking in technology education classes. A conceptualisation of higher-order thinking is synthesised in Chapter 2. This conceptualisation is advanced as representing the complexity and interdependent nature of individual cognition, behaviour setting and activity within higher-order thinking. A visual representation of this relationship is displayed in Figure 2.3. Chapter 3 advances the concept of classroom program as an important component of higher-order thinking and predicts that a classroom program that facilitates particular student activities over others may promote students’ use of higher-order thinking in technology education classes (See Section 3.4 for details). The following section details the approach taken to achieve the aim of the study.
4.1.1 Research Approach and Aim

The research used a deductive approach (Graziano & Raulin, 1997) within a positivist-humanist paradigm (Cohen, Manion & Morrison, 2000; Neuman, 1994). The combination of these two paradigms is argued by Bernard to be beneficial because:

\[ In the end, the tension between science and humanism is wrought by the need to answer practical questions with evidence and the need to understand ourselves — that is, the need to measure carefully and the need to listen hard. \]

(Bernard, 2000, p.18)

The research was undertaken through two studies to examine the technology education classroom factors that influence students’ use of higher-order thinking in two countries. The studies combined quantitative (survey) and qualitative (case study) research methods (Babbie, 2001; Campbell & Stanley, 1963) to provide a deductive framework that facilitated the intended aim of the study. The study aimed to identify teaching and learning activities and actions that promoted students’ use of higher-order thinking in technology education classrooms. Additionally, the study examined factors that supported lower-order thinking in technology education classrooms.

Two studies were conducted to achieve this aim. The first study examined a sample of Australian technology education classrooms (i.e. Study 1) and the second study examined a sample of technology education classrooms in America (i.e. Study 2). Both studies used the Cognitive Holding Power Questionnaire (CHPQ) (Stevenson, 1998) to identify technology education classrooms that supported different types of student thinking (the CHPQ concept is explained later in this section). Once identified, Study 1 used video and video-stimulated interview techniques to examine differences between the various Australian technology classrooms. Particular classrooms were selected for this examination based on their results for the CHPQ. Study 2 was conducted in America. All classes in Study 2 were surveyed using the CHPQ and observed using an observation checklist. The CHPQ results were used to select American technology education classrooms for further in-depth analyses to identify factors
that differed between particular classrooms (See Section 4.3.3.3 for details of the study phases).

As previously mentioned, the research project reported in this thesis comprises two studies. One of these was conducted in schools in North Carolina, United States of America and the other in Queensland, Australia. There were some similarities in the methodologies employed in both studies. Both had the aim of understanding the characteristics of technology learning environments that encouraged higher-order thinking. However, the studies should not be looked at as a two-country comparative study, other than in the most general sense. For financial and logistical reasons, the most in-depth data collection and analysis was undertaken with the Australian study where it was possible to undertake the extensive video recording and video-stimulated recall interviews. Similarly, while both studies employed the Cognitive Holding Power Questionnaire (CHPQ) there were differences. For the Australian study, the CHPQ was used as a pre and post-test to facilitate case study selection and analyses, while in the US study the CHPQ was administered once to identify classes that would be used for observational data analyses. The two studies are thus complementary with similar and different features.

The CHPQ was used to identify the perceptions of students in a number of technology education classrooms in Study 1 and Study 2 regarding the press for higher and lower-order thinking. In this thesis, press refers to the learning environment's influence on individual goal attainment (See sections 2.4 & 2.5 for further details of the Cognitive Holding Power concept).

Stevenson (Stevenson, 1986a; Stevenson and Evans, 1994; Stevenson, 1998) has developed an instrument to measure the learning environment's capacity to press students into engaging in certain types of cognitive activity. The Cognitive Holding Power Questionnaire (CHPQ) assesses the levels of press for students to use different levels of procedural knowledge
because of the characteristics of the learning environment (Stevenson, 1998). The purpose of the questionnaire is to examine students’ perceptions of the types of tasks they undertake. In general, these tasks are influenced by a range of factors within the learning environment (Grossman & Stodolsky, 1994). Specifically, the CHPQ interprets the influence of the teaching strategies, tools and subject matter (Stevenson, 1998).

The Cognitive Holding Power Questionnaire has been validated through various studies (Stevenson & Evans, 1994; Stevenson, 1998; Walmsley, 2001; Xin, 2008; Xin & Zhang, 2009) to distinguish between cognitive activities at the level of either first or second order procedural knowledge. Due to the influence of the press or holding power of the learning environment to encourage these types of cognitive activities from students, it is said that an environment which activates the use of first order procedures (i.e. lower-order thinking) has first order cognitive holding power (FOCHP). First order procedures are used when students follow teacher instructions and perform tasks exactly as they are modelled. Learning occurs in situations that are very similar to those experienced at the source of the original information. An environment rich in the use of second order procedures (i.e. higher-order thinking) is said to be high in second order cognitive holding power (SOCHP) (Stevenson, 1998). Second-order procedures are those used when students initiate or are encouraged to initiate problem-solving strategies. Thus with second order procedures, learning may occur within problem situations significantly different from those of their conception.

The CHPQ survey results were used to identify particular Australian (Study 1) and American (Study 2) technology education classrooms for further case study investigations using video, video-stimulated interviews and checklist observations (See Section 4.3.4 for details of data collection methods). Both studies interpret teacher and student actions and interactions within technology education classes with reference to the questionnaire results relating to the press for different types of student thinking (i.e. FOCHP and SOCHP). Thus, the CHPQ (quantitative) was used to identify that a particular phenomenon (high or low CHP) was
occurring in particular technology classrooms and the case studies (qualitative) were used to investigate why.

Such an approach is supported by Fraser and Tobin who argue that the: *confluence of qualitative and quantitative methods is a desirable future direction for research on learning environments* (Fraser & Tobin, 1991, p.290). Combined methods assist in providing researchers with avenues that are more fruitful for discovery, more so than when adopting either qualitative or quantitative methods independently in classroom environment research (Fraser & Tobin, 1991; Carlson, 1999; Levin & O’Donnell, 1999; Stanovich, 1999).

For example, Zandvliet (1999) conducted a cross-national study of Internet based high school classrooms within Australia and Canada by using a combination of both questionnaire and case study methods. Zandvliet argues that the findings from the quantitative section of his study (classroom surveys using a questionnaire) were in turn supported and complemented by qualitative case studies of individual classrooms (observations coupled with student and teacher interviews).

The inclusion of complementary research methods within investigations of learning environments has the potential to: *enhance researcher’s [sic] understanding of their empirical findings* (Levin & O’Donnell, 1999, p.187). Therefore, this study of student higher and lower-order thinking within technology education classrooms was structured to facilitate the convergence of quantitative and qualitative methods of inquiry. This structure has the potential to provide comparable and supportive empirical evidence. Figures 4.1 and 4.2 below provide an overview of the Australian (Study 1) and American (Study 2) studies respectively.
Figure 4.1
Research Design: Study 1 (Australia)

**Study 1**
Australia
Research Question

- How can students use of higher-order thinking be improved in Technology Education Classrooms?

**Study 1-Phase 1**
2003 school Year

- Australian Pre-test CHPQ: Assess existing Technology Education Classrooms for types of student thinking (Early school year).

**Study 1-Phase 2**
2003 school Year

- Stage 1: Select Australian Technology Education classes for Case Study Investigation based on Study 1-Phase 1 CHPQ results.
- Stage 2: Investigations of learning environment characteristics that appear to be supportive of student higher-order thinking in Technology Education Classrooms (Case Study Investigations using Video and Video Stimulated Interviews).

**Study 1-Phase 3**
2003 school Year

- Australian Post-test CHPQ: Assess existing Technology Education Classrooms for types of student thinking (Late school year).

**Research Findings**

- Synthesise factors which may improve students use of higher-order thinking in Technology Education classrooms given the results drawn from: Study 1-Phases 1, 2 & 3: Australian Study.
Studies 1 and 2 adopted a research approach that gathered evidence using quantitative surveys (questionnaire) and qualitative inspection (classroom observations and interviews) and used these to interpret characteristics of technology learning environments. The methodological rigour (Levin & O’Donnell, 1999) and pragmatic nature of this study sought to examine actual teaching and learning practices in technology education classrooms (Wollman-Bonilla, 2002).
Through this practical approach, the study aimed to interpret the activities and interactions of teachers and students in terms of their influence on student thinking (i.e. FOCHP & SOCHP) in technology education classrooms.

4.1.2 Research Questions
The research study focused on identifying teacher and student actions and interactions that were prevalent in technology education learning environments which pressed students to use higher-order and/or lower-order thinking. The study addressed the following research questions:

1. What differences exist between a number of Australian technology education classes regarding the press for higher-order and lower-order thinking?
2. What factors appear to press for higher-order and lower-order thinking within these Australian technology education classes?
3. What differences exist between a number of American technology education classes regarding the press for higher-order and lower-order thinking?
4. What factors appear to press for higher-order and lower-order thinking within these American technology education classes?
5. Do factors that appear to promote a press for student higher-order and lower-order thinking in technology education vary across Australian and American technology education classrooms?

Overall these five questions address the main aim of this study: that is, to identify teacher and student activities and actions that promote students use of higher and lower-order thinking in a sample of Australian and American technology education classrooms.

4.1.3 Chapter Structure
This Chapter describes the research methodology and design. The conceptual basis for the methodology and the research design derived from it is first discussed (Section 4.2) and the choice of research design is justified. The stages of inquiry are subsequently explained and include: procedures for site selection (Section 4.3.1), subject selection (Section 4.3.2), research
procedures (Section 4.3.3) and quantitative and qualitative data collection (Section 4.3.4). The various methods used to analyse the data are then discussed (Section 4.4). The strengths and limitations of the research design are then outlined (Section 4.5).

4.2 Research Design
This thesis examines theoretical issues relating to cognition, the learning environment, activity and instruction in technology education. Syllabus documents (Queensland, Australia) (QSA, 2003) and standards statements (America) (ITEA, 2000) indicate that students should engage with critical and creative (higher-order) thinking skills during their technological problem-solving activities. Technology education students are provided with opportunities to develop complex thinking skills by: working technologically (QSA, 2003, p. 6). The Queensland Studies Authority (QSA) (2003) defines working technologically as:

...a way of working that interweaves technology practice, information, materials and systems with consideration of appropriateness, contexts and management. The implicit purpose of ‘working technologically’ is the design and development of products that enable people to meet their needs and wants and to capitalise on opportunities.

(QSA, 2003, p. 6)

Technology education’s potential to support students as they work technologically has led to researchers posing questions about such issues as: the nature of design and problem-solving (Lee, 1996; McCormick, 1996; McCormick & Davidson, 1996; McCormick, Murphy & Hennessy, 1994; Williams, 2000), the structure of technological knowledge (McCormick, 1997; Schultz, 2000; Herschbach, 1997, 1996; DeMiranda & Folkestad, 2000) and teaching strategies which facilitate student learning in technology education (Eggleston, 1992; Fritz, 1996; Hansen, 1996, Johnson, 1992, 1996, 1997; Kemp & Schwaller, 1988; Lauda 1988).

In response to these types of questions, this study examined year nine classrooms in Australia (Queensland) studying the course Technology and in America (North Carolina) classrooms studying the course Fundamentals of Technology in terms of teacher and student activities, actions and interactions. The Fundamentals of Technology course was developed to:
...provide students with an opportunity to develop basic technological literacy through application of principles, processes, skills, and specific knowledge found in technological fields of study. This course of study helps students develop and enhance their decision-making, problem-solving, and creative-thinking skills through activity-based instruction. (Public Schools of North Carolina, 2002, p. iii)

The study analysed teacher and student actions and interactions to interpret the relationship among design and problem-solving, particular teaching strategies and different types of student thinking in technology education classes across two countries. The conceptual framework of this current study draws on cognitive theory, setting theory, activity theory and instructional theory (See Chapters 2 & 3 for details) and provides theoretical support and justification for the study’s methods and results.

4.2.1 Summary of Research Studies and Phases
The two research studies are summarised in this section as displayed in Figures 4.1 and 4.2. Study 1 included phases 1, 2, and 3, while Study 2 included phases 1 and 2. Study 1 and Study 2 phase 2 each incorporated two stages of investigation. For a more detailed description of each study, see Section 4.3.3.

In addition, Figure 4.3 provides the timeline that details the implementation of Study 1 (Australia) during the 2003 school year and Figure 4.4 provides the timeline that details the implementation of Study 2 (America) during the 2004 / 2005 school year.
Study 1 Australia

Study 1-Phase 1: This phase of Study 1 provided empirical evidence (quantitative - surveys) of the types of thinking Australian year nine technology students were pressed to use during their learning experiences in April 2003 (early in the school year). This phase of the study provided an empirical basis for the selection of a number of technology classes for Phase two.
**Study 1-Phase 2:** In Stage 1 of this phase technology education classes were selected based on the results found in Phase 1. Additionally, in stage 2 of this phase actions and interactions of teachers and students were examined (qualitative examination - video observation and video stimulated interviews). This occurred in the selected Australian technology education classes from August to September in the 2003 school year.

**Study 1-Phase 3:** This phase examined (quantitative - surveys) the types of thinking Australian year nine technology students were pressed to use during their learning experiences in October 2003 (late in the school year).

**Study 2 America**

**Study 2-Phase 1:** In this phase of Study 2 (quantitative - surveys) the types of thinking American technology education students were pressed to use during November / December of the 2004 school year were examined.

**Study 2-Phase 2:** In Stage 1 of this phase, technology education classes were selected on the basis of the results found in Phase 1. In Stage 2 of this phase, the actions and interactions of teachers and students were examined (qualitative examination - researcher observation checklist) in the selected American technology education classes.

This dual study multi-phase research approach provided plausible evidence (Levin & O’Donnell, 1999) linking classroom teaching and learning practice and the press for student higher-order and lower-order thinking in selected Australian and American technology education classes.

**4.2.2 Research Design: Stages of Inquiry**

**4.2.2.1 Site selection**

Eleven schools were selected in Australia (Study 1) and eight schools were selected in America (Study 2) on the basis that the secondary high schools in each country were situated in similar socioeconomic regions (where possible), were of comparable size in terms of school population, and all taught similar technology education related subjects. That is, schools in
Australia were selected based on the similarity of their community and curriculum, as were schools in America.

This purposive sampling method (Bernard, 2000; Krathwohl, 1993) was used to ensure that the target students from each technology education class were taught similar subject content. That is, students were required to be exposed to a technology curriculum that supported their learning activities within a technological problem-solving framework through the application of propositional knowledge related to materials, processes, information and the systems of technology. It was considered impractical to randomly sample schools and obtain these subject characteristics because of the variations in current technology subject content and teaching methods (Newberry, 2001; Sanders, 2001, Fritz, 1996).

The use of this sampling method does affect the external validity (Campbell & Stanley, 1963) of the study. That is, because of the non-random nature of the sampling method employed, the results of the study cannot be generalised to other technology classrooms outside the study confines. However, there was no indication that the classes selected were systematically different from other technology education classes that may have been used.

In Study 1 (Australia), the nine secondary high schools were required to be located within a reasonable travelling distance (100 kilometres) of the researcher’s usual workplace. In addition, the curriculum of each school was required to be formulated from a technology syllabus in Australia, or technology standards statement in America that encouraged students to understand and apply concepts drawn from knowledge of various types of materials, processes, information and systems during their technological problem-solving activities.

Some differences occur between Study 1 (Australia) and Study 2 (America) in terms of the physical structure of the classrooms. The Australian technology education classrooms were structured around the traditional industrial work-shop and the American technology education
classrooms were structured to incorporate modules (See Section 3.3 for details of MTE). The variation between the technology education classrooms situated in the two countries provides the study with an opportunity to examine in two different types of behaviour settings, the links between teacher and student activities and the press for higher-order and lower-order thinking in technology education classrooms. That is, what teacher and student actions and interactions influence the press for technology education student’s use of higher-order and lower-order thinking in similar or different ways across these two countries? In other words, do different setting programs impact differently on the press for student’s use of higher-order and lower-order thinking?

4.2.2.2 Subject Selection
The subjects for this study included 21 technology teachers and their 13 to 14 year old students across 29 year nine technology education classrooms in Queensland, Australia (441 students) and 8 technology teachers across 23 Fundamentals of Technology classrooms in North Carolina, America (414 students). In each country, the students chosen for inclusion in the study were involved in a technology curriculum that supported their learning through various types of technological problem-solving activities. As a means toward solving these types of technological problems, the curriculum required students to be active in seeking an understanding of materials, processes, information and the systems of technology.

4.2.2.3 Teachers
Technology education teachers were selected on the basis that they were willing to have their classroom activities studied. A number of technology teachers (less than ten) consented to be involved in Study 1-Phase 1 but not in Study 1-Phase 2. In general, the reasons given for non-participation by teachers in this regard, centred on the lack of available teacher time and the difficulties encountered with gaining parental or carer consent from students for Study 1-Phase 2. However, it was expected that technology teachers willing to participate in all phases of Study 1 would nevertheless vary from each other pedagogically. It is assumed in this thesis that this variance would occur in teachers, despite the necessity for them to have a set of
predisposed attributes, (e.g. willingness to accept changed classroom conditions, flexibility, cooperation and enthusiasm) as seen to be necessary for their effective participation in the study.

Teachers agreed to participate in Study 1 with full knowledge that the investigative processes were extensive and required a high level of commitment to the study’s aims and objectives. Teachers were required to have particular attributes. For example, teachers needed to have understanding, willingness to discuss teaching and learning methods, willingness to provide their time and a willingness to accept some minor disruptions to class routine. Some or all of these attributes may influence the external validity (Campbell & Stanley, 1963) of the study. Soliciting technology teachers with certain characteristics may reduce the extent to which the results of the study can be generalised across other teachers. However, as technology education is continuing to undergo pedagogic and subject content change, resulting in differences between schools, both intra-nationally and internationally (McCormick, 1996; Linnell, 1994; Fritz, 1996; Lewis, 1999; Newberry, 2001; Sanders, 2001), the selection procedures used to recruit teachers for Study 1 are assumed to have been effective. To a lesser degree, the American technology education teachers in Study 2 were required to accept some minor disruptions to normal classroom routine to allow researcher classroom observation and survey administration.

4.2.2.4 Students
Students participating in technology education courses were targeted as the student subjects for Study 1 and Study 2 (i.e. approximately 500 students in Australia and 500 students in America). As indicated in Section 4.2.2.1, technology education classrooms were selected on the basis that they encouraged students to understand and apply concepts drawn from knowledge of various types of materials, processes, information and systems during their technological problem-solving activities. Therefore, regardless of subject area descriptor (e.g. Industrial Technology and Design, Design and Technology, Fundamentals of Technology,
Manual or Industrial Arts) it was the curriculum of each school that came under scrutiny during the selection process rather than subject title.

In Australia (Study 1), 441 year nine students were chosen for the study. These students were selected because in many Queensland schools this year level provides the first opportunity for students to participate in technology education for the entire school year. That is, year nine students participate in technology education learning experiences at an introductory level for one complete school year. Study 1 required repeated access to students during the school year because of the nature of the research design (See Section 4.2.1 for details).

In North Carolina (America), 414 Fundamentals of Technology students were selected for Study 2 because it was considered that these students would be comparable to the students selected in Study 1. That is, that the students would be involved in technology education learning activities at an introductory level for sufficient duration.

4.2.2.5 Approaching Schools

Schools that met the selection criteria (See section 4.2.2.1) were contacted well in advance of the proposed study commencement date. For high schools in Australia (Study 1) the commencement date was March 2003 (i.e. Study 1-Phase 1) and for high schools in America the commencement date was November 2004 (i.e. Study 2-Phase 1).

Study 1 Australia

In Queensland, Australia, the Queensland Education Department (Ed. Qld) provided its approval for the research on the condition that all initial researcher contact with Ed. Qld schools occurred with school principals or their representatives. Principals were supplied with a research information document (See Appendix 1), which provided an outline of the study and a list of assurances that would be adhered to by the researcher in reference to relevant
ethical considerations. In addition, the approval to conduct the research was obtained from Griffith Universities Human Research Ethics Committee.

After first obtaining the principal’s consent to allow the research to be conducted in each of the schools, year nine technology teachers (21 teachers across 11 schools) were approached and supplied with the school research information document. The research procedures were explained to teachers and questioning was encouraged to reduce misunderstandings. Each technology teacher was then provided with an opportunity (1-2 weeks) to consider their willingness to commit their time, effort and year nine technology students to the study.

Study 1 involved 29 year nine technology teachers, teaching in total, 441 year nine students, who would be willing to consent to the research study during the 2003 school year. Consent forms were distributed to students before each phase of the study. That is, all students provided consent for the questionnaire for Study 1- Phases 1 and 3 (pre-test and post-test surveys) (See Appendix 3). However, only those students involved in Study 1- Phase 2 (video observation and video-stimulated interviews) were asked to provide consent for that section of the study (See Appendix 4). It was considered reasonable to expect that by asking for consent for the various phases of the study only as necessary, the number of students and teachers willing to participate would be larger than if consent for all phases was requested at the outset.

Study 2 America
Ethical clearance for the study to proceed in America was facilitated by an appointed research professional from the North Carolina schools’ district. Copies of the ethics clearances from Australia were provided to complement submissions made within America. Submissions for ethics approval and clearance were initially made with Appalachian State University and subsequently with a number of North Carolina school districts, for the research to proceed with Fundamentals of Technology classes. Eight technology teachers across 23 Fundamentals of Technology classes (within eight schools) containing 414 students were targeted for Study 2
(Study 2-Phases 1 & 2). The consent process used to provide information to school principals, teachers and students was compiled and administered by the American researcher.

4.2.2.6 Research Phases
Each study (i.e. Study 1 & Study 2) moved through various research phases. Study 1-Phases 1, 2 and 3 occurred within Australia and Study 2- Phases 1 and 2 within America. Details of each study are provided in the following sections. For a summary of the research studies and phases see Figures 4.1 and 4.2 and Section 4.2.1.

Study 1 - Phase 1
Phase 1 involved pre-test surveying all consenting year nine students early in the 2003 school year using the Cognitive Holding Power Questionnaire (CHPQ) (Stevenson, 1998) (See Section 4.1.1). Walmsley (2001) examined year nine and ten technology education classrooms in Australia using the CHPQ. In that study, Walmsley (2001) modified only the title of the CHPQ to become the Technology Environment Response Form (TERF) because he argued that a title change may be less intimidating and confusing to the age groups of respondents targeted in that study. For the same reason this study adopted Walmsley’s (2001) modified title of TERF for the administration of the CHPQ (See Appendix 5). However, the original title of the questionnaire (i.e. Cognitive Holding Power Questionnaire: CHPQ) will be used in all future reference to the questionnaire within this thesis.

Students were provided with information and consent packages for their own and their parents’/carers’ information on the research’s aims and objectives (See Appendix 2). Only those students who returned signed consent forms were permitted to respond to the CHPQ. As indicated in the timeline for this study, (See Figure 4.3) the pre-test administering of the questionnaire occurred after approximately ten weeks of instruction into the Australian 2003 school year. Therefore, the consent package was supplied to students several weeks before this
time. This permitted the return of the consent form before administering the questionnaire, as stipulated by research ethics approval.

Teachers presented a researcher-prepared text to students immediately before they responded to the CHPQ (See Appendix 6). This provided each class with a consistent introduction to the questionnaire. The questionnaire packets were coded to identify the survey results of each technology class. Approximately 700 consent forms and questionnaires were distributed to 29 technology classes within eleven high schools in the southeast corner of Queensland, Australia. A deadline was set for return of the consent forms (April 2003). 441 students participated in Study 1-Phase 1. The questionnaire required approximately thirty-minutes of class time to complete. The questionnaires were returned to the researcher for tabulation and data analysis on completion.

**Study 1 - Phase 2**

The data obtained in Study 1-Phase 1 were tabulated and recorded using the Statistical Package for the Social Sciences Version 11.0 (SPSS ver.11, 2001). The data were subsequently analysed (See Section 4.4.1 for details) to provide empirical research evidence concerning each technology learning environment’s press for first order cognitive holding power (FOCHP) and second order cognitive holding power (SOCHP) (Stevenson, 1998) (See Section 4.1.1 for details of the cognitive holding power concept). Based on the results of the quantitative data analysis, two Australian technology classes were chosen for video and video stimulated interview data collection. One class was chosen for its high result for SOCHP and low result for FOCHP. The other was chosen because of its high result for FOCHP and low result for SOCHP (See Section 5.4 for details).
Table 4.1 above displays the summary characteristics of each technology class and school setting under case study investigation. The information provided in Table 4.1 allows for an examination of the similarities and differences across the technology classes that come under case study investigation in Study 1. It is important to acknowledge that each of the two classes was considered by their teachers to use a design-based problem-solving curriculum to support student learning activity.

This phase aimed to identify the various teacher and student activities and interactions that appeared to contribute to differences in student perceptions (i.e. responses to the CHPQ) of the press of the technology learning environment for first (FOCHP) or second (SOCHP) order cognitive holding power. That is, at this point the analysis of the CHPQ results was used to identify classes that had scored low or high on either FOCHP or SOCHP.
Class teachers and their students were contacted and provided with information and consent packages as a precursor to the case studies involving videotaping classroom activities and conducting video-stimulated interviews. Classroom observation were conducted using two video cameras, one to focus on teacher activities and the other to focus on the students’ activities (See Section 4.3.2.1 for details of the method used for video data collection). The recordings were later analysed and coded for particular types of teacher and student activities and interactions (Pirie, 1996; Roschelle, 1999; Hall, 1999; Jacobs, Takako & Stigler, 1999; Stevenson & McKavanagh, 1994) (See Section 4.4.2 for details of video data analysis).

Interviews were conducted with the teacher and a number of students from each videotaped technology class. Three students were chosen for the interviews in consultation with the class teacher. The selection criteria required that each student selected was a volunteer and able to respond to interview questions. The selected students were invited to volunteer and there was no penalty imposed on students if they declined to participate. These interviews were structured for a video-stimulated recall technique (Pirie, 1996, Clarke, 1998). This format required the interviewee to view video-footage of particular classroom episodes and provide the interviewer with verbalised accounts of their motivations for specific classroom activities and actions (See Section 4.3.2.2 for details).

Interviews of fifteen-minute duration were conducted with individual students during the next available technology lesson after the video-recorded lesson. The student interviews took place in an adjacent and vacant classroom to ensure that student responses were uninhibited by external influences (e.g. other students, noise). Teacher interviews of sixty-minute duration (i.e. time allowed to view the complete lesson videotape) were held when convenient for teachers before, during or after school hours. Several interviews extended past the lesson duration because of extensive teacher interest in many aspects of the lesson’s activities. Teacher interviews were held as soon as practicable after the video-recorded lesson in an area that facilitated viewing of the footage without undue interruption. Each interview was audio-
recorded for later transcription and correlation with video data. Further details of the video-stimulated recall technique used in this study are provided in Section 4.3.2.2. The video-footage for each lesson was coded every minute for particular types of interactions occurring both in the foreground (directly involving the teacher) and background (no direct teacher interaction) (See Appendix 12). The conceptual framework for the coding system followed that devised by Stevenson and McKavanagh (1994) (See Section 4.4.2 for details of video data analysis).

Study 1 - Phase 3
Study 1-Phase 3 involved post-test surveying (CHPQ) of the same technology education classes as for Study 1-Phase 1 later in the 2003 school year (See Figure 4.2 for details). Consent for student participation in this phase was not required as this was provided earlier in the year. That is, the original consent form included parent/carer permission for the Phase 3 post-test administration of the CHPQ. 380 students participated in Study 1-Phase 3. The administration and data collection procedures for Phase 3 were the same as for Phase 1. Phase 3 provided data on the press of the Australian technology education classrooms later in the school year. This was important because it provided data that interpreted the press for FOCHP and SOCHP on two occasions within the same technology education classes early and late in the same school year.

Study 2 - Phase 1
Study 2-Phase 1 involved the use of the CHPQ in selected American Fundamentals of Technology classes. Schools from several districts were contacted and consent sought for the study to occur within technology education classes undertaking the Fundamentals of Technology course. Schools and teachers were given an information package that provided details of the research’s aims and objectives. Additionally, students were provided with an information and consent sheet for their own and their parents’/carers’ information on the research’s aims and objectives. Only those students who returned signed consent forms were
permitted to respond to the CHPQ and to be involved in researcher observations of classroom learning and teaching activity.

As indicated in the timeline for this study (See Figure 4.4), the administration of the questionnaire occurred during November / December of the American 2004-2005 school year. Therefore, the consent package was supplied to students several weeks before this time. This permitted the return of the consent form before administering the questionnaire or observing classroom activity, as stipulated by research ethics approval.

As with previous administrations of the questionnaire, a prepared text was delivered to students immediately before they responded to the CHPQ (See Appendix 6). Unlike Study 1, a research assistant conducted the Study 2 administration of the CHPQ to all Fundamentals of Technology classes. This provided a consistent method of introduction to the questionnaire for each class. The questionnaire and observation checklist packets were coded to allow the researcher to identify the results for each American technology class. Approximately 440 consent forms and questionnaires were distributed for completion by students within 23 technology classes from 8 high schools in North Carolina, America. A deadline was set for return of the consent forms (December 2004). As with Study 1-Phases 1 and 3 of the Australian study, the questionnaire required approximately thirty-minutes of class time to complete. 414 questionnaires were returned to the researcher for tabulation and data analysis on completion.

**Study 2 - Phase 2**

Each American technology education class was observed for one lesson by a researcher using a checklist (See Appendix 16) to code teacher and student activity occurring in the foreground and background of the lesson, as in Study 1-Phase 2 (See Section 4.4.2 for details). The CHPQ was administered to each Fundamentals of Technology class on one occasion only and the results correlated with the information provided by researcher observations of the classroom
activities (i.e. the observation checklist). Based on the results of the quantitative data analysis, three American technology classes were selected for qualitative data analysis because of the significant difference between their SOCHP results (See Section 6.2 for details). Table 4.2 below displays the summary characteristics of each Fundamentals of Technology class and school setting under case study investigation. Note that classes 232 and 233 were from the same school. Each class was taught by the same technology teacher in the same classroom and as such are located within the same column in Table 4.2.

Table 4.2
Study 2 America Case Study Technology Class & School Characteristics

<table>
<thead>
<tr>
<th>Class Identification</th>
<th>232 &amp; 233</th>
<th>251</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Gender</td>
<td>Male</td>
<td>Male</td>
</tr>
<tr>
<td>Student Gender</td>
<td>Male / Female</td>
<td>Male</td>
</tr>
<tr>
<td>Type of Curriculum</td>
<td>Modular technology Education supported by the North Carolina Fundamentals Curriculum Guide.</td>
<td>Modular technology Education supported by the North Carolina Fundamentals Curriculum Guide.</td>
</tr>
<tr>
<td>Academic / Non-academic Cohort</td>
<td>Non-academic</td>
<td>Non-academic</td>
</tr>
<tr>
<td>Physical Environment</td>
<td>Computer Modules and rows of desks set up in a traditional classroom style.</td>
<td>Small room set up with computer modules.</td>
</tr>
<tr>
<td>Public / Private School</td>
<td>Public: District administered</td>
<td>Public: District administered</td>
</tr>
<tr>
<td>Socioeconomic location</td>
<td>Middle income</td>
<td>Middle income</td>
</tr>
</tbody>
</table>

4.3 Data Collection
4.3.1 Cognitive Holding Power Questionnaire (CHPQ)
For phases of the two studies requiring student surveys using the CHPQ (i.e. Study 1-Phases 1 and 3 and Study 2-Phase 1), teachers provided class numbers to enable class bundles of information, consent, questionnaires and introductory instructional texts to be prepared. The bundled documents were delivered in person by the researcher to the teachers of each of the
technology education classrooms under examination in Australia and likewise by a research assistant in America. On completion, the consent forms and responses to the CHPQ were collected from each of the participating schools (See Section 4.3.1.1 for details of the CHPQ).

In Australia, teachers administered the questionnaire (CHPQ) to their own technology education classes during Study 1-Phases 1 and 3. In American Fundamentals of Technology classrooms (i.e. Study 2-Phase 1), a research assistant administered and collected the questionnaires. Table 4.3 displays the numbers of response forms supplied and returned completed during each phase of the two studies. An introductory text ensured a consistent introduction to the questionnaire across teachers and schools and reduced the possibility of response bias.

<table>
<thead>
<tr>
<th>Phase &amp; Test</th>
<th>CHPQ Supplied</th>
<th>CHPQ Completed</th>
<th>Percentage Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study 1 Phase 1 Pre-test</td>
<td>700</td>
<td>441</td>
<td>63%</td>
</tr>
<tr>
<td>Study 1 Phase 3 Post-test</td>
<td>441</td>
<td>380</td>
<td>86%</td>
</tr>
<tr>
<td>Study 2 Phase 1 Pre-test only</td>
<td>440</td>
<td>414</td>
<td>94%</td>
</tr>
</tbody>
</table>

In Study 1 teachers were requested to administer the questionnaire during a lesson that suited their own requirements. This factor was considered unlikely to significantly affect student responses. Study 1 employed the teacher administration method in recognition of the considerable difficulties that researcher administration of the questionnaire would encounter, for example, differences in school time-tableting and the need to collect data from many technology classes within a considerable number of schools in different locations within a short timeframe. Where possible, each class group responded to the questionnaire within the same week. However, some teachers requested extra time to allow for the return of as many consent forms as possible. The researcher imposed cut off dates for return of both the completed consent forms and questionnaires.
4.3.1.1 Research Instrument

The Cognitive Holding Power Questionnaire (CHPQ) (Stevenson, 1986a; Stevenson & Evans, 1994; Stevenson, 1998) was used to quantify the press of technology education classrooms in Australia and America for different types of student thinking (i.e. FOCHP and SOCHP). The questionnaire (See Appendix 5) included the minor title change as detailed in Section 4.2.2.6 Study 1-Phase 1.

The CHPQ required students to indicate their gender for data correlation purposes. The questionnaire was structured around the identical thirty questions used in previous research on cognitive holding power (e.g. Stevenson, 1998) (See Section 4.1.1 for details of the cognitive holding power concept). Each question required students to indicate their response according to a five-tiered Likert scale, ranging from almost never to very often. Each response was allocated a rating from one to five during tabulation of the results, one corresponding to almost never and five to very often.

A scoring key (See Appendix 7) enabled the conversion of responses into measures of first (FOCHP) and second order cognitive holding power (SOCHP). The scoring key was adjusted from that originally provided by Stevenson and Ryan, (1994) and further validated by Stevenson & Evans, (1994) and Stevenson, (1998) (See Section 5.2 and Appendix 15 for further explanation). Within the CHPQ, thirteen questions ask students to interpret the press for utilisation of second-order procedures. Responses to questions such as, “I ask questions to check my results” and “I try out new ideas” gave an indication of the extent students perceive such press (SOCHP). Twelve questions such as, “I copy what the teacher does” and “I feel I have to work exactly as I am shown” required students to indicate their perceptions of a learning environment that presses for use of first-order procedures (FOCHP). Five questions were discarded because of the results indicated in the statistical analysis for phase 1 of this study. That is, the statistical analysis of the CHPQ responses indicated that the students
surveyed in this study did not display a shared understanding of the five questions discarded. This adjustment to the CHPQ has not affected the factor structure of the two scales or the reliability of the questionnaire to assess for either FOCHP or SOCHP (See Section 5.2 and Appendix 15 for details).

The validity of the CHPQ as initially developed has been substantiated through development and testing in primary and secondary schools, technical and further education colleges (TAFE) and higher education (Stevenson & Evans, 1994; Stevenson, McKavanagh & Evans, 1994; Stevenson, 1998; Walmsley, 2001; Xin, 2008; Xin & Zhang, 2009). Stevenson & Evans (1994) draw attention to several studies for validation of the questionnaire’s ability to assess educational environments relative to the two scales of first and second order cognitive holding power (i.e. FOCHP & SOCHP). The results of these studies indicated that the validity and reliability of the two scales were maintained throughout the various educational settings investigated. Table 4.4 displays the results from a number of previous studies that have produced Cronbach’s $\alpha$ reliability statistics for the two scales of FOCHP and SOCHP.

<table>
<thead>
<tr>
<th>Study incorporating CHPQ</th>
<th>N</th>
<th>FOCHP</th>
<th>SOCHP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study 1</td>
<td>1211</td>
<td>0.84</td>
<td>0.82</td>
</tr>
<tr>
<td>Study 2</td>
<td>470</td>
<td>0.87</td>
<td>0.86</td>
</tr>
<tr>
<td>Study 3</td>
<td>1203</td>
<td>0.82-0.87</td>
<td>0.76-0.80</td>
</tr>
<tr>
<td>Study 4</td>
<td>480</td>
<td>0.76-0.81</td>
<td>0.78-0.82</td>
</tr>
</tbody>
</table>

Study 3 - Secondary high schools, various subject areas: Stevenson (1998).

Stevenson (1992 in Stevenson and Evans, 1994) reported data from 1211 students across four secondary high schools and found that the reliability of each scale calculated as Cronbach’s $\alpha$ was 0.84 for FOCHP and 0.82 for SOCHP. Results for reliability analysis in TAFE colleges
reaffirmed these results with a Cronbach’s $\alpha$ of 0.82 – 0.86 for FOCHP and 0.77 – 0.87 for SOCHP (Stevenson, 1990 in Stevenson, 1998). In addition, Cronbach’s $\alpha$ reliability scores were calculated from data retrieved from higher educational settings and were found to be, FOCHP – 0.87, SOCHP – 0.86 (Clarke & Dart, 1991 in Stevenson, 1998). The reliability of the scales was further substantiated in secondary high schools by Stevenson (1998), where the CHPQ was administered to 1203 students in four Brisbane (Queensland, Australia) state high schools across various subject areas. The $\alpha$ reliabilities ranged from 0.82 – 0.87 for FOCHP and 0.76 – 0.80 for SOCHP in that study. A study of years nine and ten technology education classes by Walmsley (2001) found that the reliability of the CHPQ scales of FOCHP and SOCHP were consistent with prior investigations. The results of the $\alpha$ reliability calculations for FOCHP and SOCHP in terms of the various data categories in Walmsley’s (2001, p.64) study are displayed in Table 4.5 below (FOCHP - 0.76 to 0.81 & SOCHP - 0.78 to 0.82).

<table>
<thead>
<tr>
<th>Data Categories</th>
<th>N</th>
<th>FOCHP</th>
<th>SOCHP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>366</td>
<td>0.78</td>
<td>0.80</td>
</tr>
<tr>
<td>Female</td>
<td>126</td>
<td>0.81</td>
<td>0.80</td>
</tr>
<tr>
<td>Year level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 9</td>
<td>241</td>
<td>0.79</td>
<td>0.78</td>
</tr>
<tr>
<td>Year 10</td>
<td>239</td>
<td>0.79</td>
<td>0.82</td>
</tr>
<tr>
<td>Teaching</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design</td>
<td>161</td>
<td>0.78</td>
<td>0.79</td>
</tr>
<tr>
<td>Industrial Arts</td>
<td>171</td>
<td>0.81</td>
<td>0.81</td>
</tr>
<tr>
<td>Combined</td>
<td>148</td>
<td>0.76</td>
<td>0.80</td>
</tr>
</tbody>
</table>

(Walmsley, 2001, p.64)

Alpha Reliabilities for this current study are presented in Table 4.6 below. The reliabilities are reported for the data in the categories of the Total Study (i.e. all the data combined from Studies 1 and 2) and Studies 1 and 2 independently. The results of the Alpha Reliability analyses for this current study are comparable to those calculated for previous studies (e.g.
Stevenson & Evans, 1994; Stevenson, McKavanagh & Evans, 1994; Stevenson, 1998; Walmsley, 2001; Xin, 2008; Xin & Zhang, 2009) and as indicated above.

Table 4.6
Current Study
Alpha Reliabilties for FOCHP and SOCHP
(N = Number of students represented in each category)

<table>
<thead>
<tr>
<th>Data Categories</th>
<th>N</th>
<th>FOCHP</th>
<th>SOCHP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Study</td>
<td>1235</td>
<td>0.83</td>
<td>0.78</td>
</tr>
<tr>
<td>Study 1</td>
<td>821</td>
<td>0.83</td>
<td>0.75</td>
</tr>
<tr>
<td>Study 2</td>
<td>414</td>
<td>0.82</td>
<td>0.82</td>
</tr>
</tbody>
</table>

Additionally, principle component analyses validated the two scales of FOCHP and SOCHP as superior factors when accounting for the variations in CHPQ responses in Study 1-Phase 1 (32.6% of the variance explained) and Study 2-Phase 1 (35.9% of the variance explained) of this current study (See Appendix 15 for details of Study 1-Phase 1 principle component analysis).

Stevenson and McKavanagh (1991) reported a study that compared videotaped activities within TAFE classrooms with results obtained from administration of the CHPQ. The aim of the study was to correlate the amount of time devoted to different kinds of classroom activity with FOCHP and SOCHP. The results of the study indicated that both of these variables arose from different types of classroom activities. Examples provided from the study included: *teacher and student initiation, presentation and elicitation and different group sizes* (Stevenson and McKavanagh, 1991). FOCHP was found to be associated with teacher initiation of activities and larger group sizes. Alternately, SOCHP was found to be associated with student initiation of activities and smaller group sizes. Therefore, Stevenson (1998) argues that learning environments that press for SOCHP are more likely to facilitate single student to teacher communication.
Additionally, Stevenson and Evans (1994) conducted a confirmatory factor analysis for FOCHP, SOCHP and other alternate scales from within 107 TAFE and school classes (2028 students). This study validated FOCHP and SOCHP as superior factors when accounting for the variations in CHPQ responses across educational settings.

The results of these aforementioned studies, including this current study, are argued to support the construct validity of the CHPQ and the reliability of the two scales in providing assessment of the press exerted by learning environments relative to FOCHP and SOCHP. However, Stevenson and Evans (1994) caution researchers to recognise that the instrument (CHPQ) measures only the procedural component of the learning environment. The instrument does not measure the press of the learning environment relative to students use and development of propositional knowledge in support of students’ procedural competencies.

4.3.2 Classroom Observations and Interviews.

4.3.2.1 Video

A video research package (VRP) (See Appendix 8) was assembled to facilitate the collection and later analysis of video data collected from within technology education classes during Study 1-Phase 2 of the study. The VRP included two digital video cameras, which captured footage of teacher and student teaching and learning activities. The quality of these cameras was adequate for the purposes required by this research project. One camera was kept static and positioned to capture as much of the classroom activity as was possible (i.e. background activity). The other camera was used to capture the teacher’s activity throughout the technology classroom (i.e. foreground activity). A research assistant in control of the teacher-specific camera was instructed to keep the teacher within the camera frame at all times during the lesson. The frame of the teacher camera captured the teacher and any student or students who were in direct communication with or being influenced by the teacher. Both cameras were permanently mounted on separate tripods within the classroom, and positioned to reduce any impediment to classroom teaching and learning activity.
The video recording from the two cameras was mixed on site using a vision mixer. The vision mixer enabled the creation of a television screen view from both cameras using a picture-in-picture format. The larger portion of the screen originated from the whole class camera and a smaller in-picture portion of the screen originated from the teacher camera. A television monitor was used on site to allow the viewing and adjustment of the mixed footage by the researcher. In addition, the monitor enabled the researcher to note interesting segments of the lesson (using the form in Appendix 1) for later investigation during video-stimulated interviews with teachers and students.

Video data were collected from two technology education lessons during the 2003 school year. The video-data collection occurred immediately before the Study 1-Phase 3 post-test administering of the CHPQ (See Figure 4.3). Two Australian technology education classes were video-recorded between August and October 2003. The duration of each class’s video session depended on school timetables, with Class 21 taking 70 minutes and Class 91 taking 50 minutes.

As classroom observation using video capture methods are scarce in technology education, this study has relied heavily on reviewing techniques acknowledged in research investigations of student learning in mathematics and science education classrooms (Clarke, 1998; Ulewicz & Beatty, 2001). The study encountered several minor problems due to the specific and atypical requirements of technology education classrooms as described in the following paragraphs.

In each class two video cameras were used (Clarke, 1998), one to record teacher interactions and activities (i.e. foreground) and the other to record student interactions and activities independent of the teacher (i.e. background). The placement of the cameras, recording and associated equipment was prearranged with the class teacher. Decisions were made primarily in recognition of the needs of the teacher and students (e.g. clear-ways, machinery access and
disruption minimisation). Therefore, in some instances requisite camera placement reduced the quality of the video recordings. Additionally, because of the variation in classroom shape (e.g. long and narrow or short and wide) the class camera (background) was unable to capture the total class image in many of the technology classrooms. The square or rectangular shape of the rooms and the lens angle of the camera resulted in the researcher deciding which camera position would capture the most classroom activity. Hence, the background camera was placed to record the bulk of class activity. While this factor was a concern initially, its effect during interviews proved to be minimal. The quality of the video footage that resulted from this process was more than adequate for the purposes required in this study.

Audio was gathered via two sources, a lapel radio (RF) microphone (Body Pack System & Microphone) (teacher) and a shotgun directional microphone (general class). The RF microphone provided audio reception of the teacher’s conversations with students. The shotgun microphone was required to permit student conversations to be monitored apart from the teacher. The sound quality was monitored by the researcher through headphones and adjusted by an audio mixer to provide the best possible audio coverage of the learning environment relative to the video footage.

The audio recording provided by the teacher’s lapel-positioned radio-microphone was of a high quality and provided a good record of teacher to student dialogue. However, at times this microphone was turned off because of excessively loud machinery noise. This generally occurred during teacher demonstrations of machine use. A shotgun microphone was used to capture conversations between students, apart from the teacher in the lesson background. Clark (1999) used similar methods to capture group conversations in the background of mathematics’ lessons. However, it was discovered that the shotgun microphone was not capable of capturing conversations within noisy technology education classrooms. Too often machinery noise would interfere with the quality of the audio. During most lessons, it proved to be more useful to rely on the teacher’s lapel microphone for all audio input from the lesson.
The shotgun microphone was generally used to supplement sound input only. Regardless of this shortcoming, the sound quality proved to be sufficient for the aims of the study.

The mixed video and audio footage was captured on a DVD recorder on site. The recorded footage (DVD) facilitated playback of the recorded lesson using the combined functions of the DVD player and the television monitor. The researcher was then able to conduct post-lesson, video-stimulated recall interviews with the teacher and students selected for interview using this facility.

A number of technology class teachers were approached to obtain their involvement in Study 1-Phase 2. These classes were chosen because of the results of Study 1-Phase 1 (pre-test). That is, classes were selected based on high or low FOCHP and SOCHP in the findings of Study 1-Phase 1. This process resulted in the inclusion of two classes in Study 1-Phase 2. These classes were supplied with information and consent forms to obtain permission from students to allow the observations and subsequent video-stimulated interviews to take place. In each class, several students declined to be observed and were therefore provided with alternative activities in a different class location during the videotaped lessons.

The researcher visited each technology class before videotaping. This allowed discussions with each technology teacher to take place regarding appropriate locations for the placement of the video equipment. The cameras required positioning so that light would not overly reduce the quality of the recording (e.g. from the sun entering windows). The static camera also needed to be positioned to capture as much of the classroom activity as was possible and the teacher camera needed to have clear line of sight to all areas of the classroom. Additionally, other information needed to be identified, such as the availability of power outlets and the movement areas of students, so that the equipment did not inhibit normal classroom activity. The positioning of the equipment within each class was achieved to accommodate the above constraints. The VRP equipment included a collapsible table and
chair; power, video and audio leads; and storage containers for the equipment. This enabled the package to be self-sufficient and therefore did not require the addition of any school supplied equipment.

4.3.2.2 Video-stimulated Interview
Two class sets of video-stimulated interviews were conducted with teachers and three selected class students. These students were chosen collaboratively by the teacher and researcher. Each student was selected on the basis of their willingness to participate and the teacher’s judgment that they would provide responses during the interviews. The interviews were designed to complement the video-data through a semi-structured approach (Fontana & Frey, 1994). This approach was used to facilitate teacher and student explanations for classroom activities and to focus interviewees on particular behaviour episodes within the video-data while still allowing for respondent elaboration.

Video-stimulated recall (Clarke, 1999; Meade & McMeniman, 1992; Nespor, 1984b; Pirie, 1996) was used to focus teachers and students on specific events within the lesson. Pirie, (1996) and Nespor, (1984a) suggest that video-stimulated recall interviews should be held as soon as possible after the video-taped lesson, as delays of seven days or more reduce the reliability of the data. Therefore, all interviews in this study were conducted as soon as practicable after each technology lesson (Clarke, 1999). Student interviews were conducted during the next available lesson after the videotaping. This sometimes meant that a weekend occurred between the two occasions, this factor did not appear to have a marked affect on the ability of the students to recall their thoughts concerning the lesson under discussion. Clarke (1999) argues that:

An individual’s video-stimulated recall account will be prone to the same potential for unintentional misrepresentation and deliberate distortion that apply in any social situation in which individuals are obliged to explain their actions. A significant part of the power of video-stimulated recall resides in the juxtaposition of the interviewee’s account and the video record to which it is related. Any apparent discrepancies revealed
by such a comparison warrant particular scrutiny and careful interpretation by the researcher.

(Clarke, 1999, p.4)

It is not the normal course of events for teachers firstly, to have their lessons video-recorded and secondly, to view and explain their thoughts and actions afterwards (Nespor, 1984b). Some teachers in this study commented that they felt uncomfortable during the process of videotaping and interviewing. The researcher conducted prior meetings with each teacher to explain the video-recording and interview process. These meetings were held in an attempt to alleviate teacher concerns. In addition, the open, semi-structured nature of the interview protocol permitted teachers to comment on any aspect of the lesson. In general terms, teachers considered the video-stimulated interview process as being a positive learning experience. Teachers also reported that they as teachers were more nervous about the process than were their students.

Calderhead (1981) argues that much of what teachers do within their classrooms becomes routine and automatic. The nature of these types of teaching behaviours is that they are often tacit and therefore difficult to verbalise and teachers may vary in their ability to provide verbal accounts of these types of tacit behaviours (Calderhead, 1981; Nespor, 1984b). The format of the interview process used in this study encouraged the researcher to question teachers further if their explanations of instances were incomplete or unclear. This process facilitated a joint construction of meaning between the researcher and the interviewee regarding situations specific to the lesson. The researcher and teacher were involved in a social event which lead to an understanding of a version of reality rather than an actual account of reality as it occurred retrospectively. Nespor argues that:

...viewing a tape of his or her classroom is viewing a different stimulus environment than the one they encountered in actually teaching the class...what the teacher sees at the end of the day on the videotape is an event about which the teacher possesses interpretive frameworks quite different from the ones he or she possessed as the class actually unfolded.

(Nespor, 1984b, p.28)
In addition, the videotape provides the teacher with a very different view of the class than that experienced during the lesson. The various camera positions provide the teacher with access to various stimuli that may have not been previously apparent during the lesson (Nespor, 1984b). This situation may lead teachers to alter their explanations of experiences as they happened during the lesson, to account for their subsequent observations of the lesson during the interview process. To limit this possibility, the interview protocol requested that teachers make a distinction between their thoughts as they occurred during the lesson and their thoughts about the lesson retrospectively as they viewed the videotape. Teachers were able to make this distinction, although, it is unclear to what extent this factor has influenced teacher responses. However, the videotape data do provide the researcher with an additional frame of reference regarding teacher responses.

In spite of the various concerns highlighted above, video-stimulated interviewing is argued to be a useful method with which to evaluate teachers: *in-flight thoughts and decisions* (Nespor, 1984a, p.120). The method provides teachers with a clear and concise picture of lesson activity and is a technique, when combined with other data collection methods that promotes a more complete understanding of classroom cognition and activity (Calderhead, 1981; Nespor, 1984a, 1984b). The interview technique used in this study provides complementary evidence for video-coding categories. That is, the linkage of student and teacher dialogue with video recordings, facilitates a more complete and accurate interpretation of technology classroom events and activities (Clarke, 1999).

The collection of interview data was subject to situation specific restrictions, in terms of class access before, during and after lessons. In addition, student interviews were restricted to around 15 minutes to allow several students’ participation. The length of teacher interviews for the two lessons averaged approximately 90 minutes which is in line with Nespor’s (1984b) study. Interviews with teachers and students were audio-taped for later transcription. This
ensured minimal loss of data. Teacher and student interviews were held as soon as practicable after the video-recorded lesson (Meade & McMeniman, 1992; Morine-Dershimer, 1983; Nespor, 1984a). In most cases, the interviews were conducted within one or two days in the same school week after the recorded lesson.

Before conducting each interview, the researcher provided a standard introduction to the video-stimulated recall interview process for both teachers and students (See Appendices 9 & 10 respectively). The interviews were structured similarly to Nespor’s (1984a) techniques and in recognition of Calderhead’s belief that despite some reservations the technique has the potential to: explore more fully the cognitive aspects of classroom behaviour, and perhaps to develop new insights into the nature of teaching (Calderhead, 1981, p.216). That is, through observation of actual classroom teaching and learning events, teachers have the opportunity to diagnose classroom activity retrospectively. Teachers have the opportunity through this process to verbalise their perceptions of classroom teaching and learning activity and the strategies used to support the activities.

The teacher interviewees were made aware that the interview process was to be informal. The informal nature of the interview process was considered important in recognition of the unusual nature of the task imposed upon the teacher interviewee (Nespor, 1984b). That is, the teachers were asked to view the video recording of their class and to comment on any teaching strategies they identified themselves as using. The teacher was instructed to stop the playback at these strategies and to respond to three questions:

1. How you describe the strategy?
2. Why you decided to use the strategy?
3. What effect do you believe the strategy has on student learning?

Strategy was used as a descriptor for teacher actions rather than tactics, in recognition of the widespread acceptance of strategy as a term for describing such teaching practices (Jonassen, Grabinger & Harris, 1990). When appropriate, the researcher sought clarification of teacher
explanations for the identified strategies. In addition, teachers were asked to advise the researcher of differences noted between their reasons for using particular strategies during the lesson and their reflective interpretations as they observed the video-recording. Teachers were encouraged to comment on any aspect of the lesson video footage that they felt was of interest to them. This was suggested in recognition of the novelty of the video-stimulated interview environment (Nespor, 1984b). When the teacher did not choose to stop the footage at classroom situations deemed to be of interest to the researcher, the researcher adopted a proactive role, stopped the footage and requested teacher comment. The researcher noted these points of interest in an observation sheet during filming of the technology lesson (See Appendix 1). At the conclusion of each interview, the teacher was asked to provide details of their teaching experience and an overall interpretation of their teaching role within the videotaped lesson. For example, teachers might consider themselves as a facilitator of student learning, while others might consider that they were in control as the master of a ship would be. The question was asked to gain knowledge of the teacher’s perception of his or her role within the video-recorded lesson.

The time taken for each teacher interview was close to two hours. The duration depended upon the length of the videotaped lesson and the extent of teacher comment. Several areas of repetitive classroom video footage, in terms of teacher and student activity (e.g. the teacher monitoring students as they engaged with their design and technology projects), were disregarded because of limitations in the amount of available teacher time and the probability that these segments would not yield useful data.

Student interviews were conducted informally, though with more researcher direction than were teacher interviews. Students were asked to comment on specific instances within the taped footage as identified by the researcher. The researcher previously noted these instances (i.e. the time within the footage) on an observation form (See Appendix 11). The time-slip function of the DVD player facilitated movement through the footage from identified point to
point with minimal time wastage. At these particular points in the lesson video-recording, students were asked to explain:

1. What they were thinking about during or immediately after that point in the lesson?
2. What they did as a result of teacher actions at that point in the lesson?
3. What they thought the teacher was trying to achieve at that point in the lesson?

In each case if further clarification was required, the students were asked to elaborate on their responses. As with teachers, students were encouraged to extend their comments beyond the above questions if they wished to do so. Each student interview took approximately fifteen minutes.

The interviews (teacher and students) were audio-recorded for later transcription. The audio recorder captured all sound (i.e. interviewee and interviewer comments, questions and responses and video footage audio) for the duration of the interview. This removed the necessity of logging teacher comments to particular times within the video footage. The links provided through the interview audio recordings allowed the researcher to correlate the teachers’ responses with the video for later interview transcriptions using Transana (The Board of Regents of the University of Wisconsin System, 1996-2003). Transana is a software program designed to enable the transcription and qualitative analysis of video and audio data. Similarly, the Transana program allowed each series of student responses to be linked to the same video as was the teacher’s responses (See Section 4.4.4 for details).

4.3.2.3 Researcher Observation
During Study 2-Phase 2, data were collected via direct researcher observations of technology classroom activities. The researcher was able to employ the identical coding system used during analysis of the video-data collected in Study 1-Phase 2 (See Section 4.4.2 for details). The codes, which define classroom activities in terms of teacher and student actions and interactions, were tabulated to record classroom events that occurred for every one-minute period during the observed lesson (See Appendix 16).
4.4 Data Analysis

4.4.1 Quantitative Data: Cognitive Holding Power Questionnaire (CHPQ)

Study 1 and Study 2 examined and measured quantitatively the perceptions of technology students, using the Cognitive Holding Power Questionnaire (CHPQ) (Stevenson, 1986a; Stevenson, 1998; Stevenson & Evans, 1994) (See Section 4.3.1.1). These student perceptions are considered to be individual assessments of a group behaviour setting (Barker, 1968) (total class) experience over many lessons (Fraser, 1991). Fraser argues that, student perceptual measures can be: ...found to account for considerably more variance in student learning outcomes [more so than] ... directly observed variables (Fraser, 1991, p.4). Individual student perceptions are therefore considered the units of analysis for this component of the study. However, student perceptions are subsequently aggregated to describe the overall characteristics of each individual classroom learning environment (Babbie, 1998) in terms of the press for different levels of procedural knowledge (i.e. FOCHP and SOCHP) (Stevenson, 1998).

The student responses to the CHPQ were tabulated and recorded as class group, pre-test, post-test and gender categories using SPSS Ver 11.0 (2001). Means and standard deviations of student responses for FOCHP and SOCHP were analysed with reference to each data category. For Study 1-Phases 1 and 3, and Study 2-Phase 1, a principal component analysis with Varimax rotation, and Cronbach’s Alpha reliability scores (Bryman & Cramer, 1997; Field, 2000; Morgan & Griego, 1998) for the tested variables were used to ascertain the reliability of the two scales FOCHP and SOCHP and the validity of the CHPQ construct. In addition, a Shapiro-Wilk Test of Normality (Field, 2000; Morgan & Griego, 1998) was conducted for each data category to ascertain the distribution of responses for FOCHP and SOCHP within Study 1 and Study 2.

The Study 1-Phase 1, Study 1- Phase 3 and Study 2-Phase 1 FOCHP and SOCHP means were analysed using a single factor analysis of variance F – test (One-Way ANOVA). Levene’s
statistic was used to indicate the homogeneity of variances between groups. In addition, Gabriel’s pairwise post hoc comparisons were used to establish the significance of between-category responses (Bryman & Cramer, 1997; Field, 2000; Morgan & Griego, 1998). The Gabriel’s pairwise post hoc test was selected to utilise its statistical power and ability to cope with unequal group sizes (Field, 2000, 2005). As the class group sizes were slightly unequal in this study, this test was chosen in preference to other post hoc comparisons that are less robust in their ability to restrict the likelihood of a type I error (i.e. inferring a result when in fact no true relationship exists between the independent and dependent variables) or type II error (i.e. inferring no result when in fact a true relationship exists between the independent and dependent variables) under these conditions (Crano & Brewer, 2002; Field, 2000, 2005). That is, as the numbers of students in each technology education class varied slightly in this study, Gabriel post hoc comparisons were used to restrict the possibility of inferring an incorrect relationship between the variables under examination (i.e. FOCHP, SOCHP, technology education class, gender). Field argues that: *If sample sizes are slightly different then use Gabriel’ procedure because it has great power, but if sample sizes are very different use Hochberg’s GT2* (Field, 2005, p. 341). Therefore, Hochberg’s GT2 post hoc tests were also conducted to provide additional verification of the Gabriel’s post hoc results because of the slight variation in class sizes (Field, 2005). In all cases, Hochberg’s GT2 tests confirmed the accuracy of the Gabriel’s pairwise tests results.

The mortality (Bernard, 2000) of responses to the questionnaire precluded the possibility of a repeated measures analysis for each of the 29 technology classes within Study 1. While this mortality influence is minimal in regards to the aggregate mean response for FOCHP and SOCHP for each class, it does make a repeated measures form of analysis untenable (Bernard, 2000). The post hoc comparisons of the class means for FOCHP and SOCHP were used to identify and subsequently select classes that were significantly different from other classes in terms of the technology education classroom press for FOCHP and SOCHP.
Keselman et al (1998) argue that educational research most frequently employs the data-analytic technique of ANOVA $F$-test in the testing of mean equality in between-subjects univariate designs. Additionally, Keselman et al, (1998) state that care must be taken to ensure that the underlying assumptions of the test are not violated (i.e. that the data are normally distributed, that the variances are homogeneous, and that the group sizes are equal). This study addresses these concerns by testing for distribution of responses and homogeneity of variance, and by maintaining equal group sizes (as far as possible) in order to restrict the possibility of a Type 1 error (Crano & Brewer, 2002).

In addition, the thesis examines the construct validity and reliability of the CHPQ by conducting a Principle Component Analysis with Varimax Rotation and Cronhach’s Alpha Reliability tests for the factors of FOCHP and SOCHP throughout all quantitative phases (i.e. CHPQ) of Study 1 and Study 2. The inherent strength of the quantitative component of these studies is the construct validity of the CHPQ and reliability of the two scales of FOCHP and SOCHP as confirmed through this and previous studies (See Section 4.3.1.1 for details).

4.4.2 Video Data: Study 1-Phase 2
The classroom activities and interactions of teachers and students in selected Australian technology education classrooms were recorded as detailed in Section 4.3.2.1. The video-data were analysed in line with the method employed by Stevenson and McKavanagh (1994). Stevenson and McKavanagh developed a coding system to analyse the activities and cognitive interactions of teachers and students within Colleges of Technical and Further Education (TAFE) learning settings. Stevenson and McKavanagh’s coding system allows for analysis of the foreground activities (teacher participation) of the learning setting. The current coding system has been expanded to include a system for coding background activities (i.e. student independent of the teacher learning activity). Each code letter represents a minor code description and is contained within one of five major code categories; 1) Teaching / Learning
Technique; 2) Initiation; 3) Group Size; 4) Resources used to Aid Instruction or Learning; 5) Cognitive Activity.

Modifications were made to the original schedule designed by Stevenson and McKavanagh (1994) because of the specific nature of the technology education learning environments being examined in this study. The study required the incorporation of background as well as foreground technology classroom activities within the data analysis. This was required in order to identify self-directed autonomous learning experiences argued to support student higher-order thinking (Perkins, 1993; Resnick, 1987) (See Section 2.4 for details). Background activities are those that include any student learning activities that occur outside the direct influence of the teacher (i.e. in the background). Foreground activities are those that include the direct influence and attentions of the class teacher (i.e. in the foreground).

Table 4.7 below displays the five major coding categories and the minor sub-categories for each code letter. One code letter from within each major code category forms a five-part description of the activity that takes place within the learning environment in the foreground and background for every one-minute period.
### Table 4.7

#### Video Code Letter Descriptions

<table>
<thead>
<tr>
<th>Code</th>
<th>Code Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teaching Learning Technique</strong></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Students doing as instructed by the teacher as a group (i.e. taking out projects and tools at the start of a lesson or packing up at the conclusion).</td>
</tr>
<tr>
<td>N</td>
<td>Foreground: Pause or no instruction by the teacher for 40 seconds or more.</td>
</tr>
<tr>
<td>N</td>
<td>Background: Students are working independently on individual or group projects without direct instruction from the teacher (i.e. experiential learning on project or experimentally based work).</td>
</tr>
<tr>
<td>P</td>
<td>Presenting verbally or presenting by demonstration. Student or teacher providing information or demonstrating procedures.</td>
</tr>
<tr>
<td>E</td>
<td>Eliciting a verbal response or eliciting an action from others.</td>
</tr>
</tbody>
</table>

**Initiation**

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Interaction with students initiated by the Teacher or Lecturer.</td>
</tr>
<tr>
<td>S</td>
<td>Student(s) initiate interaction with the teacher or other students.</td>
</tr>
<tr>
<td>R</td>
<td>Background: Student action initiated by a resource, such as 1) written instructions on the board, in a manual, or an exercise sheet, 2) student projects and equipment.</td>
</tr>
</tbody>
</table>

**Group Size**

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>The whole class (everybody).</td>
</tr>
<tr>
<td>F</td>
<td>Foreground: The teacher and more than one student, but fewer than the whole class (i.e. a few students)</td>
</tr>
<tr>
<td>F</td>
<td>Background: A group of students, but fewer than the whole class (i.e. more than one student, a few students)</td>
</tr>
<tr>
<td>O</td>
<td>Foreground: A student working on their own with the teacher.</td>
</tr>
<tr>
<td>O</td>
<td>Background: A student working on his or her own.</td>
</tr>
</tbody>
</table>

**Resources used to aid instruction or learning**

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>Written verbal materials in use (e.g. words on the board, in a text, on a work sheet, student or teacher-produced notes, tables of words etc.).</td>
</tr>
<tr>
<td>I</td>
<td>Image in use (e.g. student or teacher sketches, pictures, diagrams etc.).</td>
</tr>
<tr>
<td>C</td>
<td>Real or concrete objects in use (e.g. student projects, materials, tools and equipment and any other object).</td>
</tr>
</tbody>
</table>

**Cognitive Activity**

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>Using propositional knowledge or knowledge that (e.g. information, knowledge about things, experiences, facts or concepts).</td>
</tr>
<tr>
<td>A</td>
<td>Using knowledge about how to perform a skill, without actually doing it (i.e. not showing or being shown how, but being told how or telling others how).</td>
</tr>
<tr>
<td>Y</td>
<td>Watching demonstrations of or performing a specific skill (first order procedure); receiving techniques from others rather than deducing it for oneself; performing a known action (e.g. copying, performing a specific technique, method or algorithm).</td>
</tr>
<tr>
<td>G</td>
<td>Using a higher-order procedure (e.g. students working out a strategy or procedure for performing an action or solving a problem for themselves).</td>
</tr>
<tr>
<td>M</td>
<td>Teacher monitoring, checking and correcting results, techniques and approaches of students (e.g. providing answers, hints, cues, suggestions, focus).</td>
</tr>
</tbody>
</table>

**Notes**

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>X signifies no entry from a category (i.e. no corresponding action has taken place) e.g. NXXXX indicates that: no instruction has occurred in the lesson foreground e.g. PSFXT indicates that: A student presents information without the use of a resource to a group of peers.</td>
</tr>
</tbody>
</table>

The code contains 5 categories 1. Teaching learning technique; 2. Initiation; 3. Group size; 4. Resource; 5. Cognitive activity. However each code may contain more than one resource signifier. Codes with more than one signifier for Cognitive activity are shown as Y/G and indicate an activity where a student is using a hint or cue from a teacher in order to solve a higher-order problem for themselves.

(Adapted from Stevenson & Mckavanagh, 1994, p.179)
However, the code letters from within the ‘resources used to aid instruction or learning’ and cognitive activity’ categories were at times used more than once within code letter descriptions. This occurred because either the students or the teacher was engaging or engaged with more than one resource, or using more than one form of cognitive activity, and as such this was reflected in the code description. In such cases, the code letter descriptions became longer in length to record accurately the resources in use at that time.

Additionally, the cognitive activity code became one of two-parts. For example, a student may have been using a hint or cue provided by a teacher to solve a higher-order problem alone. In this case, the activity would have been signified by the combined code Y/G. This method of combined codes was deemed a more accurate description of these types of classroom activities. These descriptions were recorded for every one-minute period throughout the lesson and described activity in both the background and foreground as it occurred simultaneously.

Stevenson and McKavanagh argue that one-minute intervals: reflect the range of discrete instructional events and the range of cognitive structures being developed in actual classes (Stevenson & McKavanagh, 1994, p.178). If more than one interaction occurred in the foreground during a minute period, the activity coded represented that which was dominant (i.e. the activity that took place for more than 50% of the coded minute). In addition, the activity coded in the background represented the majority of student learning activity (i.e. the code reflected the activities of more than 50% of the students).

The teaching / learning technique category contains code letters that indicate activity in the foreground and background. Foreground activity indicates the teaching strategies and tactics in use and the methods students are employing in their direct interactions with the teacher. For example, the teacher or students may be presenting (P) information verbally or through demonstrations when in direct consultation with each other. The teacher or students may be
eliciting (E) a verbal response or an action from each other, or there may be no (N) activity in the foreground for more than 40 seconds. In the background, students may be working independently or in groups (N) while engaged with their technological learning activities. In the background, students also work independently while using teacher instructed activity. That is, the students may be doing (D) as instructed by the teacher, though without any direct contact with the teacher during the activity. Typical examples of this activity occur when students unpack their projects from cupboards (i.e. prepare for the lesson), or replace their projects, and clean up the classroom before lesson closure (i.e. pack up). Students engage with this activity independently, yet in a manner that has been prearranged to comply with teacher expectations. As this type of activity was prevalent within the technology classes under examination in this study, a particular code (D) was incorporated in the analysis to allow its direct representation.

The initiation category describes whether the teacher or lecturer (L), student or students (S) initiate the interaction in the foreground or whether a resource (R) initiates the interaction with a student or students in the background. For example, the teacher may ask a student or students to indicate their understanding of a technological principle by demonstrating a procedure or presenting their knowledge of the topic to the teacher and or other students. Likewise, a student may ask the teacher or another student a question that initiates, for example, an explanation or demonstration of a technological concept. In addition, students may engage with their technological projects independently or in groups in the background. Problems inherent in these types of technology projects create situations where student actions are initiated in relation to investigations of possible solutions. This category (R) recognises the importance of hands-on learning in technology education and the interaction between goal (project) and student or students.

The group size category describes the number of students involved in the activity in either the foreground or background. In the foreground, the teacher or student might be engaged with the
whole class (V). This situation typically occurs in technology education classes when the teacher decides that a particular piece of information should be shared with everybody. This situation eventuates because of the information’s perceived importance and relevance to every student’s understanding of the underlying technological concepts related to their activities. Occasions arise when the teacher may interact with one student (O) or with a few students (F) (i.e. more than one student but less than the whole class) during the normal course of events occurring within the foreground of the lesson. Similarly, in the background of the lesson, students may be working on their own (O) or with a few students (F) while engaged with their technological activity independent of the teacher.

The resources category describes what resources are being used within the learning environment to facilitate teaching and learning. Within both the background and foreground of any technology education lesson, there is a potential for resources such as written verbal materials (W), images (I), and real or concrete objects (C) to be in use.

The cognitive activity category describes the types of thought processes the teacher intends and the students appear to use during their foreground and background classroom activities. The teacher or students may use propositional knowledge (T) or knowledge about things related to the underlying technological concepts of student learning experiences. The teacher or students may tell others how to perform a skill (A), in order to assist others during their technological activity. The teacher or students may watch demonstrations of specific skills’ (Y) in order for the students to repeat or copy these skills during subsequent lesson experiences. This form of cognitive activity may lead to learning activities where students display known processes that have been previously shown to them, rather than students working out processes for themselves. Students and the teacher may be involved in activity that supports their use of higher-order procedures (G). For example, students might be engaged in attempting to solve technological problems in the background of the lesson. Alternatively, the teacher might be attempting to solve a problem in the foreground that has
proven too complex for a student or students. The teacher may model his or her thought processes for the student or students, or the teacher may provide cues or hints that facilitate the student or students solving the problem for themselves (i.e. scaffolding). The teacher might choose to monitor (M) student activity. This monitoring results in the students moving from the background to the foreground of the lesson as the teacher interacts with them, as either individuals or groups of students. Teacher monitoring activity may provide support for any of the aforementioned cognitive activities experienced by students within the technology education lesson.

Codes developed from video observations of foreground or background one minute periods, which do not incorporate activities from any one of the five major categories were replaced with an X rating. For example, the teacher might leave the class momentarily to find equipment for a student. The next few minutes of classroom foreground activity would be coded as NXXXX to signify that no instruction or any other activity has occurred during the teacher’s absence. Additionally, when the whole class is involved in foreground learning activities only (e.g. the teacher presenting propositional knowledge to the whole class about real objects; code = PLVCT), there is an accompanying lack of activity in the background and is therefore coded as NO/BG (i.e. no background). Each of the two videotaped lessons was coded using this system. The code was entered into a spreadsheet within the Transana video analysis program (The Board of Regents of the University of Wisconsin System, 1996-2003) and time coded to link each minute of the foreground and background code directly to the video footage. Table 4.8 below provides an excerpt from an example (See Appendix 12 for the complete example) of the coding tabulation used in this study.
Table 4.8
Excerpt from an Example of the Technology Education Lesson Coding Table

<table>
<thead>
<tr>
<th>TIME</th>
<th>FG/CODE</th>
<th>FG/DESCRIPTION</th>
<th>BG/CODE</th>
<th>BG/DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.30-3.40</td>
<td>PLVXT</td>
<td>T introducing lesson to S' outside class</td>
<td>NO / BG</td>
<td></td>
</tr>
<tr>
<td>3.40-4.40</td>
<td>PLVXT</td>
<td>T introducing lesson to S' inside class around front bench</td>
<td>NO / BG</td>
<td></td>
</tr>
<tr>
<td>4.40-5.40</td>
<td>ELVCA</td>
<td>T using demo object questioning S' about processes</td>
<td>NO / BG</td>
<td></td>
</tr>
<tr>
<td>5.40-6.40</td>
<td>ELVCA</td>
<td>T using demo object questioning S' about processes</td>
<td>NO / BG</td>
<td></td>
</tr>
<tr>
<td>6.40-7.40</td>
<td>ELVCA</td>
<td>T using demo object questioning S' about processes</td>
<td>NO / BG</td>
<td></td>
</tr>
<tr>
<td>10.40-11.40</td>
<td>PLOCA</td>
<td>T showing how to do a process to S</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
<tr>
<td>11.40-12.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
</tbody>
</table>

Each distinct coded activity was subsequently tabulated and displayed showing the number of minutes during the lesson each set of codes was used. Table 4.9 provides an excerpt from an example table (See Chapters 5 and 6 for selected class coding tables) that displays the number of minutes each code activity occurred during the lesson. The master codes and corresponding code descriptions are provided in Appendix 14.

Table 4.9
Excerpt from an Example Code and Code Descriptions Table

<table>
<thead>
<tr>
<th>CLASS: 12</th>
<th>LESSON: 1</th>
<th>DATE: 19/08/03</th>
<th>“FOREGROUND”</th>
</tr>
</thead>
<tbody>
<tr>
<td>CODE</td>
<td>CLASS TIME</td>
<td>CODE DESCRIPTION</td>
<td></td>
</tr>
<tr>
<td>PLVXT</td>
<td>2 min</td>
<td>The teacher presents information to the whole class using knowledge about things.</td>
<td></td>
</tr>
<tr>
<td>PLOCA</td>
<td>1 min</td>
<td>The teacher providing information about how to perform a skill using real objects to a student.</td>
<td></td>
</tr>
<tr>
<td>PLOCM</td>
<td>23 min</td>
<td>The teacher demonstrates procedures for a single student using a real object while monitoring of performance and progress.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLASS: 12</th>
<th>LESSON: 1</th>
<th>DATE: 19/08/03</th>
<th>“BACKGROUND”</th>
</tr>
</thead>
<tbody>
<tr>
<td>CODE</td>
<td>CLASS TIME</td>
<td>CODE DESCRIPTION</td>
<td></td>
</tr>
<tr>
<td>NO / BG</td>
<td>12 min</td>
<td>No background activity.</td>
<td></td>
</tr>
<tr>
<td>NROCY</td>
<td>30 min</td>
<td>Students working independent of the teacher on their own using known procedures in response to the specific requirements of a real object (project).</td>
<td></td>
</tr>
</tbody>
</table>
4.4.3 Classroom observations: Study 2-Phase 2
The same coding system was used to record the activities of the teacher and students in the foreground and background of each of the observed American technology lessons in a tabulated format (Observation Checklist: See Appendix 16). The data, collected during researcher observations were analysed in the same manner as the video data for Study 1-phase 2 (See Section 4.4.2 for details).

To support inter-coder reliability, discussions were held between the researcher and the American research assistant. These discussions focused on the meanings and interpretations of the coding system used in this study. Because the Australian study (i.e. Study 1) used video-recordings of technology classes during the coding process, this allowed the researcher to replay sections of the footage to verify coding categories. In the American study (i.e. Study 2) technology classrooms were observed in situ with no post hoc opportunity to verify decisions made regarding the coding categories. Regardless of this variation between studies, every attempt has been made to ensure a consistent interpretation and use of the code categories during the coding of technology classroom activity in Australia and America. Additionally, this thesis does not seek to make direct comparison of results obtained from technology classes from Studies 1 and 2, given that some differences in coding interpretation may have occurred.

4.4.4 Interview Data
4.4.4.1 Introduction
The data collected from video-stimulated interviews during Study 1-Phase 2 were analysed using two methods. Each of these methods is detailed in the following sections. Section 4.4.4.2 provides the details of the researcher (manual) analysis of the interview data using researcher-generated code categories that emerged from the data. Section 4.4.4.3 provides details of the automated text analysis capacity of Leximancer (Smith, 2006) to find and link important concepts from within the interview data. The use of these two methods is important
because each supports and thus strengthens the other. Additionally, the use of several methods of data analysis acknowledges the importance of the interview data in the context of this study. That is, because the interview data links actual teaching and learning activity in technology education classrooms with teachers’ and students’ thoughts and feelings, it is important that the data are interpreted from several perspectives. This examination helps to further explain the results of the CHPQ in assessing why technology education classrooms press students to use higher-order (SOCHP) and lower-order (FOCHP) thinking.

4.4.4.2 Researcher (Manual) Data Analysis

The audio recordings were transcribed into Transana (The Board of Regents of the University of Wisconsin System, 1995-2003) to facilitate the analysis of the video and audio data. The video-stimulated interview data were linked to the video footage (MPEG format) by a process of time-coding. The time-codes were imbedded into the transcript to link teacher comments, relating to particular teaching strategies or tactics, with the corresponding episode within the video-recording.

Transana incorporates a facility for key-word searches of the transcribed data and can isolate sections of the video into meaningful groups based on these key-words. The key-words can be increasingly refined to allow for the generation of units of meaning as they evolve from an interpretation of the interview data (Cohen, Manion & Morrison, 2000; Moallem, 1998).

These key-words form codes (categories) that were used to reduced the data into meaningful portions, which were used to analyse similar episodes from within different interview transcripts (Moallem, 1998). Redundant codes were dropped as the raw data became incorporated within other more representative codes formulated specifically for the purpose. The aim of this process was to refine codes and sub-codes until accurate descriptions of technology education teaching and learning activities were evident across the various sets of interviews (Cohen, et al, 2000). This process is defined as being a system of constant
comparison (Moallem, 1998; Cohen, et al, 2000), and was used to identify, compare and refine data categories as they emerge from the data (Moallem, 1998). The code categories were linked to activity system components (Jonassen, 2000) to provide a theoretical framework that can be used to describe technology classroom activity. The frameworks are used to provide a conceptual link between technology education classroom activities and the press of the learning environments for different types of student thinking (i.e. FOCHP & SOCHP).

The current study followed the interview data-analysis technique used in Moallem’s (1998) study of an expert teacher’s thinking and instructional design. Moallem allowed categories to emerge from the data and sought to define the links between categories and subcategories in an effort to discover: core categories which became guides to further data collection and analysis (Moallem, 1998, p. 43). In addition, codes were compared between different sources of data in order to seek their continual refinement. This process produced a representative set of themes that bound together the different components of Moallem’s (1998) study.

Data (transcriptions) provided through the teacher video-stimulated interviews were scrutinised for similar themes. This process revealed eleven themes emerging from within the data. These themes are indicative of each teacher’s interpretation of the activities that emerged from within their respective technology lesson. The themes are provided in Table 4.10 below and are listed under headings that segregate each theme into an activity theory component (i.e. tools, subjects, rules & division of labour) (Jonassen, 2000). Each theme is significant in terms of interpreting the teacher’s strategies and tactics used within each lesson. Student interviews allowed the researcher to confirm the teacher’s interpretation of the learning outcomes from the student’s perspective.

The division of labour theme provides an indication of the types of collective activity that occurs within the technology education classroom setting. The tools theme provides an indication of the instructional emphasise of the teacher and of the types of intermediate and
micro-level strategies selected to engage students with the object of the activity system. The subjects theme provides the basis for interpreting the characteristics of the students and their actions in pursuit of personally important goals. The rules theme supports an interpretation of the setting program by providing insight into the object of the activity from the teacher’s perspective. This would seem to be important given that activity theory argues that individual actions and collective activity derive their meaning only when interpreted in the context of the object of the activity system (See Section 2.6 for details).

Table 4.10
Video-Stimulated Interview Themes
Segregated into Activity Theory Components

<table>
<thead>
<tr>
<th>TOOLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FT- Focusing techniques (how the teacher focuses students to engage with their learning activities)</td>
</tr>
<tr>
<td>TM- Teacher Modelling (problem-solving, skills, attitudes etc.)</td>
</tr>
<tr>
<td>TLRW- Teacher linking the project or activity with the real world (reflected in the goals of the activity i.e. skills development, thinking skills or conceptual development)</td>
</tr>
<tr>
<td>TF- Teacher facilitator (monitoring, cueing, hinting, providing answers –showing or telling)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SUBJECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLA- Student learning attitudes (linked to student ability, motivation, and enjoyment)</td>
</tr>
<tr>
<td>ISLN- Individual student’s learning needs (knowing the students and how they learn best , building rapport with the students)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RULES</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBASL- Teacher’s beliefs about students and learning</td>
</tr>
<tr>
<td>TP- Teacher’s philosophy about the purpose of the learning activity (why should students be involved in this activity, what is the ultimate goal, purpose or outcome of the activity)</td>
</tr>
<tr>
<td>CD- Classroom discipline (keeping students on task, how is class discipline maintained)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DIVISION OF LABOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>R- Responsibility for learning (is the teacher or the student responsible for the learning outcomes)</td>
</tr>
<tr>
<td>TSI- Teacher student interaction (the teacher interacting with individuals, with groups of students or with the whole class)</td>
</tr>
</tbody>
</table>

In this study of technology learning environments, the researcher summarised each set of video-stimulated interviews (i.e. one teacher and three students) to provide a description of the rationale behind each teacher’s technology lesson and the teaching strategies and tactics employed in the facilitation of lesson activities.
4.4.4.3 Leximancer (Automated) Data Analysis

Leximancer (Smith, 2006) is an automated text analysis program designed to identify and establish the strength of relationships between concepts from within large amounts of textual data. Smith and Humphries state that:

*The system [i.e. Leximancer] goes beyond keyword searching by discovering and extracting thesaurus-based concepts from the text data, with no requirement for a prior dictionary, although one can be used if desired. These concepts are then coded into the text, using the thesaurus as a classifier. The resulting asymmetric concept co-occurrence information is then used to generate a concept map.*

(Smith & Humphries, 2006, p.262)

The raw data were first entered into the Leximancer program as one of a number of text file types (e.g. .doc, .txt, .pdf) and an initial analysis was performed. The initial analysis identified and ranked frequently used terms to establish a list of concepts that was representative of the interview data. Subsequent analysis scanned the data to establish relationships and the strength of relationships between concepts. Leximancer does this by analysing a portion or window of textual data: *at a high resolution* (i.e. usually 3 sentences) (Smith & Humphries, 2006, p.262).

Concepts automatically selected by Leximancer can be refined, merged, selected or discarded by the researcher. For example, in the case of Study 1-Phase 2, concepts such as think, thinking and thought were merged to become the one concept of think, and girls, boys, guys, student and students were merged to become the one concept of students. In this way, the researcher was able to refine the output of the program to represent the concepts as interpreted by different teacher and student interviewees, more accurately.

Leximancer produces several outputs for data analysis (See Section 5.5.4). A ranked list of concepts is provided which displays the frequency of the different concepts within the textual data and the relative frequency of the concepts compared as a percentage of the concept most frequently used. Leximancer interprets the strength of concept relationships by identifying and
selecting text that signifies these relationships. For example, Leximancer supplies a list of all the textual data (i.e. interview transcriptions) that signifies a relationship between co-occurring concepts, such as teaching and thinking or students and thinking (See Figure 4.5 below for an example Leximancer text extract). This is important because it allows the researcher to revisit the raw data to contextualise the Leximancer results.

| Class 52 TchL2.doc~1.html#S1_29 | Hopefully that allows them to think that it is more real and they can well okay I have got a job to do and just do it. Hopefully to the benefit of the rest of the students. | Concepts: think AND students |

As a final phase of analysis, Leximancer produces a concept map which supports a visual interpretation of concept relationships from within the data. Within the concept map, concepts are located to establish the strength of their inter-relationships. That is, concepts that are located close together are strongly related and those located further apart are less related. Concepts are also clustered into themes that identify closely related concepts under stronger parent concepts. In the concept map, these parent concepts or schematic circles represent themes of closely related concepts. In this way, Leximancer enables the researcher to view important concepts and the relationship between and across these concepts. The Leximancer program has the facility for the researcher to adjust the number of concepts and themes displayed within the concept map. Additionally, the researcher can rotate the concept map to improve the interpretability of the range of concept relationships within the map. Figure 4.6 provides an example of a Leximancer generated concept map (Galea, & Loosemore, 2006).
Smith & Humphries state that a: *major goal of the Leximancer system is to make the analyst aware of the global context and significance of concepts and to help avoid fixation on particular anecdotal evidence, which may be atypical or erroneous* (Smith & Humphries, 2006, p.262). Therefore, by combining manual and automated Leximancer text analysis methods, the study was able to interpret the video-stimulated interview data from two complementary perspectives as a means to strengthening the validity of the analysis. Validation of the Leximancer text analysis program has been published (Smith and Humphries, 2006).
4.5 Strengths and Limitations of the Research Design

4.5.1 Strengths

The following paragraphs outline the strengths of the research design of this study. These strengths include the size of the sample population, conduct of the study in two countries, the method used to select participants, and the quantitative and qualitative research methods combined to support an understanding of the technology education classroom activities that promote students’ use of higher-order thinking.

In this study, 1235 students have been surveyed using the CHPQ (within Study 1-Phases 1 & 3 and Study 2-Phase 1) regarding the level of press of their technology education classrooms for the use of first-order procedures (FOCHP) and second-order procedures (SOCHP). The size of this sample is comparable with previous research that has used the CHPQ and has been large enough to validate the responses to the questionnaire in this study. In addition, the sample includes students surveyed at different times within the school year (i.e. Study 1-Phases 1 & 3). This supports an understanding of how student thinking develops as the school year progresses.

The purposive sampling method used to select schools in Australia and America is a strength of the research design as it provided a sample of technology education classrooms that were comparable in important ways. That is, these classrooms involved students in a technology education curriculum that was based on technological problem-solving incorporating hands-on learning activity using various materials, processes and systems. Additionally, students were selected who were relative novices to technology education (i.e. year nine students in Australia and Fundamentals of Technology students in America). Therefore, given that the curriculum content and student populations across classes were comparable, different results for FOCHP and SOCHP (i.e. CHPQ surveys) provided opportunities for understanding why these differences had occurred through qualitative investigation of technology education classes.
Combining quantitative and qualitative research methods gave strength to this study because it allowed the researcher to:

1. Access the perceptions of a large number of students regarding the press of their technology education classrooms for higher and lower-order thinking (quantitative) and therefore identify technology education classrooms with particular characteristics.

2. Identify factors that appeared to influence technology education students to think in different ways (qualitative) by examining the complex characteristics of particular technology education classrooms.

That is, the CHPQ was used to interpret the types of thinking students were pressed to use within the technology education classroom. Subsequent case studies of selected classes [video, video-stimulated interviews (Study 1) and researcher observations (Study 2)] assisted in identifying the factors that appeared to influence the press for student higher and lower-order thinking. In this way, the study combined quantitative and qualitative research methods within a complementary framework to isolate technology education classrooms with certain characteristics in order to gather rich data to support an interpretation of why such characteristics existed. Additionally, the interpretations were validated across classes in two different countries (See Section 4.1.1 for further details).

The Cognitive Holding Power Questionnaire provided strength to this study because of its established validity and reliability in interpreting student perceptions of classrooms that press for first and second-order cognitive holding power (FOCHP & SOCHP). A number of previous studies (e.g. Stevenson & Evans, 1994; Stevenson, McKavanagh & Evans, 1994; Stevenson, 1998; Walmsley, 2001; Xin, 2008; Xin & Zhang, 2009) have provided evidence of the construct validity of the two scales of FOCHP and SOCHP and of the reliability of the CHPQ to provide consistent results across educational settings within different countries (See Section 4.3.1.1 for details).
Use of video (Study 1-Phase 2) and direct researcher observations (Study 2-Phase 2) of technology education teaching and learning activities strengthened this study because of the rich nature of the data collected through these techniques. The value of these data was twofold. Firstly, it enabled analysis of teacher and student actions and interactions within the foreground and background of the observed technology education lesson (i.e. Study 1-Phase 2 & Study 2-Phase 2). Secondly, the video recordings supported the video-stimulated interview process (i.e. Study 1-Phase 2 only). In the case of Study 1-Phase 2, the video-recordings were a snapshot and a permanent record of the teaching and learning activities of these classes. This footage was able to be revisited to examine teaching and learning within these technology education classrooms from different perspectives. (See Sections 4.3.2.1 & 4.3.2.3 for further details).

The video-stimulated recall interview technique gave strength to this study because of its ability to provide a rich source of data regarding teaching and learning activities. In the case of Study 1-Phase 2, both teachers and students interpreted these activities. In addition, the semi-structured nature of the interview protocol allowed for teacher and student input and a comprehensive set of explanations for the use of teaching strategies and their effect on student learning within the lessons (See Section 4.3.2.2 for further details).

The analysis of qualitative data has centred on interpreting and understanding the range of actions and interactions that occurred between teachers and students within selected technology education classrooms in Australia and America. The video-data analyses, video-stimulated interview data analyses and researcher observation data analyses were supported by knowledge of similar analyses used in previous studies. Therefore, the strength of the qualitative data analyses used in this study, stemmed from the experiences of prior research and were further supported by the results of the study reported in this thesis.
The theoretical support for this study is drawn from literature in relation to cognitive theory, behaviour setting theory and activity theory. On this basis, higher-order thinking is conceptualised, in terms of an interrelationship between individual cognition, the behaviour setting and activity (See Section 3.4). As argued earlier, the CHPQ survey of technology education classes was a valid instrument with which to measure the press of the learning environment for different types of student thinking (i.e. cognition / higher-order thinking - SOCHP & lower-order thinking-FOCHP), and the qualitative methods of enquiry used in this study provided a valid assessment of the differences between technology education classes, in terms of the activities of teachers and students (behaviour setting & activity). Therefore, it is argued that the confluence of quantitative and qualitative methods of enquiry used in this study provided a valid measure and interpretation of the technology learning environments under investigation, in terms of the theory examined (i.e. Chapters 2 & 3).

In addition, it is argued that the study is reliable in its assessment of the technology education classes under investigation. The reliability of this study is generated by engaging reliable research methodologies used in prior research studies. In this way, this study draws reliability from, and adds reliability to, the methods of enquiry employed in previous learning environment research.

4.5.2 Limitations
The following paragraphs outline the limitations of the research design of this study. These limitations include aspects of the video-stimulated interview technique and of the video and researcher observation methods employed in this study.

The video-stimulated recall interview process is unusual for teachers and can be confronting (See Section 4.3.2.2 for details). Therefore, teachers may be inclined to interpret classroom activities retrospectively, rather than giving explanations for events as they occurred. In recognition of this situation, the interview protocol required teachers to identify when
comments reflected their thoughts during the lesson or their interpretations of events while watching the lesson video recording. Additionally, the interview process was used to build a version of reality constructed by the interviewer and interviewee while observing the recorded lesson. However, despite the limitations, the interviews stimulated by video footage supported an interpretation of technology education classroom teaching and learning activity (See Section 4.3.2.2 for further details). The problem was reduced by triangulating results with those drawn from direct observation and videos of classroom interactions.

Video and direct researcher observations potentially alter the normal operation of a classroom. That is, the video observations required the setting of equipment at various locations throughout the classroom. In this study operators were involved in using the equipment to observe teacher and student activity. After an initial, but short period of becoming accustomed to the variation, most teachers and students simply ignored the equipment and conducted classroom business as close to normal as could be expected. Most teachers considered that the students reacted well to the inclusion of the equipment in the classroom. While it is acknowledged that some change in normal classroom activity is inevitable because of this process, the classroom observations appeared to have minimal impact. Given that Study 1-Phase 2 video recording of classroom activity experienced minimal impact on normal classroom activity, it is considered reasonable to assume that researcher direct observation using an activity checklist (Study 2-Phase 2) did likewise.

4.6 Conclusion
It is argued in this thesis that to analyse the environmental factors that may influence technology education students to think in particular ways requires a combination of both quantitative and qualitative methods of enquiry. Study 1 integrated quantitative and qualitative methods of investigation through three interconnected and mutually supported phases in Australia. Study 2 provided quantitative and qualitative data from two interconnected and mutually supported phases within America. The research design addresses the complexities of
technology education learning environments through the combination of these methods and phases. The studies measured technology education classes using the CHPQ to ascertain the press of the learning environments for different types of student thinking (i.e. FOCHP & SOCHP). The studies subsequently observed and analysed the teaching practices of technology educators in significant technology education classes (i.e. significant in terms of FOCHP and/or SOCHP) from within both Australia (Queensland) and America (North Carolina). The case study observations of technology education classes aimed to identify teacher and student actions and interactions that supported students’ use of high-order and lower-order thinking in technology education classrooms.

The study is limited by factors that constrain all educational research, for example, institutional constraints (e.g. researcher access, time limits), resource constraints (e.g. limited equipment, staff, funds) and ethical constraints (e.g. informed consent) (Krathwohl, 1993). However, within these limits this research project has maintained an approach, which identifies and reduces the threats to both internal and external validity. The inherent strength of this research stems from the validity of the CHPQ and the reliability of the two scales FOCHP and SOCHP in quantifying the press of the learning environment in terms of its support for different types of student thinking, and the use of a validated coding protocol for identifying classroom interactions. In addition, the two studies and included phases are mutually supportive and interconnected in such ways as to promote the strengths and limit the weaknesses of both the quantitative and the qualitative methods used in this inquiry.

The following Chapters present the results and analyses of the various phases of the study. Chapter 5 provides the results and analyses of Study 1 (i.e. Australian study) and Chapter 6 provides the results and analyses of Study 2 (i.e. American study).
RESEARCH RESULTS AND ANALYSES: STUDY 1 AUSTRALIA

5.1 Introduction

Study 1 investigates technology education classes in Queensland, Australia, in order to understand the nature of classroom activity that promotes students’ use of higher-order thinking. This chapter reports the analyses and interpretation of the findings of the various phases of Study 1.

Chapter 2 establishes the theoretical conceptualisation of the study by synthesising teaching and learning in terms of cognitive theory, behaviour setting theory and activity theory. On the basis of this synthesis, a conceptualisation of higher-order thinking is advanced that incorporates individual cognition, the behaviour setting and activity. The conceptualisation advanced in this thesis is visually represented in Figure 2.3 and depicts the complex nature of the interdependence of individual cognition, and the activity of a person within a behaviour setting. The conceptualisation of higher-order thinking, advanced in this thesis, is examined in relation to teaching and learning in technology education classes in Chapter 3.

It is argued in Chapter 3 that technology education teachers have the potential to influence student higher-order thinking by the creation of a supportive classroom program. Additionally, it is argued that teachers create or facilitate a particular classroom program through teaching strategy selection. In particular, strategies at the intermediate and micro-levels are argued to have a direct influence on student learning activity and on the tactics teachers’ employ at these lower levels in support of strategies. That is, technology education students use of higher and lower-order thinking is conceptualised as being influenced by the types of tasks they are required to encounter and by the types of tactics teachers use to facilitate student engagement.
with these learning tasks. Chapter 3 advances the concept of classroom program as an integral component of the conceptualisation of higher-order thinking as advanced in this thesis.

On the basis of the conclusions reached in Chapters 2 and 3, it is predicted that particular types of activities would support student higher-order thinking in technology education classes (See Section 3.4). The activities predicted are general in nature and provide a focus or emphasis for instructional design, rather than specific strategies that can be applied directly to technology education instruction to promote student higher-order thinking. That is, it is predicted that technology education classrooms that promote students’ use of higher-order thinking will display strategies that support:

1. Students to achieve personally important goals.
2. Students to self-regulate or take responsibility for their classroom activities.
3. Students to construct knowledge based on what they already know and may need to know, so that they might solve problems that inhibit personally important goal attainment.
4. An understanding of the value of the independent nature of student learning (i.e. higher-order thinking).

The chapter is structured in the following way and illustrated in Figure 5.1. Section 5.2 briefly reports on the CHPQ (described in Chapter 4) in terms of the construct validity and reliability of the scales of FOCHP and SOCHP from the data collected from the various phases of Study 1. Section 5.3 presents the Study 1-Phase 1 pre-test and Study 1-Phase 3 post-test mean results and analyses of variance for FOCHP and SOCHP. Section 5.4 presents the results and analyses of the selection of a number of Australian technology education classes for video and video-stimulated interview case studies. Section 5.5 presents the results and analyses of case study observations of selected Australian technology education lessons. Section 5.6 provides a summary of the results and analyses of Study 1.
5.2 CHPQ Verification: Current Study

The Cognitive Holding Power Questionnaire was originally designed for use with post-compulsory age students (Stevenson & Evans 1994). Few published studies have examined students from high school settings (Stevenson, 1998; Walmsley, 2001). Therefore, the question of validity and reliability with this current study needs to be addressed. This need arises also because of the slight modification of the instrument for the present study (i.e. the removal of five questions from the analyses). The results of this study have upheld the construct validity of the CHPQ and the reliability of the scales of FOCHP and SOCHP of earlier studies. Section 4.3.1.1 and Appendix 14 provide a detailed account of this analysis.

However, it would appear that the particular nature of the technology education learning environment, when compared to subjects surveyed in other studies, such as mathematics or
history, leads students to interpret some questionnaire items differently. This situation has resulted in questions 15 and 23 being discarded from the analysis during this current study. Additionally, questions 10, 14 and 25 (See Appendix 5 for CHPQ questions) have been discarded from the analysis based on the results of this and prior studies (Stevenson & Ryan, 1994; Walmsley, 2001). Twenty-five questions remain in the analysis. Twelve questions are indicative of a learning environment’s press for lower-order procedures (FOCHP) and thirteen questions are indicative of a learning environment’s press for higher-order procedures (SOCHP). Despite the omission of the additional questions from the original instrument, the CHPQ as used in this study was effective in differentiating between learning environments that characterise the press for first and second-order procedures (See Appendix 14). It is argued that the validity of the CHPQ and the reliability of the scales FOCHP and SOCHP have been strengthened by this current study because of the international application of the instrument. The confirmatory factor analyses provided in Appendix 14 support this argument.

The following sections of this chapter examine the press of various technology classrooms on students to use different types of thinking processes (i.e. FOCHP and SOCHP). The press is quantified (measured using the CHPQ) and the nature of the classroom activity is examined (case studies using video and video-stimulated interviews). That is, the CHPQ (quantitative) measured the types of thinking and the case studies (qualitative) examined possible causes for the different types of thinking used in technology education classes.

5.3 Study 1-Phase 1 CHPQ Pre-test Results
Responses to the CHPQ were collected from 29 Australian technology classes (441 students) during Study 1-Phase 1. Table 5.1 provides the FOCHP and SOCHP mean results (SPSS, Ver11, 2001) for Study 1-Phase 1 technology class identification and gender. The distribution of the data as analysed using a Shapiro-Wilk (SPSS, Ver11, 2001) test of normality indicated that the technology class mean results for FOCHP and SOCHP were normally distributed apart for class 11 (FOCHP) and classes 21, 23, 42, 92,101 and 104 (SOCHP). However,
Bryman and Cramer (1997) argue that supportive evidence indicates that non-normal data can be used in parametric analysis with little negative effect on the results. Kesselman et al (1998, p. 358) state that: *Although the ANOVA F test may be relatively insensitive to violations of the normality assumption in terms of the Type I error control, it is highly sensitive to differences in population variances.* The Levene statistic (SPSS, Ver11, 2001) for the homogeneity of variances within the data for FOCHP (0.405) and SOCHP (0.464) indicated that the variances of the 29 class groups were equal (Field, 2000). Hence, the result of the Levene homogeneity of variances and the Shapiro-Wilk normality tests indicated that the data fulfil the parametric analysis requirements (Field, 2000). Therefore, because of the relatively small subset of the results that varied from a normal distribution and the supportive evidence of Bryman and Cramer (1997) and Kesselman et al (1998), this study accepts the small number of normality violations in the data. In addition, because of the robust nature of the ANOVA (Field, 2000) the slight variations in class size would not have adversely affected the results when population variances were found to be equal (Kesselman et al, 1998).
Table 5.1
Study 1-Phase 1 Pre-test FOCHP & SOCHP Means
Technology Class & Gender
(Standard Deviations in Brackets, N = Number)

<table>
<thead>
<tr>
<th>Tech Class Identification &amp; Gender</th>
<th>N</th>
<th>FOCHP Mean</th>
<th>SOCHP Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tech Class 11</td>
<td>15</td>
<td>3.17 (0.52)</td>
<td>3.17 (0.39)</td>
</tr>
<tr>
<td>Tech Class 12</td>
<td>18</td>
<td>**3.41 (0.80)</td>
<td>2.97 (0.54)</td>
</tr>
<tr>
<td>Tech Class 13</td>
<td>14</td>
<td>**3.49 (0.83)</td>
<td>3.21 (0.30)</td>
</tr>
<tr>
<td>Tech Class 14</td>
<td>21</td>
<td>**3.35 (0.54)</td>
<td>3.01 (0.43)</td>
</tr>
<tr>
<td>Tech Class 21</td>
<td>17</td>
<td>*3.31 (0.66)</td>
<td>2.99 (0.58)</td>
</tr>
<tr>
<td>Tech Class 22</td>
<td>17</td>
<td>3.25 (0.62)</td>
<td>3.24 (0.50)</td>
</tr>
<tr>
<td>Tech Class 23</td>
<td>21</td>
<td>3.23 (0.39)</td>
<td>3.10 (0.42)</td>
</tr>
<tr>
<td>Tech Class 24</td>
<td>18</td>
<td>*3.30 (0.56)</td>
<td>2.90 (0.64)</td>
</tr>
<tr>
<td>Tech Class 31</td>
<td>12</td>
<td>2.83 (0.65)</td>
<td>3.08 (0.55)</td>
</tr>
<tr>
<td>Tech Class 32</td>
<td>15</td>
<td>*3.33 (0.71)</td>
<td>3.13 (0.39)</td>
</tr>
<tr>
<td>Tech Class 41</td>
<td>12</td>
<td>3.35 (0.62)</td>
<td>2.99 (0.45)</td>
</tr>
<tr>
<td>Tech Class 42</td>
<td>21</td>
<td>3.12 (0.63)</td>
<td>3.18 (0.44)</td>
</tr>
<tr>
<td>Tech Class 43</td>
<td>11</td>
<td>3.00 (0.64)</td>
<td>3.21 (0.29)</td>
</tr>
<tr>
<td>Tech Class 51</td>
<td>14</td>
<td>3.19 (0.62)</td>
<td>3.14 (0.52)</td>
</tr>
<tr>
<td>Tech Class 52</td>
<td>17</td>
<td>2.52 (0.53)</td>
<td>3.09 (0.44)</td>
</tr>
<tr>
<td>Tech Class 61</td>
<td>21</td>
<td>2.92 (0.71)</td>
<td>*2.80 (0.62)</td>
</tr>
<tr>
<td>Tech Class 62</td>
<td>15</td>
<td>2.99 (0.65)</td>
<td>3.01 (0.37)</td>
</tr>
<tr>
<td>Tech Class 63</td>
<td>26</td>
<td>*3.25 (0.54)</td>
<td>3.25 (0.56)</td>
</tr>
<tr>
<td>Tech Class 71</td>
<td>16</td>
<td>3.00 (0.40)</td>
<td>3.08 (0.41)</td>
</tr>
<tr>
<td>Tech Class 72</td>
<td>11</td>
<td>3.13 (0.66)</td>
<td>3.35 (0.44)</td>
</tr>
<tr>
<td>Tech Class 81</td>
<td>15</td>
<td>2.69 (0.47)</td>
<td>2.84 (0.46)</td>
</tr>
<tr>
<td>Tech Class 82</td>
<td>11</td>
<td>2.70 (0.44)</td>
<td>3.29 (0.51)</td>
</tr>
<tr>
<td>Tech Class 91</td>
<td>10</td>
<td>2.79 (0.40)</td>
<td>3.54 (0.42)</td>
</tr>
<tr>
<td>Tech Class 92</td>
<td>18</td>
<td>2.77 (0.46)</td>
<td>3.14 (0.48)</td>
</tr>
<tr>
<td>Tech Class 101</td>
<td>12</td>
<td>3.16 (0.48)</td>
<td>3.18 (0.52)</td>
</tr>
<tr>
<td>Tech Class 102</td>
<td>9</td>
<td>3.12 (0.36)</td>
<td>3.20 (0.39)</td>
</tr>
<tr>
<td>Tech Class 103</td>
<td>10</td>
<td>3.38 (0.47)</td>
<td>3.05 (0.32)</td>
</tr>
<tr>
<td>Tech Class 104</td>
<td>8</td>
<td>3.17 (0.45)</td>
<td>3.02 (0.52)</td>
</tr>
<tr>
<td>Tech Class 111</td>
<td>16</td>
<td>3.14 (0.60)</td>
<td>3.24 (0.39)</td>
</tr>
<tr>
<td>Male</td>
<td>358</td>
<td>#3.14 (0.62)</td>
<td>3.09 (0.48)</td>
</tr>
<tr>
<td>Female</td>
<td>83</td>
<td>#2.98 (0.59)</td>
<td>3.19 (0.49)</td>
</tr>
<tr>
<td>Total</td>
<td>441</td>
<td>3.11 (0.61)</td>
<td>3.10 (0.48)</td>
</tr>
</tbody>
</table>

* Identifies a significant difference to bolded mean at the 0.05 level
** Identifies a significant difference to bolded mean at the 0.01 level
# Identifies a significant difference between gender means at the 0.05 level
The significance of the results displayed in table 5.1 is discussed in section 5.4. However, the data indicated significant differences between particular technology classes for FOCHP and SOCHP and gender for FOCHP.

5.3.1 Study 1-Phase 3 CHPQ Post-test Results
A Shapiro-Wilk test of normality for the 29 technology classes (380 students, Study 1-Phase 3 post-test) for FOCHP and SOCHP indicated that two classes differed from a normal distribution for FOCHP (classes 63 and 22) and three classes differed from a normal distribution for SOCHP (classes 12, 62 and 63). Levene’s test for the homogeneity of variances indicated that the variances were equal for SOCHP ($p = 0.789$) and FOCHP ($p = 0.170$). ANOVA for FOCHP indicated significant differences between the means of technology classes ($F = 2.228; p = 0.000; Eta squared = 0.151$) and no significant difference for SOCHP means ($F = 1.433; p = 0.075; Eta squared = 0.103$). However, Gabriel’s (SPSS, Ver11, 2001) post hoc analysis indicated a significant difference between class 91 and class 22 means for SOCHP ($p = 0.024$) and no significant difference between class means for FOCHP.

Analysis of the results for gender indicated that the distributions were normal and the variances were equal. There was no significant difference indicated between the gender means for FOCHP and SOCHP. Table 5.2 provides the FOCHP and SOCHP mean results (ANNOVA) (SPSS, Ver11, 2001) for Study 1-Phase 3 post-test technology class identification and gender.
<table>
<thead>
<tr>
<th>Tech Class Identification &amp; Gender</th>
<th>FOCHP Mean</th>
<th>SOCHP Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tech Class 11</td>
<td>2.86 (0.48)</td>
<td>3.12 (0.37)</td>
</tr>
<tr>
<td>Tech Class 12</td>
<td>2.85 (0.76)</td>
<td>3.06 (0.54)</td>
</tr>
<tr>
<td>Tech Class 13</td>
<td>2.96 (0.69)</td>
<td>2.97 (0.59)</td>
</tr>
<tr>
<td>Tech Class 14</td>
<td>3.18 (0.67)</td>
<td>3.06 (0.57)</td>
</tr>
<tr>
<td>Tech Class 21</td>
<td>3.09 (0.74)</td>
<td>2.98 (0.50)</td>
</tr>
<tr>
<td>Tech Class 22</td>
<td>3.26 (0.57)</td>
<td>*2.81 (0.57)</td>
</tr>
<tr>
<td>Tech Class 23</td>
<td>3.20 (0.46)</td>
<td>2.91 (0.50)</td>
</tr>
<tr>
<td>Tech Class 24</td>
<td>3.27 (0.43)</td>
<td>3.25 (0.36)</td>
</tr>
<tr>
<td>Tech Class 31</td>
<td>2.39 (0.43)</td>
<td>2.89 (0.40)</td>
</tr>
<tr>
<td>Tech Class 32</td>
<td>3.36 (0.62)</td>
<td>3.01 (0.41)</td>
</tr>
<tr>
<td>Tech Class 41</td>
<td>2.87 (0.43)</td>
<td>3.21 (0.70)</td>
</tr>
<tr>
<td>Tech Class 42</td>
<td>2.66 (0.49)</td>
<td>3.31 (0.41)</td>
</tr>
<tr>
<td>Tech Class 43</td>
<td>2.81 (0.48)</td>
<td>3.39 (0.50)</td>
</tr>
<tr>
<td>Tech Class 51</td>
<td>3.11 (0.43)</td>
<td>3.02 (0.47)</td>
</tr>
<tr>
<td>Tech Class 52</td>
<td>2.54 (0.60)</td>
<td>3.00 (0.50)</td>
</tr>
<tr>
<td>Tech Class 61</td>
<td>2.63 (0.67)</td>
<td>3.21 (0.51)</td>
</tr>
<tr>
<td>Tech Class 62</td>
<td>3.01 (0.83)</td>
<td>3.05 (0.52)</td>
</tr>
<tr>
<td>Tech Class 63</td>
<td>2.88 (0.64)</td>
<td>3.09 (0.53)</td>
</tr>
<tr>
<td>Tech Class 71</td>
<td>2.69 (0.54)</td>
<td>3.26 (0.46)</td>
</tr>
<tr>
<td>Tech Class 72</td>
<td>3.04 (0.28)</td>
<td>3.32 (0.69)</td>
</tr>
<tr>
<td>Tech Class 81</td>
<td>2.86 (0.59)</td>
<td>3.10 (0.40)</td>
</tr>
<tr>
<td>Tech Class 82</td>
<td>2.92 (0.69)</td>
<td>3.11 (0.46)</td>
</tr>
<tr>
<td>Tech Class 91</td>
<td>2.48 (0.80)</td>
<td>3.68 (0.44)</td>
</tr>
<tr>
<td>Tech Class 92</td>
<td>2.92 (0.76)</td>
<td>3.07 (0.43)</td>
</tr>
<tr>
<td>Tech Class 101</td>
<td>3.33 (0.65)</td>
<td>3.22 (0.59)</td>
</tr>
<tr>
<td>Tech Class 102</td>
<td>3.22 (0.42)</td>
<td>2.86 (0.44)</td>
</tr>
<tr>
<td>Tech Class 103</td>
<td>2.73 (0.56)</td>
<td>3.02 (0.56)</td>
</tr>
<tr>
<td>Tech Class 104</td>
<td>2.93 (0.37)</td>
<td>3.03 (0.20)</td>
</tr>
<tr>
<td>Tech Class 111</td>
<td>3.12 (0.55)</td>
<td>3.27 (0.33)</td>
</tr>
<tr>
<td>Male</td>
<td>2.96 (0.62)</td>
<td>3.09 (0.50)</td>
</tr>
<tr>
<td>Female</td>
<td>2.93 (0.70)</td>
<td>3.17 (0.50)</td>
</tr>
<tr>
<td>Total</td>
<td>2.95 (0.63)</td>
<td>3.10 (0.50)</td>
</tr>
</tbody>
</table>

*Identifies a significant difference to bolded mean at the 0.05 level*
5.3.2 Comparing Study 1-Phase 1 Pre-test and Study 1-Phase 3 Post-test Results

The post-test was administered after the collection of qualitative data (video and video-stimulated interviews). However, the thesis presents these data prior to the reporting of case study results. This allows the two data sets to be reviewed, for purposes of comparison, within the same section. Figure 5.2 compares the Study 1 pre-test and post-test means of the 29 technology classes for FOCHP and SOCHP.

![Figure 5.2](image)

(Standard Deviations in Brackets)

- (Pre-test Term 2 / Post-test Term 4)
- Statistical Significance for changes in FOCHP $p = 0.000$
- Statistical Significance for changes in SOCHP $p = 0.974$
- FOCHP Means: Pre-test = 3.11 (0.61) Post-test = 2.95 (0.63)
- SOCHP Means: Pre-test = 3.10 (0.48) Post-test = 3.10 (0.50)

The pre-test (Phase 1) and post-test (Phase 3) results for Study 1 indicate that the distributions were substantively normal and the variances could be assumed to be equal for the data groupings. Participant mortality (Bernard, 2000) reduced the number of post-test responses to the questionnaire (i.e. from 441 to 380 responses). An ANOVA for the (2003) pre-test and post-test means of the 29 technology classes indicates that there were significant differences
between the means for FOCHP ($F = 13.140; \ p = 0.000; \ Eta \ squared = 0.016$) and no significant differences between the SOCHP means ($F = 0.001; \ p = 0.974; \ Eta \ squared = 0.000$).

Therefore, the data from Study 1 (Displayed in Figure 5.2) indicates that the majority of technology education classrooms pressed students more into using first order procedures (FOCHP) early in the school year. As the school year preceded this press was reduced. That is, teachers were showing or telling students how to do things more early in the school year, (i.e. lower-order thinking) (See Section 4.1.1 for details of FOCHP & SOCHP) and later in the school year this support was reduced. Alternatively, teacher support for second-order procedures (SOCHP) remained at a constant level for the whole school year. That is, teachers were generally supporting students’ devising strategies and problem-solving (i.e. higher-order thinking) to the same extent throughout the entire school year. It should be noted that the results displayed within Figure 5.2 are interpreted as being the result of normal instructional progression within these technology classes and not substantially influenced by the study. Apart from those classes chosen for case study investigation, there was no contact between the researcher and the teachers of these classes between the Study 1 pre-test and post-test administrations of the CHPQ.

5.4 Class Selection for Case Study Investigations: Study 1-Phase 2 Stage 1
The results of the ANOVA and post hoc analysis for the Study 1-Phase 1 CHPQ results (See Table 5.1) indicated significant relationships within the data. Justification for the selection of technology classes for case study investigations was based on understanding why these differences existed. The approach taken to selecting classes for case studies was to identify significant cases in terms of difference in first or second order cognitive holding power. Classes 52 and 91 exhibited significantly different values for FOCHP and SOCHP respectively. Class 52 obtained the lowest result for FOCHP, indicating that students’ perceived that the learning environment pressed them least for the use of lower-order
procedures. Class 91 obtained the highest result for SOCHP, indicating that students’ perceived that the learning environment pressed them to the highest extent to use higher-order procedures. Both of these classes were chosen for qualitative investigation because of these results.

In addition, it appeared that several classes were significantly more supportive of the press for lower-order procedures than class 52. Classes 12 and 21 were chosen for case study analysis on this basis and because of their similar result for SOCHP. In other words, these three classes were included to determine what differences existed between the learning environments of classes 52, 12 and 21 that may have caused this FOCHP result. Class 61’s result for SOCHP was significantly different from that of class 91 and was chosen for further analysis on this basis. Class 82 was a graphics class (hand drafting) and was chosen for case study investigation because of the different layout of the learning environment and the possible effect of setting on student and teacher behaviour.

Therefore, the six classes initially chosen for case study investigation using video observation and video-stimulated interviews were classes 12, 21, 52, 61, 82, and 91. However, the results of the Stage 1-Phase 3 post-test, administered soon after the case study examination of the six technology classes (late 2003 school year) revealed that classes 21 and 91 exhibited notable differences for both FOCHP and SOCHP. That is, it was confirmed that class 21 still pressed high for FOCHP and low for SOCHP and conversely class 91 still pressed high for SOCHP and low for FOCHP. However, classes 12, 52, 61 and 82 did not continue to indicate significant differences in the Study 1-Phase 3 post-test data and were therefore discarded from qualitative analyses. The Study 1 pre-test and post-test FOCHP and SOCHP means for the technology classes chosen for case study investigation are shown in Table 5.3. Therefore, while six classes were originally chosen for case study examination because of the Study 1-Phase 1 pre-test results, the case study data from two classes only have been selected for
further analysis because of the Study 1-Phase 3 post-test results. Therefore, only the results of the case study data analyses for classes 21 and 91 are presented in Section 5.5.

Table 5.3
Comparison of FOCHP and SOCHP means
Study 1-Phase 1 Pre-test and Study 1-Phase 3 Post-test: Case Study Classes Only
(Means with Standard Deviations in Brackets)

<table>
<thead>
<tr>
<th>Class</th>
<th>Pre-test Means</th>
<th>Post-test Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FOCHP</td>
<td>SOCHP</td>
</tr>
<tr>
<td>12</td>
<td>**3.41 (0.77)</td>
<td>2.97 (0.54)</td>
</tr>
<tr>
<td>21</td>
<td>*3.31 (0.66)</td>
<td>2.99 (0.58)</td>
</tr>
<tr>
<td>52</td>
<td>2.52 (0.53)</td>
<td>3.09 (0.44)</td>
</tr>
<tr>
<td>61</td>
<td>2.92 (0.71)</td>
<td>*2.80 (0.62)</td>
</tr>
<tr>
<td>82</td>
<td>2.70 (0.44)</td>
<td>3.29 (0.51)</td>
</tr>
<tr>
<td>91</td>
<td>2.79 (0.40)</td>
<td>**3.54 (0.42)</td>
</tr>
</tbody>
</table>

* ** signifies a significant difference to bolded mean at the 0.01 level
* * signifies a significant difference to bolded mean at the 0.05 level

5.5 Case Study Results and Analyses: Study 1-Phase 2 Stage 2

5.5.1 Introduction
The case study collection of data from the two technology classes occurred between August and October 2003. The methodologies employed to investigate the activities of each technology lesson are described in Chapter 4 and included video-recording and analysis of lesson activities, and video-stimulated interviews conducted with teachers and students.

This section presents the results and analyses for technology classes 21 (high FOCHP) and 91 (high SOCHP). The data gathered through the case study investigation were collated and compared with each of the technology lessons under investigation. The differences highlighted by this comparison are used to build on the knowledge gained through quantitative analysis of each learning environment’s press for different types of student thinking.
In the following sections the video data are examined and linked to teacher and student video-stimulated interview responses for each technology class. The case study data for each technology education class are subsequently compared to identify differences from within the data.

5.5.2 Video and Video-Stimulated Interview Data Analysis
Each technology class was video recorded and the video data were coded for different types of foreground and background teaching and learning activities. The coding system and methodology are described in Chapter 4. An example of the analysis of the coded foreground (i.e. the lesson foreground is defined as any learning activity under the direct influence of the teacher) and background (i.e. the lesson background is defined as any learning activity that occurs independent of the teacher) classroom activity for each technology class lesson is provided in Appendix 12. Further analysis of the data, provides the code, the code descriptions as identified during the data analysis, and the total amount of time each code occurred within the lesson (See Appendix 13).

The data (transcriptions) provided through the video-stimulated interviews were scrutinised for similar themes. The methodology, as described in Section 4.4.4.2, revealed eleven themes emerging from within the data. These themes were taken to indicate the teacher’s and students’ interpretation of the activities within their respective technology lesson. Each theme is significant in terms of interpreting the activity system within each class lesson.

The teacher’s and students’ video-stimulated interviews from each lesson were first manually interpreted to identify themes. A summary of each lesson was extracted from the data as interpreted by the researcher using the themes (See Section 4.4.4.2 for details). Leximancer automated text analysis software (Smith, 2006, Version 2.25) was then used to provide a second interpretation of the data. The case study summaries of each lesson (video and video-
stimulated interviews) are presented in the following sections. The leximancer analyses are presented in Section 5.5.3.

5.5.2.1 Class 21 Case Study

Class 21 Video

On the day of video observation, class 21 was involved in producing a wooden practice product (folding camping-stool). The students were approximately mid-unit and the teacher stated that the aim of the unit was to support the students in preparation for design-based activities in the following unit. The teacher used a significant portion of this lesson to lecture the students regarding the design folio requirements for the following design-based unit.

<table>
<thead>
<tr>
<th>Class</th>
<th>Phase 1 Pre-test Means</th>
<th>Phase 3 Post-test Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FOCHP</td>
<td>SOCHP</td>
</tr>
<tr>
<td>21</td>
<td>3.31 (0.66)</td>
<td>2.99 (0.58)</td>
</tr>
</tbody>
</table>

The phase-3 CHPQ data indicated that class 21 students were pressed high to use lower-order procedures (FOCHP) and pressed low to use higher-order procedures (SOCHP) (See Table 5.4 above for details). The video-data analysis indicated that twenty-two different types of action occurred within the foreground of this lesson (See Table 5.5). The actions in Table 5.5 are represented by codes and described in the corresponding column with the lesson time taken for each code included. The teacher spent a large proportion of class time interacting with the whole class, either by presenting information using written materials, images and real objects (class project), eliciting information or actions, or demonstrating processes. The students worked independently in the background using skills provided by the teacher. These skills were reinforced during the lesson either by the teacher reminding students about the appropriate procedures verbally, or by the teacher demonstrating the procedures for the students as individuals or to the whole class.
### Table 5.5
Class21
Lesson Actions

<table>
<thead>
<tr>
<th>Code</th>
<th>Class Time</th>
<th>Foreground Code Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELVXX</td>
<td>2 min</td>
<td>The teacher elicits a response from the whole class.</td>
</tr>
<tr>
<td>ELVCY</td>
<td>3 min</td>
<td>The teacher elicits a known action from the whole class in relation to real objects (project related).</td>
</tr>
<tr>
<td>PLVWT</td>
<td>7 min</td>
<td>The teacher presents written information to the whole class using knowledge about things.</td>
</tr>
<tr>
<td>ESVWT</td>
<td>1 min</td>
<td>A student elicits information about written material from the teacher in front of the whole class.</td>
</tr>
<tr>
<td>PLVIT</td>
<td>12 min</td>
<td>The teacher provides information about images to the whole class.</td>
</tr>
<tr>
<td>ELVCM</td>
<td>3 min</td>
<td>The teacher elicits information from the whole class about real objects (project related) in order to monitor their performance and progress.</td>
</tr>
<tr>
<td>PLVCY</td>
<td>8 min</td>
<td>The teacher demonstrating a skill using real objects to the whole class.</td>
</tr>
<tr>
<td>PLFCA</td>
<td>3 min</td>
<td>The teacher presenting information to a group of students about how to perform a skill using a real object.</td>
</tr>
<tr>
<td>ESFCA</td>
<td>3 min</td>
<td>A group of students elicits information from the teacher about how to perform a skill using a real object.</td>
</tr>
<tr>
<td>PLOCY</td>
<td>2 min</td>
<td>The teacher demonstrating a process with a real object for a single student.</td>
</tr>
<tr>
<td>PSOCA</td>
<td>1 min</td>
<td>A student asking the teacher to how to perform a skill using a real object.</td>
</tr>
<tr>
<td>ESFCM</td>
<td>3 min</td>
<td>A group of students elicits information about a real object from the teacher and the teacher responds by monitoring their progress and performance.</td>
</tr>
<tr>
<td>ELFCM</td>
<td>4 min</td>
<td>The teacher elicits a response from a group of students about a real object in order to monitor their performance and progress.</td>
</tr>
<tr>
<td>PLVCM</td>
<td>1 min</td>
<td>The teacher presents information about a real object to the whole class while monitoring performance and progress.</td>
</tr>
<tr>
<td>PLVCA</td>
<td>2 min</td>
<td>The teacher providing information about how to perform a skill using real objects to the whole class.</td>
</tr>
<tr>
<td>ESOCM</td>
<td>1 min</td>
<td>A student elicits a response from the teacher about a real object in order to gain ideas and the teacher responds by monitoring their progress and performance.</td>
</tr>
<tr>
<td>ELOCM</td>
<td>1 min</td>
<td>The teacher elicits a verbal explanation of a real object (project) from a single student to check student progress and understanding.</td>
</tr>
<tr>
<td>ELVXY</td>
<td>1 min</td>
<td>The teacher elicits a known action from the whole class.</td>
</tr>
<tr>
<td>PLOXT</td>
<td>1 min</td>
<td>The teacher presents information about things to a single student.</td>
</tr>
<tr>
<td>ELVXM</td>
<td>2 min</td>
<td>The teacher elicits a response from the whole class in order to monitor their performance and progress.</td>
</tr>
<tr>
<td>PLVXT</td>
<td>2 min</td>
<td>The teacher presents information to the whole class using knowledge about things.</td>
</tr>
<tr>
<td>ESVXT</td>
<td>1 min</td>
<td>A student elicits information about things from the teacher in front of the whole class.</td>
</tr>
</tbody>
</table>

**Background Code Description**

<table>
<thead>
<tr>
<th>Code</th>
<th>Background Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO/BG</td>
<td>44 min No background activity</td>
</tr>
<tr>
<td>NROCY</td>
<td>16 min Students working independent of the teacher on their own using known procedures in response to the specific requirements of a real object (project).</td>
</tr>
<tr>
<td>DROCY</td>
<td>4 min The class doing as instructed by the teacher and individual students performing known procedures as initiated by a real object (project).</td>
</tr>
</tbody>
</table>
The video-stimulated interview data are now examined to determine the teacher’s and students’ interpretation of this lesson.

**Class 21 Video-Stimulated Interviews**

The following passages provide a summary of the information gathered through teacher and student interviews for technology class 21. The information is separated into the themes that link to activity theory components as presented in Table 4.10.

The Teacher’s and students’ video-stimulated interviews for class 21 revealed that:

**Tools**

- The teacher focused students by providing advice and demonstrating processes for students (individuals, groups, and the whole class).
- The teacher demonstrated the correct procedures for students using stepwise methods initially. Quicker students were encouraged to apply prior knowledge in order to move ahead independently.
- The teacher used his demonstration work-piece to facilitate the students’ learning activity (i.e. the teacher does the same project as the students: foundation project / skill development).
- The teacher often linked student activity with real world knowledge of things related to their projects.
- The teacher monitored student learning activity (students generally came to him) so that he could advise students as to the correct processes. If a mistake was made consistently, he decided when to instruct the whole class in order to correct the error. This activity promoted quality work and therefore student self-esteem.

**Subjects**

- The teacher made judgements in regard to the level of quality he would accept in relation to each student’s project.
- The students understood the benefits of listening to what the teacher told them about how and why they were to do things.

**Rules**

- The teacher believed that each student should be encouraged to give their best effort and regardless of the eventual grade, he was happy providing they had performed to their best.
The students were made aware that they should ask for advice and seek approval for stages of their project so that mistakes were kept to a minimum. This activity was linked to students’ efforts to do their best work (i.e. students who do this were regarded as trying to do their best).

The teacher linked student activity with his own experiences of what worked best for students in similar situations (i.e. I wouldn’t ask them to do anything I wouldn’t do).

**Division of labour**

- Students were encouraged to ask (generally the teacher) for assistance in situations where their knowledge and understanding was inadequate.
- Students worked generally by themselves on their own projects. (Foundation projects providing skills leading to a design task).
- The teacher shared responsibility with the student, though the teacher considered that he was primarily responsible for student success or failure and it was up to him to actively facilitate student success.
- Students hoped that the teacher would solve their problems, though they knew this may not occur. That is, if you don’t know, ask, though the teacher may not provide the correct answer, but provide hints to help you solve your own problems. However, ultimately, the teacher would support the students by providing the correct answer and the teacher believed that this maintained the students’ self-esteem.

In summary, the video-stimulated interviews indicated that class 21’s teacher employed instructional tactics that facilitated a strategy of leading students toward a design-process curriculum. The practice project provided students with an opportunity to build their competencies and to improve their confidence and self-esteem.

The program of the class is interpreted as being determined by the teacher’s desire to support the students in a positive manner. It appeared to be important to the teacher that the students experienced success. The students put in the effort, the teacher provided the information, the procedures, and in some cases hints or cues that facilitated each student’s success within the activity. The students understood the benefits of the teacher’s tactics (i.e. his actions that supported student success) in their attainment of self-esteem, production of a product, and a
good grade. The support provided by the teacher and the subsequent effort supplied by the students reduced discipline problems and improved the students’ understanding of materials and processes, which the teacher interpreted as being important in later life. Teacher modelling facilitated the creation of an improved student work ethic. This is linked to the aforementioned effort and the desire of the teacher to have the students interpret the class (including the teacher) as a team-working environment.

The teacher believed that student enjoyment was an important outcome of instruction. This helped to maintain student motivation and commitment (effort). The teacher acted in ways he believed supported the students’ enjoyment by taking the bulk of responsibility for any problems and mistakes that might have occurred within the class. The students believed that they shared learning responsibility with the teacher. Therefore, it would appear that the object of the activity system of class 21 was student enjoyment maintained by positive (i.e. successful) classroom experiences relative to artefacts (i.e. student projects). The teacher’s actions gain meaning when interpreted in terms of this object.

5.5.2.2 Class 91 Case Study

Class 91 Video

At the time of video observation, class 91 was close to concluding a unit of work on mechanisms. The students had previously completed a number of lessons researching different types of mechanisms and compiling this information into a design folio. To demonstrate their understanding of the technological content of the unit, students were required to apply this knowledge in the design and construction of a child’s toy that incorporated some form of mechanism. The mechanism was required to redirect an input motion into a movement output in an alternate motion or direction (e.g. a rotary motion input into a reciprocating motion output or a vertical rotary motion input into a horizontal rotary motion output). The majority of students were working on their projects during this 50-minute lesson.
The phase-3 CHPQ data indicated that class 91 students were pressed high to use higher-order procedures (SOCHP) and pressed low to use lower-order procedures (FOCHP), and the students perceived that they had more control over their activities (i.e. goal driven actions) as the year progressed (See Table 5.6 below for details).

<table>
<thead>
<tr>
<th>Class</th>
<th>Pre-test Means</th>
<th>Post-test Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FOCHP</td>
<td>SOCHP</td>
</tr>
<tr>
<td>91</td>
<td>2.79 (0.40)</td>
<td>3.54 (0.42)</td>
</tr>
</tbody>
</table>

The analysis of the video data indicates that nineteen different actions occurred between the teacher and the students during this lesson. In Table 5.7 below, these actions are represented by codes and described in the corresponding column with the lesson time taken for each code included. The data indicate that the teacher’s actions when interacting with the students in the foreground of this lesson were generally teacher initiated. The students rarely initiated teacher-student interactions and when they did it was to elicit information from the teacher about their project work. The teacher presented information to the students and elicited information from the students as individuals and as the whole class for most of the lesson.

During his interactions with students, the teacher used real objects (student projects) to focus students on the underlying technological content of the unit (i.e. mechanisms and their application). The students spent much of the lesson working as individuals without the teacher’s assistance and at no time during the lesson did the students ask for teacher help. This is interpreted to indicate that the students were taking more responsibility for their activity (i.e. goal driven actions) than was the teacher.
<table>
<thead>
<tr>
<th>Code</th>
<th>Time</th>
<th>Foreground Code Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLVXT</td>
<td>3 min</td>
<td>The teacher presents information to the class using knowledge about things.</td>
</tr>
<tr>
<td>ELVXT</td>
<td>1 min</td>
<td>The teacher elicits information from the whole class.</td>
</tr>
<tr>
<td>ELVO/VXT</td>
<td>1 min</td>
<td>The teacher elicits information from single students and the whole class.</td>
</tr>
<tr>
<td>ELVXA</td>
<td>1 min</td>
<td>The teacher elicits an explained (how to) action from the whole class.</td>
</tr>
<tr>
<td>ELVXY</td>
<td>1 min</td>
<td>The teacher elicits a known action from the class.</td>
</tr>
<tr>
<td>ELOCT</td>
<td>6 min</td>
<td>The teacher elicits information about a real object from a single student.</td>
</tr>
<tr>
<td>ELOCM</td>
<td>11 min</td>
<td>The teacher elicits a verbal explanation of a real object (project) from a single student to check student progress and understanding.</td>
</tr>
<tr>
<td>ELOCG</td>
<td>5 min</td>
<td>The teacher elicits a single student’s deeper understanding (higher-order knowledge) of a real object’s (project) function and design.</td>
</tr>
<tr>
<td>PLOCT</td>
<td>1 min</td>
<td>The teacher presents information to a single student about a real object (project).</td>
</tr>
<tr>
<td>ESOCG</td>
<td>2 min</td>
<td>A student eliciting a response from the teacher by explaining a higher-order procedure they have used or devised.</td>
</tr>
<tr>
<td>PLVCT</td>
<td>2 min</td>
<td>The teacher providing information about a real object to the class.</td>
</tr>
<tr>
<td>PS/LVCT</td>
<td>2 min</td>
<td>A student, with teacher support, providing information to the whole class about a real object (project).</td>
</tr>
<tr>
<td>PLOCA</td>
<td>3 min</td>
<td>The teacher providing information about how to perform a skill to a student.</td>
</tr>
<tr>
<td>ESOCT</td>
<td>1 min</td>
<td>A student elicits information about a real object from the teacher.</td>
</tr>
<tr>
<td>EROCG</td>
<td>1 min</td>
<td>A real object (project fault) initiates a problem-solving response from the teacher with a single student.</td>
</tr>
<tr>
<td>PROCY</td>
<td>2 min</td>
<td>The teacher demonstrating a problem-solving process with a real object (project fault) for a single student.</td>
</tr>
<tr>
<td>PLOCY</td>
<td>2 min</td>
<td>The teacher demonstrating a specific process for a single student on a real object (project).</td>
</tr>
<tr>
<td>ELVCT</td>
<td>2 min</td>
<td>The teacher eliciting information from the class about real objects.</td>
</tr>
<tr>
<td>NXXXX</td>
<td>1 min</td>
<td>No foreground activity.</td>
</tr>
</tbody>
</table>

**Background Code Description**

<table>
<thead>
<tr>
<th>Code</th>
<th>Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO/BG</td>
<td>12 min</td>
<td>No background activity.</td>
</tr>
<tr>
<td>DROCY</td>
<td>5 min</td>
<td>The class doing as instructed by the teacher and individual students performing known procedures as initiated by a real object (project).</td>
</tr>
<tr>
<td>NROCG</td>
<td>31 min</td>
<td>Students working independent of the teacher on their own and devising procedures in response to the specific requirements of a real object (project).</td>
</tr>
<tr>
<td>NRFCG</td>
<td>2 min</td>
<td>Students working independent of the teacher in a group and devising procedures in response to the specific requirements of a real object (project).</td>
</tr>
</tbody>
</table>
The video-stimulated interview data are now examined to determine the teacher’s and students’ interpretation of this lesson.

Class 91 Video-Stimulated Interviews

The following passages provide a summary of the information gathered through teacher and student interviews for technology class 91. The information is separated into the themes as presented in Table 4.10.

The Teacher’s and students’ video-stimulated interviews for class 91 revealed that:

**Tools**
- The teacher focused students by questioning and probing for responses that clarified students own understanding of the underlying principles of the activity.
- The teacher may not have provided the correct answer for students but rather cued students to consider the possibilities and to make decisions based on their own understanding and research.
- The teacher modelled problem-solving for the students. He verbalised his thought processes whenever he had cause to seek clarification from the students (i.e. difficult problems were solved in front of the students in an explicit manner).
- The teacher linked student activity with real world situations wherever possible.

**Subjects**
- The teacher made judgements in regard to the level of support he provided to individual students. He believed that success with too much support was a poor second place to failure and subsequent student reflection that lead to an understanding of why failure had occurred.
- The students understood the benefits of the teacher’s tactics (i.e. what the teacher did to support their learning) in regards to theirs and others learning.

**Rules**
- The teacher believed that each student was central in regards to their own learning activity.
- The students were made aware that failure was a positive learning experience and as long as reflection and understanding resulted, students could still gain good results (assessment).
Division of labour

- Students were encouraged to explain / present their knowledge to other students (i.e. the students became the experts).
- Students worked generally by themselves on their own design projects.
- The teacher shared responsibility with the students, however, the students accepted that regardless of success or failure the learning was up to them.
- Students were expected to take responsibility for their own learning.

In summary, the teaching strategies (activities) and tactics (actions) used by class 91’s teacher are interpreted as reflecting a belief that students should be responsible for their own learning and that the object of the activity system was for students to gain knowledge of pertinent technological content with teacher support. The teacher facilitated learning situations for students as they engaged with their own individual learning experiences (i.e. goal driven actions). The students understood that they were ultimately responsible for the outcomes of their learning activities. In this class, success and failure were not considered by the teacher and the students to be mutually exclusive concepts because both were concerned with promoting learning. That is, failure could be as important as success, providing both the students and teacher acknowledged the learning gained from the experience.

The following summary examines the nature of the results from the video and video-stimulated interview data for classes 21 and 91.

5.5.2.3 Video and Video-Stimulated Interview Summary

Video Observation Summary

The video-data collected and reported in the context of foreground and background classroom activities provides evidence of the complex nature of classroom teaching and learning in technology education. In total, 43 different forms of classroom action (i.e. master codes are described in Appendix 14) occurred within the two technology lessons examined during the case study investigations in Study 1- Phase 2.
The teachers’ and students’ actions presented in Tables 5.5 and 5.7 indicate a difference in the behaviour setting programs of the two technology education classes. That is, the actions of the teachers are indicative of the types of tactics used to support strategy implementation and of the types of actions used by students to attain meaningful goals. These different actions are highlighted in the following passages.

When compared to Class 21, Class 91’s teacher used actions that emphasised:

- interaction with the whole class less often
- interaction with a single student more often
- use of real objects rather than images or written materials more often
- devising of procedures with students more often

When compared to Class 91 Class 21’s teacher used actions that emphasised:

- interaction with the whole class and a few students more often
- interaction with single students less often
- presentation of information more often
- elicitation of information less often
- use of images or written materials rather than real objects more often
- telling and showing students how to do things more often
- devising procedures with students less often

When compared to Class 21, Class 91’s students used actions that emphasised that they were:

- more actively engaged without the teacher’s assistance
- more often working as independent individuals devising procedures using real objects

When compared to Class 91, Class 21’s students used actions that emphasised that they were:

- less actively engaged independently without the teacher’s assistance
- working less often as independent individuals
• using known procedures more often
• devising procedures less often
• using real objects less often
• asking for teacher assistance more often

Table 5.8 below provides an overview of the technology education classroom actions that are interpreted to support student higher-order thinking given the video-data analysis. Table 5.8 displays the type of teacher and student classroom action, the emphasis of the action and the study’s interpretation of the relative support required to promote student higher-order thinking within technology education classrooms.

<table>
<thead>
<tr>
<th>Technology Education Classroom Program Element</th>
<th>Emphasis of the Classroom Program Element</th>
<th>More</th>
<th>Less</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity Theory Component - Tools</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive Activity</td>
<td>Students &amp; Teacher devising solutions</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Teacher showing or telling students</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The students using known processes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Activity Theory Component - Subjects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resources for Learning</td>
<td>Real objects</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Images</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Written materials</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>Activity Theory Component - Division of Labour</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Learning Activity</td>
<td>Independent of the Teacher</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Dependent on the teacher</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Individual learning activity</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Group learning activity</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Responsibility for learning</td>
<td>Student</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Teacher</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Teacher-Student Interactions</td>
<td>Single student</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Whole class or groups of students</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Eliciting information from students</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Presenting information to students</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

(Note that the Activity Theory Component - Rules is not supported by the video data)
The analysis of the video-data facilitates an interpretation of the types of activities that teachers and students engage in, however, the video-data does not provide insight into the program of the technology education classroom (i.e. the rules that moderate classroom activities and actions). That is, what strategies (as interpreted by the teacher and students) do teachers use to support students as they engage with their learning tasks in technology education? The video-data identifies what classroom actions are associated with higher-order thinking, but it does not identify why these actions achieve this. The video-stimulated interviews with teachers and students were conducted to provide the study with an understanding of the teacher’s reasoning for particular strategy selection and thus, to support an interpretation of the technology education classroom program.

Video-Stimulated Interview Summary
The video-stimulated interviews collected from classes 21 and 91 display similarities and differences. In this summary, differences are identified rather than the similarities. This is because it is important to understand differences in the nature of the learning interactions between the teachers and the students and the impact this had on the types of thinking that students used in technology classrooms. Therefore, it is the difference in the nature of the lesson, as identified by the teacher and the students from within each technology classroom, which forms the unit of analysis in this summary of the video-stimulated interview data.

Class 21’s teacher accepted that he was primarily responsible for student learning outcomes. He believed that it was up to him to be active in promoting student success in order to sustain student motivation, self-esteem and good behaviour. The students understood that the teacher would ultimately provide answers to their problems (after some hints and cues) and it was important that they performed activities as instructed by the teacher. The teacher demonstrated processes for students and students were encouraged to ask the teacher for assistance when their knowledge was inadequate (i.e. when they had forgotten how to perform a skill or encountered a problem). The teacher believed that he knew what worked best for students and
it was up to him to facilitate student success by monitoring that the correct procedures were being used. It was important that mistakes were kept to a minimum so that student interest, motivation and success were maintained.

Alternatively, class 91’s teacher believed that responsibility for learning was up to the individual student. The teacher took responsibility for supporting this learning by probing for responses that indicated and clarified the student’s understanding of the underlying principles of the activity. The teacher sought to scaffold student learning based on his knowledge of the level of support required by each individual student. Students were provided with hints and cues and were encouraged to make decisions based on their own understandings and research.

Class 91’s teacher modelled problem-solving on occasions when students encountered difficult problem situations during their learning activities. The teacher facilitated student problem-solving without diminishing student responsibility for learning by regulating his level of support for individual students. He maintained distance from the students’ learning in an attempt to promote them taking responsibility for the learning outcomes.

Class 91’s teacher encouraged students to communicate with peers so that information could be shared. That is, students became experts because of the different activities they experienced. The teacher acknowledged student expertise by encouraging student presentations that supported the learning of other students in the technology classroom. The presentations were designed to give students the opportunity to verbalise their understanding of the underlying technological content related to their learning activity. In addition, the rest of the class was provided with knowledge of technological content that they may not have realised, because their own learning activity may not concern this type of content.

Class 91’s teacher was content for students to experience failure within an activity provided learning was the outcome. Class 91’s students understood that success or failure was not as
important as reflection on why either had occurred and that failure could be a positive learning experience. The students understood that grades were not necessarily linked to success or failure within an activity and that good grades were maintained by reflection and understanding of why both success and failure occurred. Class 91’s students were expected to take responsibility for their own learning and the students accepted this responsibility.

In summary, the differences between classes 21 and 91 as identified through teacher and student video-stimulated interviews are grouped into the following activity theory components.

**Tools**

Teacher modelling:
- *Class 21*: Process skills (generally whole class and individuals)
- *Class 91*: Problem-solving / thinking skills (generally individuals)

Level and structure of support:
- *Class 21*: Showing or telling students (whole class and individuals)
- *Class 91*: Cueing or hinting students based on individual student need (generally individuals)

**Subjects**

Student success or failure:
- *Class 21*: Linked to grades, motivation (effort), self-esteem and behaviour
- *Class 92*: Linked to positive learning experiences based on reflection and understanding of why success or failure occurred

**Rules**

Focus of instruction:
- *Class 21*: Product outcome linked to the design process
- *Class 91*: Underlying technological content understanding used within a design process

**Division of Labour**

Responsibility for learning:
- *Class 21*: Teacher (students generally ask the teacher for assistance i.e. the teacher is the expert)
- **Class 91**: Individual student (peer interaction and presentation i.e. the students are the experts of their own activity) and teacher sharing (using tactics that do not reduce student responsibility)

The areas of difference across classes 21 and 91, as identified through video-stimulated interviews, are indicative of how teachers and students interpreted classroom activities as observed retrospectively on video footage. Given that the CHPQ results provide evidence that class 91 supports higher-order thinking in preference to lower-order thinking, it would seem that the types of activities and actions identified through this process could provide insight into the program of technology classrooms that support student higher-order thinking.

The video-stimulated interview data (transcriptions as summarised above) were analysed manually with a coding system developed using themes that emerged from the data. These themes (See Section 4.4.4.2) have allowed an interpretation of the data as identified in the previous sections of this chapter. However, Leximancer automated text analysis software (Smith, 2006) is capable of identifying concepts from within the total data set without the requirement for researcher interpretation of the data and thus limits researcher bias. For this reason, the transcriptions (teacher and students) from each of the two classes (21 & 91) were also analysed using Leximancer’s facility to identify concepts, and the strength of relationships across concepts, from within the data. The following section presents the results of the Leximancer analysis.

### 5.5.3 Video-Stimulated Interviews: Leximancer Analysis

Leximancer provides a number of descriptive analyses. These include concept map, ranked concept list and transcription extracts that identify statements from within the data that signify linked concepts. For further details of Leximancer analysis see Section 4.4.4.3. Each technology class’s (21 & 91) video-stimulated interview data was processed by the Leximancer program. The teacher’s and students’ interview data from each class was examined separately and are presented in this section. As with data previously analysed in this
chapter, the Leximancer analysis focuses on understanding the differences between the classes. The aim of this analysis was to identify factors that may exhibit some influence on the types of thinking students used in technology education classrooms.

5.5.3.1 Teachers
The Leximancer program automatically identified concepts from the teachers’ video-stimulated interview data of class 21 and 91. Similar concepts from within each class were merged by the researcher. For example, think, thinking and thought were merged to become one concept; student, students and kids were merged to become one concept. The concepts used by each teacher to describe the activity that occurred within their respective classes are displayed in Table 5.9. Of interest in this regard, are different concepts or similar concepts that are more or less prevalent.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Teacher Class 21</th>
<th>Teacher Class 91</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absolute Count</td>
<td>Relative Count</td>
</tr>
<tr>
<td>time</td>
<td>49</td>
<td>100%</td>
</tr>
<tr>
<td>work</td>
<td>43</td>
<td>88%</td>
</tr>
<tr>
<td>think</td>
<td>43</td>
<td>88%</td>
</tr>
<tr>
<td>students</td>
<td>33</td>
<td>67%</td>
</tr>
<tr>
<td>understand</td>
<td>27</td>
<td>55%</td>
</tr>
<tr>
<td>teachers</td>
<td>27</td>
<td>55%</td>
</tr>
<tr>
<td>job</td>
<td>25</td>
<td>51%</td>
</tr>
<tr>
<td>talking</td>
<td>24</td>
<td>49%</td>
</tr>
<tr>
<td>design</td>
<td>20</td>
<td>41%</td>
</tr>
<tr>
<td>important</td>
<td>19</td>
<td>39%</td>
</tr>
<tr>
<td>teaching</td>
<td>19</td>
<td>39%</td>
</tr>
<tr>
<td>making</td>
<td>12</td>
<td>24%</td>
</tr>
<tr>
<td>knowledge</td>
<td>9</td>
<td>36%</td>
</tr>
<tr>
<td>process</td>
<td>9</td>
<td>36%</td>
</tr>
<tr>
<td>correct</td>
<td>8</td>
<td>32%</td>
</tr>
<tr>
<td>school</td>
<td>6</td>
<td>24%</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>6</td>
<td>24%</td>
</tr>
<tr>
<td>taught</td>
<td>4</td>
<td>16%</td>
</tr>
<tr>
<td>problems</td>
<td>4</td>
<td>16%</td>
</tr>
</tbody>
</table>
Table 5.9 displays the concept, the absolute count of the concept (i.e. the number of instances of use within the data) and the relative count of the concept (i.e. the percentage use of a concept in comparison to the most used).

Work, think, time, teaching, teacher and students (shaded cells) are concepts that are common to each teacher’s reflections of their respective classroom’s video recording. Work, think and students were often used by both teachers to describe classroom activity within the interview transcriptions. Class 21’s teacher used some dissimilar concepts to teacher 91 to describe classroom activities. These included the concepts of understand, job, talking, design, important and making. Class 91’s teacher used different concepts to teacher 21 to interpret classroom activity. These included the concepts of learning, problem, interaction, answer, strategy, theory, knowledge, process and correct. The differences between the concepts identified as being typical to one class and not to the other were analysed to see if they would explain important differences in the classroom program across technology classes.

As the concepts identified from Class 91’s teacher’s interview data appear to link teaching and learning through problems, answers, theory and knowledge, this is interpreted to indicate that class 91’s classroom program was focused on how to provide the best support for student knowledge and problem-solving. On the other hand, the concepts identified from Class 21’s teacher’s interview data appear to link teaching and learning through talking, design, important, understand and making, and is interpreted to indicate that class 21’s classroom program was focused on communicating with students to facilitate the development of the design activity and the making of products linked to this process.
Teacher Class 21

While Table 5.9 identifies the frequency of concepts as they are used by the two teachers, it is also important to examine the relationships between and across the various concepts. Concept mapping was undertaken to outline this.

Figure 5.3 presents the concept map drawn from teacher 21’s video-stimulated interview. Within the concept map three thematic circles are overlaid by Leximancer to highlight concept associations within the data. The concept think was closely associated with teachers, teaching, and making. The concept students was closely associated with design, understand and job (i.e. project). The concept work was closely associated with time, talking and important.

Figure 5.3
Teacher 21 Concept Map
The strength of relationships between the concepts, as identified by the connection lines within Figure 5.3, are interpreted to indicate that the teacher considered that design, making and understanding were important aspects of class 21’s classroom program, as these concepts are linked to students and are closely related to the concepts of think and work by proximity. The similar proximity of the concepts of understand, design and job to students is interpreted to signify that the teacher considered each to be equally as important to design, making and understanding activities in relation to student projects (i.e. job). The teachers and teaching concepts are connected to the concept think and this is interpreted to indicate that the teacher believed that he was responsible for this aspect of his classroom. While the concept map allows one to view the possibility of close relationships within the data, it is Leximancer’s facility to extract the raw interview data that strengthens an interpretation in support of these concept associations.

For example, it is interpreted that class 21’s teacher emphasised the design process in his teaching (i.e. design, making, understanding and job or project) and this was important to the program of the classroom. The following interview extract supports this interpretation of the teacher’s views:

| Class 21 Tch.doc~1.html#S1_151 | TCH 21: ... we have made a big push with, especially in the junior school, because we want to move to a design based curriculum, outcomes based, you are, you are getting the kids to think. We are not teachers now, we are facilitators, and we are allowing the kids to learn via a means that they sort of choose in the room, but they are too used to being spoon-fed. Quite often a kid will come up to me and they'll say I've got this how do I fix it, what can we do, why has it gone wrong for a start. | Concepts: think AND teachers |

In addition, it is interpreted that the teacher believed that he was responsible for facilitating the design process through his teaching, and that student-generated design problems were to be solved collaboratively with his assistance. That is, the teacher considered that he was
responsible for activities associated with supporting student thinking in his classroom. The following interview extracts support this interpretation of the teacher’s views:

<table>
<thead>
<tr>
<th>Name</th>
<th>Extract</th>
<th>Concepts: think AND work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 21 Tch.doc~2.html#S1_34 3</td>
<td>That is the best part of doing design work, everyone coming together, seeing what someone else has done, well that's fantastic and then trying to help them solve a problem there and it also helps to nail home that we didn't really think about it at the very beginning did we. It’s one of those things that we sort of skipped over and we forgot.</td>
<td></td>
</tr>
<tr>
<td>Class 21 Tch.doc~2.html#S1_33 4</td>
<td>TCH 21: That will definitely change, because the way I like to run that is, I won't be teaching from out the front I'll be teaching from a desk where the kid who is working or doing that job is at and I'll okay everyone over here let’s have a look at Sam's job for a second. Sam has got a problem how are we going to solve it, what can we do. Because I mean, I have had the same problem with other schools where we do design.</td>
<td></td>
</tr>
</tbody>
</table>

It should be noted that within his explanations for classroom activity, the teacher used “we” to indicate a shared responsibility for problem-solving within the design process. This is significant because the concepts of teachers, think and teaching within the concept map were associated with that of students (i.e. the overlapping thematic circles of students and think). Given that design linked to students within the concept map, it is important to note that the teacher considered that making was an important component of the design process, which promoted students’ understanding and thinking.

The results of the Leximancer analyses for class 21 are interpreted to indicate that the teacher believed that design, making and understanding were important for the support of student learning (thinking) in his technology education classroom. Student projects (jobs) and the design process placed students in situations where their understandings were tested. The teacher accepted responsibility for supporting student thinking in these testing situations through collaborative “we” problem-solving.
The CHPQ results for class 21 indicate that the learning environment supported lower-order thinking in preference to higher-order thinking. It would also appear that the level of support for problem-solving provided by teacher 21 inhibited student higher-order thinking. Additionally, the teacher’s emphasis on process skill development and the importance of doing the job right to maintain grades, student motivation and self-esteem promoted students use of lower-order thinking. That is, by showing and telling students how to do things (even late in the school year) the teacher was encouraging students to apply previously acquired knowledge in similar situations.

It is concluded that the tactics (actions aimed at implementing strategies) teacher 21 used to deliver his design process curriculum and possibly not the design process itself, had an influence on the types of thinking students used in his technology classroom. Therefore, from the Leximancer analyses, it is argued that the classroom program of class 21 was influenced by two primary factors. The first was the format of the design process curriculum, with its emphasis on product outcomes. The second was the strategies and tactics employed by teacher 21 that diminished student responsibility for learning (i.e. higher-order thinking) and emphasised the importance of correct skill performance linked to assessment.

Teacher Class 91
Figure 5.4 displays the concept map for teacher 91’s video-stimulated interview. Concept associations within the data were indicated by four thematic circles. Teaching, students, answer and interaction were extracted by Leximancer as important concepts from within the data. The concept map shows that knowledge and problems were common to the thematic circles of students and teaching. Process and problem were common concepts in relation to the thematic circles of students and answers. The concept process is interpreted to represent the design process in this analysis. The concept students was closely associated to the concepts of think and strategy, with knowledge and time linking the concept of students to that of teacher.
Problem was closely associated to the concepts of process and answer, with problems linked to teacher, teaching, taught and school.

Figure 5.4
Teacher 91 Concept Map

The concept of learning linked to the concept of theory, problem-solving and teacher. The concept of teaching was closely associated to the concepts of theory, students, time, taught, school, learning and problem-solving. The concept knowledge lay between the concepts of teacher and students with problems being associated with knowledge. The thematic circle of interaction was set apart, indicating that this concept was less related to other concepts, although its proximity was close to the thematic circle of teaching. However, the concept of interaction linked through work and think to students and process. This association of concepts
is interpreted to indicate that the teacher considered that the students influenced the classroom interactions and that he had more of a facilitative role than a controlling influence.

The concept map is interpreted to indicate that teacher 91’s actions (tactics) centred on his teaching knowledge associated with solving problems. The teacher and his teaching also emphasised learning theory in his classroom. Thinking was a consequence of this process and it appeared that students engaged with their work activity (i.e. goal driven actions) to facilitate a process (i.e. the design-process) that supported the finding of answers to problems. Interactions occurred within the technology education classroom (student to student and teacher to student interactions), and provided support for student thinking as they worked.

The following extract from teacher 91’s video-stimulated interview provides support for the interpretation of teacher 91’s concept map. It seems that teacher 91 considered student learning to be the most important facet of his classroom’s activity. Teaching centred on promoting successful learners and this was facilitated through a design process curriculum.

<table>
<thead>
<tr>
<th>Class 91 Tch.doc~1.html#S1_385</th>
<th>Yes but the most important thing to me, for successful, for students to be successful learners, I use that purposefully. In the past it may have been the most important thing for me to be a successful teacher, which I find is incorrect. Right for the kids to be successful learners, I teach them how to learn.</th>
<th>Concepts: students AND teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 91 Tch.doc~1.html#S1_30</td>
<td>And once we are working through the design process, which we work by, brief, ideation, investigation, and selection and then we come to planning and production we go into the room next door here. Once we go into planning and production we then start to go backwards and forwards. That’s just you know they might start something, they realise hang on I need to research this a little bit better it’s not happening.</td>
<td>Concepts: process AND work</td>
</tr>
</tbody>
</table>

Note that teacher 91’s dialogue in relation to the design process (i.e. the underlined text above) indicated a sharing of ownership between the teacher and the students. However, when he started to discuss the student’s activity in relation to this process (i.e. problem-solving) he
changed his dialogue to place the responsibility with the student. This is interpreted as the teacher identifying a distinction between his responsibility for structuring the learning environment and the students’ responsibility for learning within the environment. The following extracts provide examples of the teacher’s strategy for supporting student learning within his lesson. He facilitated student activity and problem-solving through cueing and providing hints. However, he was careful not to provide hints to solve students’ problems because of his own understandings (knowledge). Students needed to seek answers given their own understanding and teacher 91 recognised his role as being a facilitator of students’ own problem-solving and not sharing problem-solving with students.

| Class 91 Tch.doc~1.html#S1_64 | INT: If you want to comment on that its fine. TCH 91: Right that strategy there I am happy with right, for several reasons. I did not give her, I did not prompt her to give me the answer that I wanted, and I prompted her to give me the answer that she thought was correct. | Concepts: think AND strategy |
| Class 91 Tch.doc~1.html#S1_69 | TCH 91: That is right, a little bit long winded in the way I said that. And that's a good example of the strategies that I'm after. Only there is not all students can follow that sequence of thought right. | Concepts: think AND students |
| Class 91 Tch.doc~1.html#S1_72 | A lot of students get stuck they look at you they're looking for facial expressions, they're looking for body language, is that the answer I want, is that the answer I should give. So that's part of achieving higher-order thinking as a part of getting the girls to be creative in their problem-solving approach and its part of getting girls to inquire about what they need to know. As far as sitting back and taking on what I think they should know. | Concepts: think AND students |

Teacher 91 indicated that his strategy for encouraging learning relied on his knowing each student’s learning needs. In this way, he centred his intentions on the learner in relation to each student’s classroom activities. Teacher 91 considered that his classroom teaching strategy accommodated learner-centred interactions. The following interview extracts support this interpretation of teacher 91’s interactions with individual student learning and problem-solving.
Right but knowing each student as an individual learner, knowing their strengths and weaknesses, enables me to cater for their needs more appropriately. Sounds good in theory impossible to do realistically. Right as you see there I cater for probably 70% of the class, the other girls were in the corner. I am then aware of their expectations and also it lends itself to a little bit of peer interaction. Which is important, which is important, trying to get away from the traditional way of teaching where its centred, throwing instructions, throwing knowledge out at the class and trying to bring around a learner centred interaction where it’s a two way thing. Ultimately and in theory I would like it to be a three way thing, me the students and the parents.

Teacher 91 identified that there were difficulties associated with understanding and catering for each student’s learning needs. The deep level knowledge required to facilitate student engagement was difficult to manage because of the number of students in the class. He also conceded that larger class sizes makes this type of strategic teaching extremely difficult and it potentially changes the classroom dynamic.

Therefore, it is concluded that teacher 91 used a design process curriculum to focus instruction. Within this structure, the underlying technological content (knowledge) was important in linking teaching and learning through student problem-solving. Teacher 91 facilitated this problem-solving activity by interacting with students as their individual needs
required. He prompted students to respond to difficulties during problem-solving by examining their own understanding of the underlying technological content. He resisted or refused to solve problems for students. In this way, students maintained ownership of their technological activity and the teacher distinguished between his responsibility to facilitate student learning and the students’ responsibility for the learning itself.

Additionally, the physical layout of the design and manufacture facility (i.e. designing and workshop area) encouraged the students to move from one area to the other. That is, the students designed products that incorporated technological concepts in the design area and manufactured products in the workshop area of the facility. During product manufacture and when a lack of understanding of the technological concepts inhibited constructing activity, the students moved back to the design area to seek further knowledge. Additionally, the students could experiment with theoretical information acquired during investigation in the design area, during subsequent workshop activity. In this way, students took responsibility for acquiring and understanding information and its application, rather than the teacher providing this information for students based on his own understandings.

The CHPQ results for class 91 indicate that the learning environment supported higher-order thinking in preference to lower-order thinking. It would appear that the type of support provided by teacher 91 promoted student higher-order thinking. The teacher promoted student understanding by emphasising the underlying technological content of student activity. He facilitated student learning by scaffolding students’ activities based on his understanding of each individual student’s learning needs. He supported students’ understanding of the technological content in relation to their individual design activity. Success in this regard was sought through recognition of student learning.
Teacher Summary

The leximancer analyses of teacher 21’s and 91’s video-stimulated interviews illustrate similarities to those resulting from other analyses reported in this chapter. However, the evidence presented in the concept mapping of both teachers’ interpretations of classroom activities indicates different areas of strategic emphasis and thus differences in classroom program. That is, class 21’s teacher used the design process to focus or motivate students such that product outcomes reflected enhanced levels of student engagement. Successful learning was measured through this process and difficult situations were seen as inhibiting student motivation and thus success. Therefore, teacher 21 shared responsibility for learning and problem-solving with the students so that successful product outcomes were maintained.

On the other hand, class 91’s teacher measured success through student learning. The design process was a vehicle for promoting student engagement with technological content, and problems encountered through this process served to strengthen student understanding and application of this technological knowledge. Thus, teacher 91 made a distinction between his responsibility for constructing learning situations and the students’ responsibility for the learning itself.

In other words, teacher 91’s instructional emphasis was to support student’s gaining technological knowledge through application in context (i.e. the design process as interpreted by teacher 91). Student engagement with problems was a consequence of this process and was monitored and supported by the teacher in terms of promoting student understanding of the technological content. Conversely, teacher 21’s instructional emphasis was on the design process (i.e. design, making and understand) as a method for instruction that was calculated to motivate students through the using of process skills previously acquired through teacher instruction. The following sections examine the Leximancer analysis of the student video-stimulated interviews of classes 21 and 91.
5.5.3.2 Students

Student video-stimulated interviews were conducted to identify the students’ interpretations of their own and their teacher’s classroom activities. That is, students were asked to explain: what they were thinking at particular points in the lesson, what they did as a result of teacher activity or instruction and what they thought was the reason for the teacher doing what he or she did in relation to the activity. The aim of this questioning was to correlate student understanding of the purposes of the lesson and lesson activities with those of the teacher. Table 5.10 below presents the concepts extracted by Leximancer for class 21 and 91 student interviews.

Table 5.10
Classes 21 & 91 (Students)
Leximancer Concept Analysis
(Common Concepts are Shaded)

<table>
<thead>
<tr>
<th>Concept</th>
<th>Absolute Count</th>
<th>Relative Count</th>
<th>Concept</th>
<th>Absolute Count</th>
<th>Relative Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>feel</td>
<td>31</td>
<td>100%</td>
<td>feel</td>
<td>44</td>
<td>100%</td>
</tr>
<tr>
<td>think</td>
<td>16</td>
<td>52%</td>
<td>think</td>
<td>44</td>
<td>100%</td>
</tr>
<tr>
<td>teacher</td>
<td>14</td>
<td>45%</td>
<td>make</td>
<td>23</td>
<td>52%</td>
</tr>
<tr>
<td>make</td>
<td>14</td>
<td>45%</td>
<td>teacher</td>
<td>23</td>
<td>52%</td>
</tr>
<tr>
<td>class</td>
<td>8</td>
<td>26%</td>
<td>work</td>
<td>18</td>
<td>41%</td>
</tr>
<tr>
<td>front</td>
<td>6</td>
<td>19%</td>
<td>class</td>
<td>16</td>
<td>36%</td>
</tr>
<tr>
<td>talk</td>
<td>5</td>
<td>16%</td>
<td>understand</td>
<td>12</td>
<td>27%</td>
</tr>
<tr>
<td>students</td>
<td>5</td>
<td>16%</td>
<td>knew</td>
<td>11</td>
<td>25%</td>
</tr>
<tr>
<td>work</td>
<td>5</td>
<td>16%</td>
<td>students</td>
<td>9</td>
<td>20%</td>
</tr>
<tr>
<td>making</td>
<td>4</td>
<td>13%</td>
<td>talking</td>
<td>8</td>
<td>18%</td>
</tr>
<tr>
<td>makes</td>
<td>3</td>
<td>10%</td>
<td>Project</td>
<td>7</td>
<td>16%</td>
</tr>
<tr>
<td>doing</td>
<td>3</td>
<td>10%</td>
<td>ideas</td>
<td>7</td>
<td>16%</td>
</tr>
<tr>
<td>lesson</td>
<td>2</td>
<td>6%</td>
<td>remember</td>
<td>7</td>
<td>16%</td>
</tr>
<tr>
<td>fact</td>
<td>2</td>
<td>6%</td>
<td>workshop</td>
<td>6</td>
<td>14%</td>
</tr>
<tr>
<td>advice</td>
<td>1</td>
<td>3%</td>
<td>time</td>
<td>5</td>
<td>11%</td>
</tr>
<tr>
<td>idea</td>
<td>1</td>
<td>3%</td>
<td>problems</td>
<td>5</td>
<td>11%</td>
</tr>
<tr>
<td>helps</td>
<td>1</td>
<td>3%</td>
<td>learn</td>
<td>5</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>interesting</td>
<td>5</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>decision</td>
<td>5</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>research</td>
<td>4</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>group</td>
<td>4</td>
<td>9%</td>
</tr>
</tbody>
</table>

In each class, three students were interviewed and the analysis for each class contains the data from all three of these interviews. The shaded concepts within the table indicate concepts that are common to each class. However, it is the concepts that are different across classes that are
of interest to this study, as these differences may have significance in terms of the learning environment’s influence on students’ use of different types of thinking. At this point, it is difficult to distinguish the significance of the different concepts across classes. However, it is interpreted that class 91 students use of concepts such as, understand, remember, knew, decision and learn indicate that they were concerned with issues related to their thoughts and learning. On the other hand, it is interpreted that class 21’s students use of doing, front (i.e. front is where the teacher supports the students), lesson and fact indicate that they were concerned with issues relating to production and teacher support. The following sections interpret theLeximancer analyses of the student video-stimulated interviews of classes 21 and 91 respectively.

Students Class 21
Figure 5.5 displays the concept map generated by Leximancer to indicate the strength of relationships between and across concepts from within the video-stimulated interview data for class 21 students.

Five main schematic themes were identified from within the data, teacher, think, feel, making and work. The concept teacher was associated with that of students, front, talk and advice. The concept think was associated with that of make, doing and fact. The concept students linked the concepts of teacher and think. The concept work was associated with that of idea and linked to make through doing. The concept feel was associated with that of makes, make, lesson and think. The main schematic theme of making was closely associated with the concept helps and linked to thinking through the concept make.
This concept map is interpreted to indicate that the students considered the teacher to be an important component of their classroom activity. That is, the concepts teacher and students were positioned close together signifying a strong association. The following interview extract supports this interpretation of the concept map.

| Class 21 St1.doc~1.html#S1_28 | STU 21/1: I think I was just figuring out if my joints were good or bad. I had never done those kinds of joints before. Just getting advice on what I should or should not do from the teacher. | Concepts: think AND teacher |

In addition, the students’ focus during the lesson appeared to be product motivated. The positioning of the main thematic circle of making is interpreted to indicate that making was an important component of the lesson and minimally associated with other concepts apart from
those of make and fact. This concept relationship is interpreted to indicate that the students were concerned about obtaining the facts in relation to their making activity. The following interview extracts indicate that the students interpreted the focus of the lesson as being about creating a product and their thinking was focused on this aspect of their activity.

<table>
<thead>
<tr>
<th>Class 21</th>
<th>St1.doc-1.html#S1_65</th>
<th>STU 21/1: It changed because I was kind of thinking like first up that I'll design like a car or something like that and then I thought we can make anything so I was thinking about using the wood lathe. And making a spinning top or something like that.</th>
<th>Concepts: think AND making</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 21</td>
<td>St2.doc-1.html#S1_31</td>
<td>STU 21/2: Because in the other classes the boys are making like traffic lights and little cities for boys, so I thought well we the girls could make a dolls’ house for the girls.</td>
<td>Concepts: think AND making</td>
</tr>
</tbody>
</table>

The program of class 21 is interpreted as one that supported students within design process-based activities. These activities appeared to be focused towards product outcomes and motivated students so that good grades were encouraged. It would appear that the students interpreted their own activities in much the same way as did the teacher. That is, that the teacher was important and that the design process helped them to create personally valued products. The following section examines the Leximancer analyses of the student interviews from class 91.

**Students Class 91**

Figure 5.6 displays the concept map generated by Leximancer to indicate the strength of relationships between and across concepts from within the video-stimulated interview data for class 91 students.

Four main schematic themes were identified from within the data, feel, think, understand and remember. The concept students was associated with that of class, group, project and feel. The concept teacher was associated with that of talking and project. The concepts that link the schematic themes of feel and think were identified by Leximancer as talking, project, class,
The concept of students linked to understand through the concept make and relied on the concepts research, learn and decision. The concept ideas was positioned close to workshop and make. The concept think was associated with the concepts problems and knew. The theme of remember was associated with teacher and included the concept interesting. Concept associations were examined further by extracting student responses that connect important concepts from within the data.

The distance of the concept teacher from concept students was interpreted to indicate that these concepts were less related than concepts such as, group, class, feel and project. The following interview extracts indicate that the students identified that the teacher was in the classroom to assist them but not to do the work for them. That is, ownership of their activity
was important to the students and the teacher provided useful support. However, the students recognised that teacher support was conditional on the difficulty they encountered during their technological problem-solving activities. In other words, if in the teacher’s opinion the student should have been able to solve the problem independently, he withdrew his support and this was understood by the students.

| Class 91 St3.doc~1.html#S1_61 | STU 91/3: Yes we do because a lot of times you can ask the teacher and he will give you a solution but it’s not, he does not know fully what you are trying to achieve. He will know little bits but he knows yes this is what she wants to get in the end. So you basically try to think of something that will help you get to what you want and just check that it will work with him. | Concepts: think AND teacher |
| Class 91 St3.doc~1.html#S1_66 | STU 91/3: It depends like if it's, I do not know it is a really simple question that we should know then he will not. He will like try to remind us oh you should have done this in like your folio or something, so try to think if you can remember it. But if it’s something that we've never heard of before and have no idea, he'll like, he will explain it to us and like try and help us. | Concepts: think AND help |

The close proximity of the concepts students, group, class, project and talking is interpreted to indicate an association across these concepts. The following interview extract provides support for this interpretation. The students were encouraged to share their knowledge with peers and the students understood that this helped them to understand their own and others’ activities during the class.

| Class 91 St3.doc~1.html#S1_119 | STU 91/3: It is because it’s like where we can all like go as a group, as an actual class not just like. Because mostly we are working on our projects although we do like to help our friends and stuff. This is the time when we all get together, like all of us and like really say what you think can help each other like a lot more. | Concepts: think AND work |

The interview extract above is interpreted to indicate that the students in class 91 experienced a sense of community during their learning. They seemed to understand that the teacher was
supporting their learning as individuals and their learning from each other. Therefore, the students of class 91 appeared to interpret the teaching strategies employed by teacher 91 in much the same way as the teacher. That is, the students seemed to know what the teacher was trying to achieve during their technology education classroom activity. Class 91 students accepted responsibility for their learning and their activity. They worked together to support each other and they realised that the teacher would support their technological problem-solving only as necessary. The following interview extract typifies the ownership and excitement students’ felt for their activity even if at times the teacher was required to provide support.

| Class 91 St2.doc~1.html#S1_40 | STU 91/2: I think he was getting me to solder one of the wires from the servo to the switch so I could get it to move. And in the previous lesson we were having trouble getting the switch to work so that’s like when we got it figured out and I was really excited about it working so. | Concepts: think AND work |

Additionally, the extract above highlights the type and level of support provided by the teacher. That is, the teacher did not generally tell or show the students how to do things, but he provided hints and cues and he sometimes modelled problem-solving with students in difficult problem situations. His level of support did not take ownership away from the students as evidenced through the student’s excitement related to the project working as intended.

Students Summary

The Leximancer analyses of the student video-stimulated interviews of classes 21 and 91 correspond well with those of teacher 21 and teacher 91 respectively. That is, it is interpreted from the Leximancer analyses that the students of these two technology education classes were aware of the teaching strategies in use within their respective classrooms. They seemed to understand the purpose for their activity and they correctly interpreted the teacher’s tactics in respect to the level of support provided and the emphasis of the curriculum.
5.6 Conclusion
This chapter provides empirical research evidence that supports the construct validity of the Cognitive Holding Power Questionnaire (CHPQ) and the reliability of the two scales of first order cognitive holding power (FOCHP) and second order cognitive holding power (SOCHP) to distinguish learning environments that press for different types of student thinking. It is argued that learning environments that press high for SOCHP are rich in second-order procedures (i.e. higher-order thinking) and those that press high for FOCHP are rich in first-order procedures (i.e. lower-order thinking) (Stevenson, 1984, 1986a, 1998). The aim of the quantitative analyses of this study was to identify technology education classes that pressed high for SOCHP and/or low for FOCHP and those that pressed high for FOCHP and/or low for SOCHP; and to examine through qualitative analyses, the factors that appeared to press students to think differently in technology education classes.

Twenty nine Australian technology education classes were surveyed early in the 2003 school year using the CHPQ during Study 1-Phase 1 pre-test. A number of classes were identified as pressing for different types of student thinking based on the analysis of the students’ CHPQ responses during Study 1-Phase 1, and were therefore chosen for case study observation (i.e. video observation and video-stimulated interviews) during Study 1-Phase 2. As stated in Section 5.4, because the CHPQ Study 1-Phase 3 post-test results identified two classes as pressing for different types of student thinking late in the 2003 school year, only the analyses of classes 21 and 91 were examined in this thesis. That is, it was discovered that class 21 pressed high for FOCHP and low for SOCHP and that class 91 pressed high for SOCHP and low for FOCHP. The differences identified through video-stimulated interview add to those discovered during video-data analysis as displayed in Table 5.8. Table 5.11 presented below, combines the two sets of analyses to facilitate the conceptualisation of a technology education classroom program supportive of student higher-order thinking.
Table 5.1
Australian Technology Education Classroom Program
Supportive of Student Higher-Order Thinking from
Video and Video-Stimulated Interview Analysis

<table>
<thead>
<tr>
<th>Technology Education Classroom Program Element</th>
<th>Emphasis of the Classroom Program Element</th>
<th>More</th>
<th>Less</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity Theory Component - Tools</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive Activity</td>
<td>Students &amp; Teacher devising solutions</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Teacher showing or telling students</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The students using known processes</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Teacher Modelling</td>
<td>Individual problem-solving/thinking skills</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Whole class/individual Process skills</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td><strong>Activity Theory Component - Subjects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resources for Learning</td>
<td>Real objects</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Images</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Written materials</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Student Success or Failure</td>
<td>Linked to positive student learning experiences</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Linked to grades, effort, self esteem and behaviour</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td><strong>Activity Theory Component - Division of Labour</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Learning Activity</td>
<td>Independent of the Teacher</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Dependent on the teacher</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Individual learning activity</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Group learning activity</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Responsibility for learning</td>
<td>Student</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Teacher</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Teacher-Student Interactions</td>
<td>Single student</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Whole class or groups of students</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Eliciting information from students</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Presenting information to students</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td><strong>Activity Theory Component - Rules</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focus of Instruction</td>
<td>Underlying technological content understanding through a design process</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Product outcome through a design process</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It is argued that the examination of the qualitative data from these two classes provides a more valid interpretation of classroom factors that press students for different types of thinking given the proximity of the post-test administration of the CHPQ and the length of student exposure to their respective technology education learning environments.

193
The results presented in this chapter facilitate an interpretation of the factors that support or inhibit student higher-order thinking in Australian technology education classes. In interpreting these results, a relationship has been suggested between particular types of teacher and student actions and interactions and the types of thinking used by students in technology education classes. Thus, the results from this study (i.e. Study 1) have led to the synthesis of factors that appear to support student higher-order thinking in Australian technology education.
classes as summarised in Table 5.11 and as depicted in Figure 5.7 above as an Australian technology education classroom activity system associated with students’ use of higher-order thinking.

In Table 5.11 these factors are presented as technology education classroom program elements within activity theory components that support teacher and student actions that form part of the teaching and learning activity of the classroom synthesised as promoting one form of thinking over another. The emphasis of these program elements is argued to press students to think in different ways within the classroom behaviour setting.

It is argued in Chapter 2 that activity, incorporating goal driven actions and automatic operations, derives meaning from its relation to the object of the activity (i.e. the collective overall goal of the activity system). In terms of class 21, the object of the activity system was found to be the promotion of student enjoyment through product creation within a design process curriculum framework. The setting program promoted activities that emphasised actions which pressed students to use lower-order thinking rather than higher-order thinking. The object of the activity system of class 91 was found to be the promotion of students learning of technological concepts (i.e. mechanisms and their movement) through a design process curriculum. The setting program promoted activities that emphasised actions that pressed students to use higher-order thinking rather than lower-order thinking. In both classroom settings, the teachers’ decisions at the macro-level concerned incorporation of a design-based curriculum to promote student engagement with technological activity so that prescribed outcomes might be realised. However, it would appear from the findings of this study that each teacher used different strategies at the intermediate and micro-levels to support learning outcomes. These strategies were implemented with the support of tactics (i.e. actions) that incorporated a particular emphasis. It is conceptualised in this thesis that the emphasis of teacher’s actions (i.e. tactics) during engagement with students influences the press of the learning environment for different types of student thinking. The results presented in this
chapter appear to support this view. The following chapter examines American technology education classrooms (i.e. Study 2-phases 1 & 2) in terms of the factors that cause students to think differently in these behaviour settings.
RESEARCH RESULTS AND ANALYSES: STUDY 2 AMERICA

6.1 Introduction
This Chapter reports the findings and analyses of Study 2. Study 2 examined American technology education classes using the CHPQ (quantitative) and through a case study (qualitative). In much the same way as Study 1 examined Australian technology education classes, the aim of Study 2 was to identify American technology education classes that pressed differently for student higher (SOCHP) and lower-order (FOCHP) thinking. The literature reviewed in this thesis advances the concept that the actions of technology education teachers influence the types of thinking used by students in their classrooms. Additionally, this thesis advances a conceptualisation of higher-order thinking and argues that technology teachers may promote students’ use of higher-order thinking by creating a classroom program in which certain kinds of teacher and student activities (i.e. goal driven actions) are promoted over others. Chapter 5 advances a set of teaching and learning actions (i.e. classroom program elements) (See Table 5.11 for details) that were associated with an Australian technology education classroom program that promoted student higher-order thinking.

Chapter 3 established a tendency for American technology education curricula to incorporate a modular design. The technology education classes examined in Study 2 are structured in this way, and as such, support an examination of modular technology education (MTE) in terms of the types of student thinking supported.

This chapter is structured in the following way. Section 6.2 presents the results and analysis of the CHPQ examination of American technology education classes (i.e. Study 2-Phase 1). Section 6.3 provides the results and analysis of the case study examinations of selected American classrooms based on the CHPQ results (i.e. Study 2-Phase 2). In addition, Section
6.3 provides a description of the technology education classroom settings selected for case study examination. In summary (Section 6.4), an American technology education classroom program was synthesised to be associated with students’ use of higher-order thinking.

**6.2 Study 2-Phase 1 CHPQ Results and Analysis**

Responses to the CHPQ were collected from 23 American technology education classes (414 students) during Study 2-Phase 1. The distribution of the data as analysed using a Shapiro-Wilk (SPSS, Ver 11.0, 2001) test of normality indicated that the technology class mean results for FOCHP and SOCHP were normally distributed apart for class 221 (SOCHP). As argued in Chapter 5, non-normal data can be used in parametric analysis with little negative effect on the results when population variances are found to be equal. The Levene statistic for the homogeneity of variances within the data for FOCHP (0.457) and SOCHP (0.860) indicated that the variances of the 23 class groups could be assumed to be equal (Field, 2000). Thus, the result of the Levene homogeneity of variances and the Shapiro-Wilk normality tests indicated that the data fulfilled the parametric analysis requirements (Field, 2000). As with previous data analyses presented in this thesis, the robust nature of the ANOVA (Field, 2000) tolerated the slight variations in class size when population variances were found to be equal (Kesselman, et al, 1998).

An initial ANOVA for the CHPQ data indicated significant differences in the data for gender and FOCHP and SOCHP. Table 6.1 presents the ANOVA results for this analysis and are interpreted to indicate that female students perceived that they were being supported more by teachers in terms of lower-order procedures (i.e. being shown and told how to do things) than were male students and that they were more independent in their use of higher-order procedures (i.e. devising procedures for unknown problem situations) than were male students.
Table 6.1
Study 2-Phase 1
Initial FOCHP & SOCHP Means
for Gender
(Standard Deviations in Brackets, N = Number)

<table>
<thead>
<tr>
<th>Gender</th>
<th>N</th>
<th>FOCHP Mean</th>
<th>SOCHP Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>360</td>
<td>2.99 (0.66)</td>
<td>3.14 (0.63)</td>
</tr>
<tr>
<td>Female</td>
<td>54</td>
<td>3.22 (0.75)</td>
<td>3.33 (0.69)</td>
</tr>
</tbody>
</table>

* Signifies a significant difference between gender means at the 0.05 level

To reduce the possible confounding effect of the significant difference between male and female results (i.e. gender differences) for both FOCHP and SOCHP, the female data have been removed from subsequent CHPQ analyses for Study 2. As each class in Study 2 included either very few or no female students, it was assumed that the removal of the small number of female students from the analyses would not significantly affect the nature of the results, given that individual student responses were collated in this analysis to examine the characteristics of American technology education classrooms relative to the press for FOCHP and SOCHP.

The means and standard deviations for Study 2-Phase 1 technology class identification (female responses removed) for FOCHP and SOCHP are provided in Table 6.2. One way analysis of variance (ANOVA) identified significant differences between technology classes for FOCHP \( (F = 1.756; p = 0.020; Eta squared = 0.103) \) and SOCHP \( (F = 2.754; p = 0.000; Eta squared = 0.152) \). Gabriel’s post hoc analysis identified significant differences between classes 232 and 233 and class 251 for SOCHP and no significant difference between classes for FOCHP. Therefore, classes 232, 233 and 251 have been selected for examination of their case study results given the results of the quantitative analyses for SOCHP. These technology education classes have been selected to support a conceptualisation of the factors that press students to think differently in American MTE classes.
Table 6.2
Study 2-Phase 1 FOCHP & SOCHP Means
Technology Class
(Standard Deviations in Brackets, N = Number)

<table>
<thead>
<tr>
<th>Tech Class Identification</th>
<th>FOCHP</th>
<th>SOCHP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>Tech Class 211</td>
<td>19</td>
<td>3.00 (0.61)</td>
</tr>
<tr>
<td>Tech Class 212</td>
<td>14</td>
<td>2.71 (0.62)</td>
</tr>
<tr>
<td>Tech Class 213</td>
<td>18</td>
<td>3.18 (0.68)</td>
</tr>
<tr>
<td>Tech Class 221</td>
<td>15</td>
<td>3.20 (0.86)</td>
</tr>
<tr>
<td>Tech Class 222</td>
<td>16</td>
<td>3.39 (0.54)</td>
</tr>
<tr>
<td>Tech Class 223</td>
<td>15</td>
<td>2.96 (0.64)</td>
</tr>
<tr>
<td>Tech Class 224</td>
<td>13</td>
<td>2.85 (0.58)</td>
</tr>
<tr>
<td>Tech Class 225</td>
<td>12</td>
<td>3.17 (0.75)</td>
</tr>
<tr>
<td>Tech Class 231</td>
<td>20</td>
<td>2.95 (0.49)</td>
</tr>
<tr>
<td>Tech Class 232</td>
<td>21</td>
<td>2.93 (0.61)</td>
</tr>
<tr>
<td>Tech Class 233</td>
<td>20</td>
<td>2.85 (0.62)</td>
</tr>
<tr>
<td>Tech Class 241</td>
<td>16</td>
<td>3.44 (0.79)</td>
</tr>
<tr>
<td>Tech Class 242</td>
<td>18</td>
<td>3.20 (0.59)</td>
</tr>
<tr>
<td>Tech Class 251</td>
<td>11</td>
<td>2.95 (0.63)</td>
</tr>
<tr>
<td>Tech Class 252</td>
<td>11</td>
<td>3.08 (0.48)</td>
</tr>
<tr>
<td>Tech Class 261</td>
<td>10</td>
<td>2.83 (0.46)</td>
</tr>
<tr>
<td>Tech Class 262</td>
<td>10</td>
<td>2.59 (0.81)</td>
</tr>
<tr>
<td>Tech Class 263</td>
<td>13</td>
<td>2.91 (0.78)</td>
</tr>
<tr>
<td>Tech Class 271</td>
<td>22</td>
<td>2.92 (0.50)</td>
</tr>
<tr>
<td>Tech Class 272</td>
<td>24</td>
<td>2.82 (0.55)</td>
</tr>
<tr>
<td>Tech Class 281</td>
<td>12</td>
<td>2.70 (0.85)</td>
</tr>
<tr>
<td>Tech Class 282</td>
<td>16</td>
<td>2.73 (0.57)</td>
</tr>
<tr>
<td>Tech Class 283</td>
<td>14</td>
<td>3.22 (0.73)</td>
</tr>
<tr>
<td>Total</td>
<td>360</td>
<td>2.99 (0.66)</td>
</tr>
</tbody>
</table>

* Identifies a significant difference to the bolded means at the 0.05 level

6.3 Study 2-Phase 2 Case Study Examinations

6.3.1 Description of Settings.
The 23 American technology classes under case study examination originated from eight high schools, within various districts in the one American State (North Carolina). In most cases, the classrooms included an area designated for didactic instruction and an area for computer
access (i.e. modules) situated within the classroom. It was not reported that any of the technology classrooms had direct access to a workshop type facility. The curriculum included a designing component and the students generally worked with print and electronic resource materials, although some classes used real objects during design activities. The technology curriculum was centrally designed and compiled, with the curriculum support materials and assessment being mandated for use by classroom teachers. The following section examines the case study data to interpret factors that may have promoted or inhibited student higher-order thinking in selected American technology education classrooms.

6.3.2 Case study Observations
Each American technology education class was observed during normal classroom activity. A researcher used the same type of activity observation sheet as used in Study 1 to log activities as they were observed for each classroom minute (See Appendix 16). These activities occurred in the foreground (under the direct influence of the teacher) and in the background (students working independent of the teacher) of each lesson. Details of both the observation sheet and of the activity categories are provided in Chapter 4. The categories were identical in both the American and Australian case study analysis of technology education classroom activity (i.e. goal driven mediated actions).

As noted in Section 6.2, classes 232, 233 and 251 were chosen for closer examination of their case study (i.e. classroom observations) because of significant differences indicated in the learning environments’ press for SOCHP. At the time of observation, class 232 students were involved in a lesson that initially required the students to complete a review worksheet of content covered in a previous lesson. When the review worksheet was completed, the teacher lectured the students on computer aided drafting (CAD) using a Power-Point presentation as support. At the conclusion of the lecture, the students were required to complete a revision worksheet on the CAD content covered in the teacher’s lecture. Table 6.3 below presents the actions of the teacher and students of class 232 during this one 75 minute lesson. The actions
are represented by codes and described in the corresponding column with the lesson time taken for each code included.

The data in Table 6.3 indicate that the lesson incorporated similar amounts of foreground and background action. The background actions would seem to confirm the literature presented in Chapter 3 and suggests MTE classrooms encourage students to work independent of the teacher in a manner that is self-regulated through interaction with workbooks, media and computers. On the other hand, the foreground actions seem to suggest a considerable amount of class time dedicated to teacher instruction which would seem at odds with the literature for the same reason.

### Table 6.3
Class 232
Lesson Actions

<table>
<thead>
<tr>
<th>Code</th>
<th>Class Time</th>
<th>Foreground Code Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLVWITAM</td>
<td>11 min</td>
<td>The teacher providing information to the whole class about the written material using knowledge about things and images and how to perform skills, while monitoring student understanding.</td>
</tr>
<tr>
<td>PLVWTA</td>
<td>4 min</td>
<td>The teacher providing students with knowledge about things and about how to perform skills using written materials.</td>
</tr>
<tr>
<td>ELVWTM</td>
<td>10 min</td>
<td>The teacher eliciting knowledge about things from the whole class using written materials, while monitoring student understanding.</td>
</tr>
<tr>
<td>ELVWITM</td>
<td>2 min</td>
<td>The teacher eliciting knowledge about things from the whole class using written materials and images, while monitoring student understanding.</td>
</tr>
<tr>
<td>PLVXT</td>
<td>7 min</td>
<td>The teacher presents knowledge about things to the whole class.</td>
</tr>
<tr>
<td>NXXXXX</td>
<td>41 min</td>
<td>No foreground activity.</td>
</tr>
<tr>
<td>NO / BG</td>
<td>34 min</td>
<td>No background activity.</td>
</tr>
<tr>
<td>DLVCM</td>
<td>1 min</td>
<td>The whole class following teacher instructions and taking out materials for the lesson while the teacher monitors progress.</td>
</tr>
<tr>
<td>NROWIY</td>
<td>11 min</td>
<td>Students working independent of the teacher on their own taking notes (written materials) while watching a video (images) to identify problem-solving skills.</td>
</tr>
<tr>
<td>NROWTAM</td>
<td>12 min</td>
<td>Students working independent of the teacher on their own using propositional knowledge and knowledge about how to perform a skill in response to the specific requirements of written materials (work sheet), while the teacher monitors student progress.</td>
</tr>
<tr>
<td>NROWTA</td>
<td>12 min</td>
<td>Students working independent of the teacher on their own using propositional knowledge and knowledge about how to perform a skill in response to the specific requirements of written materials (work sheet).</td>
</tr>
<tr>
<td>NPSVXG</td>
<td>5 min</td>
<td>Students initiate interactions between each other as a whole class working independent of the teacher using higher-order procedures.</td>
</tr>
</tbody>
</table>
Table 6.4 below presents the actions of the teacher and students of class 233 during one 75 minute lesson. This lesson was structured in much the same way as class 232’s lesson, with the content and delivery method being similar.

<table>
<thead>
<tr>
<th>Code</th>
<th>Time</th>
<th>Foreground Code Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLVWITAM</td>
<td>20 min</td>
<td>The teacher providing information to the whole class about the written material using knowledge about things and images and how to perform skills, while monitoring student understanding.</td>
</tr>
<tr>
<td>PLVWTM</td>
<td>5 min</td>
<td>The teacher providing students with knowledge about things using written materials.</td>
</tr>
<tr>
<td>PLVWTAM</td>
<td>2 min</td>
<td>The teacher providing information to the whole class about the written material using knowledge about things and how to perform skills, while monitoring student understanding.</td>
</tr>
<tr>
<td>ELVWTAM</td>
<td>3 min</td>
<td>The teacher eliciting knowledge about things and about how to perform skills from the whole class using written materials, while monitoring student understanding.</td>
</tr>
<tr>
<td>ELVWITAM</td>
<td>6 min</td>
<td>The teacher eliciting knowledge about things and about how to perform skills from the whole class using written materials and images, while monitoring student understanding.</td>
</tr>
<tr>
<td>PLVXT</td>
<td>7 min</td>
<td>The teacher presents knowledge about things to the whole class.</td>
</tr>
<tr>
<td>NXXXXX</td>
<td>32 min</td>
<td>No foreground activity.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Background Code Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO / BG</td>
</tr>
<tr>
<td>NROWIY</td>
</tr>
<tr>
<td>NROWTA</td>
</tr>
<tr>
<td>NPSVXG</td>
</tr>
</tbody>
</table>

Lessons 232 and 233 display congruence in terms of the types of actions and the time dedicated to these actions in the lesson foreground and background. This may be explained by each lesson being managed by the same teacher using the same curriculum materials despite each student cohort being different. This result gives strength to the validity and reliability of the CHPQ to measure the press of the learning environment for different types of student
thinking. Given that the actions of the students and the teacher were similar in both of these classes it is important that the CHPQ results reflect this similarity. It would seem that the classroom programs were similar for each class and this resulted in similar teacher and student actions, which pressed for similar types of student thinking (i.e. SOCHP).

Table 6.5 below presents the actions of the teacher and students of class 251 during one 75 minute lesson.

<table>
<thead>
<tr>
<th>Code</th>
<th>Class Time</th>
<th>Foreground Code Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLVWITM</td>
<td>1 min</td>
<td>The teacher providing information to the whole class about the written material using knowledge about things and images and how to perform skills, while monitoring student understanding.</td>
</tr>
<tr>
<td>PLVWITAM</td>
<td>2 min</td>
<td>The teacher providing information to the whole class about the written material using knowledge about things and images and how to perform skills, while monitoring student understanding.</td>
</tr>
<tr>
<td>PLVWITYM</td>
<td>1 min</td>
<td>The teacher providing information to the whole class about the written material using knowledge about things and images and showing students how to perform skills, while monitoring student understanding.</td>
</tr>
<tr>
<td>PLVXT</td>
<td>4 min</td>
<td>The teacher presents knowledge about things to the whole class.</td>
</tr>
<tr>
<td>NXXXXX</td>
<td>68 min</td>
<td>No foreground activity.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Background Code Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO / BG</td>
</tr>
<tr>
<td>NROWITA M</td>
</tr>
<tr>
<td>NROWITYG</td>
</tr>
<tr>
<td>NROWITYG M</td>
</tr>
<tr>
<td>NROWITY M</td>
</tr>
<tr>
<td>NROWITM</td>
</tr>
<tr>
<td>NROWITY</td>
</tr>
</tbody>
</table>
At the time of observation class 251 was working on drafting and orthographic projection. Students were required to complete worksheets on these topics. When completed, the students were instructed to use the NC Fundamentals of technology Curriculum Guide to read about and see examples of dimensioning techniques. The students then worked on a computer module which consisted of a computer program called “A Home of My Own” and guided students through the processes involved in the building and selling of a house. The data in Table 6.5 indicate that less foreground activity occurred in class 251 when compared to classes 232 and 233 and students appeared to be more involved independent of the teacher in the lesson background.

A comparison of teacher and student actions across classes 232, 233 and 251 indicate that:

When compared to Class 232 and 233, Class 251’s teacher:

- presented propositional knowledge to the students less often
- elicited information from the students less often
- initiated interaction with the students in the lesson foreground less often
- interacted with the whole class less often
- used written materials, images and no resources less often
- told students how to do things less often
- monitored students less often in the lesson foreground and more often in the lesson background
- initiated monitoring of students less often in the lesson foreground and more often in the lesson background
- planned lessons to have less lesson foreground activity and more lesson background activity

When compared to Class 232 and 233, Class 251’s students:

- worked less in the lesson foreground and more in the lesson background
- worked independent of the teacher more often
- worked as individuals more often
- used known processes slightly more often
- devised procedures more often
- used written materials and real objects more often and images less often
- had their actions initiated by a resource more often

From these findings it is inferred that teacher 251 created a classroom program through the selection of teaching strategies that placed students in individual learning situations independent of the teacher for the majority of the lesson. The teacher appeared to take less direct responsibility for student learning by providing less knowledge about things (i.e. propositional knowledge) and by telling students how to do things less often, when compared to classes 232 and 233. The teacher monitored students less in the lesson foreground and more in the lesson background. The students used written materials and real objects rather than images during the learning activity that was independent of the teacher. Additionally, class 251 students engaged more in devising procedures during their background activities. To explore these inferences further the data were separated into activity theory components and classroom program elements (i.e. teacher and student mediated actions and curriculum emphasis) to conceptualise a technology education program that supports higher-order thinking based on the results drawn from three American technology education classes. Table 6.6 provides a set of teaching and learning actions that are conceptualised to support student higher-order thinking in American MTE classes.
The findings of the observations of the selected American technology classes supports a conceptualisation of an American technology education learning environment that promotes higher-order thinking in preference to lower-order thinking as one which:

1. Promotes teacher interaction with the whole class less often
2. Encourages student and teacher devising activities and discourages the teacher from telling students how to do things
3. Uses a mix of images, written materials and real objects to support teaching and learning
4. Suppresses the presenting of information (i.e. propositional knowledge) to students
5. Discourages the teacher from eliciting information from students
6. Allows students to be actively engaged independent of the teacher for the major portion of the lesson
7. Promotes student initiation of action by a resource rather than by the teacher
8. Encourages students to accept more responsibility for decision-making by promoting less reliance on teacher assistance
9. Encourages students to use known processes as previously instructed by the teacher
10. Restricts the use of written materials in the lesson foreground
11. Promotes student individual activity and suppresses group activity
12. Promotes teacher monitoring in the lesson background (focused at devising procedures/problem-solving support for individual students) and restricts teacher monitoring in the lesson foreground (focused at propositional knowledge support during whole class instruction)

The activity theory components presented in Table 6.6 and summarised above are presented below in Figure 6.1 as a depiction of an American technology education classroom activity system associated with the promotion of students’ use of higher-order thinking. Some areas of the activity system are represented as not yet known and are highlighted in Table 6.7 as requiring further study.
The case study results and analyses of the selected American technology education classrooms provide some areas of similarity and difference when compared to the results and analyses of the selected Australian technology education classrooms. As previously stated, these similarities and differences are significant because they support an interpretation of factors that support or inhibit higher-order thinking in technology education classes from within two countries. Table 6.7 provides an indication of the similarities and differences across countries as found in this study of teaching strategies and tactics (i.e. learning and teaching activity and mediated actions) that were associated with students’ use of higher-order thinking.
Table 6.7 
Australian and American Technology Education Classroom Program 
Supportive of Student Higher-Order Thinking

<table>
<thead>
<tr>
<th>Technology Education Classroom Program Element</th>
<th>Emphasis of the Classroom Program Element</th>
<th>Australia</th>
<th>America</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity Theory Component - Tools</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Cognitive Activity | Students & Teacher devising solutions  
Teacher showing or telling students  
The students using known processes  
Student actions initiated by a resource (e.g. multimedia, computer, booklets) | ✔ | ✓ | ✓ |
| Teacher Modelling | Individual problem-solving/thinking skills  
Whole class/individual Process skills | ✓ | ? | ? |
| **Activity Theory Component - Subjects** | | | |
| Resources for Learning | Real objects  
Images  
Written materials | ✔ | ✔ | ✓ |
| Student Success or Failure | Linked to positive student learning experiences  
Linked to grades, effort, self esteem and behaviour | ✓ | ? | ? |
| **Activity Theory Component - Division of Labour** | | | |
| Student Learning Activity | Independent of the Teacher  
Dependent on the teacher  
Individual learning activity  
Group learning activity | ✔ | ✔ | ✓ |
| Responsibility for learning | Student  
Teacher | ✔ | ? | ? |
| Teacher-Student Interactions | Single student  
Whole class or groups of students  
Eliciting information from students  
Presenting information to students | ✔ | ✔ | ✓ |
| **Activity Theory Component - Rules** | | | |
| Focus of Instruction | Underlying technological content understanding through a design process  
Product outcome through a design process | ✔ | ? | ? |

Table 6.7 merges the Australian and American findings to identify classroom programs that exhibit similarities and differences across two countries. Table 6.7 also provides an indication
of areas that require further investigation given the findings of Study 1 and Study 2. These factors are unknown (signified with a question mark?) because of the variation in research methods across Studies 1 and 2. The capacity of video-stimulated interviews to gain data associated with, responsibility for learning, focus of instruction, student success or failure and teacher modelling was not able to be applied in Study 2, and so, are questions as yet unanswered in terms of American MTE classes. In the sample of Australian technology classes chosen for Study 1 no modular equipment were used, and so, no results were found to confirm the influence of resources, such as computers, multimedia and work books, on the initiation of student independent of the teacher actions. Areas for further research are discussed in Chapter 7.

It is argued in this thesis that the technology education classroom program is created by the overall influence of strategy selection and implementation. Therefore, the results summarised in Table 6.7 are interpreted as jointly supporting the classroom program, rather than as being a series of isolated strategies or instructional activities. The conceptualisation of higher-order thinking as advanced in this thesis supports this interpretation, because the classroom program is argued to be equivalent to the behaviour setting program (i.e. technology education classroom program as conceptualised in Chapter 3) and thus influences the types of activities engaged with by students. Activity theory suggests that activity may only be interpreted in the context of the object of the activity (i.e. overall collective goal or outcome), and so the findings of this study identify actions and parts of actions (i.e. program elements and program element emphasis) that require interpretation in the context of the activity system object. The findings in Study 1 suggest that goal driven actions (i.e. learning and teaching activity) should be directed towards student independent learning of technological knowledge within a design-process framework. In Study 2, the activity system depicted in Figure 6.1 provides an interpretation of what actions occurred but not why. Therefore, Study 2 does not provide a complete interpretation of an American MTE activity system, but does associate certain types of teacher and student actions with students’ use of higher-order thinking.
The literature reviewed in Section 3.3.3 indicates that modular technology education (MTE) classrooms often use curriculum designed by commercial suppliers and that many of the teaching strategies and tactics used to implement them are not designed at the classroom level. Additionally, the North Carolina technology education curriculum was centrally designed and compiled, with the curriculum support materials and assessment being mandated for use by classroom teachers. Despite the mandated curriculum and support materials, differences were evident in the press of the American technology education classes for SOCHP. Therefore strategy implementation, or the tactics used by teachers to implement curriculum, seems to have impacted directly on the types of activities students used within classrooms and as a result influenced the types of thinking used by students. The following section provides a conclusion of the results and analyses presented in this chapter.

6.4 Conclusion

This chapter presents the results and analyses from Study 2. Study 2 investigated factors that were associated with students’ use of higher-order thinking in American technology education classes. From the American technology classrooms initially examined by quantitative analysis, the significantly different instances of support for higher-order thinking were isolated for qualitative analysis. No difference between classes was found for lower-order thinking (i.e. FOCHP) in the sample of classes for this study. The findings of the qualitative analysis (i.e. case study using classroom observations) are interpreted to indicate that higher-order thinking may be promoted by certain types of teacher and student goal directed actions (activities) within American technology education classrooms. Table 6.6 displays a set of technology education classroom program elements that summarise these actions and conceptualise links between the program elements and activity theory components. Table 6.7 connects technology education program elements from two countries that have been found to be associated with higher-order thinking in this study. Figure 6.2 below depicts these components as a technology education activity system associated with promoting student higher-order thinking. The bolded
dot-point text within the activity system represents technology education program elements that were found to have consensus across countries in terms of association with higher-order thinking. The dot-point elements displayed in plain text were found to associate with higher-order thinking in one country only.

Figure 6.2
Technology Education Activity System Associated with promoting Higher-Order Thinking

**Tools**
- **Cognitive Activity**
  - Devising Problem Solutions
  - Students using known processes
  - Students’ actions initiated by a resource

**Teacher Modelling**
- Individual problem-solving skills

**Subjects**
- **Resources for Learning**
  - Real objects
  - Images
  - Written Materials
  - Student Success or Failure
  - Linked to positive student learning experiences

**Division of Labour**
- **Student Learning Activity**
  - Independent of the teacher
  - Individual learning activity

**Responsibility for Learning**
- Students
  - Teacher-Student Interactions
  - Single student
  - Eliciting information from students

**Outcome**
- Students gaining of technological knowledge, enjoyment and excitement generated by product outcomes

**Object**
- Students’ learning of technological content independently within a design-process framework

**Rules**
- **Focus of Instruction**
  - Underlying technological content understanding through a design-process

**Subjects**
- **Community**

**Sense Meaning**
- Mediating Artefacts
The activity system is conceptualised at the classroom level, and as such, its community is the teacher and students. In other words, this activity system occurs within the behaviour setting, and therefore, is influenced by other related settings as described in Chapter 2. The mediating artefacts are the things used by inhabitants of the setting (i.e. teacher and students) that support goal attainment through use with some form of action during collective activity. In American MTE classes these may be computer programs, multimedia, modular technology and work books. In Australian technology education classes these are more likely to be hand and machine tools, student projects and design folios. In the context of this study, these artefacts are also used to identify the characteristics of the learner (i.e. subjects). That is, the preference of students to learn by engaging with real objects (i.e. to learn by doing with regard to student design projects), images (i.e. multimedia) and/or written materials (i.e. work books) within the behaviour setting, and to have positive learning outcome experiences.

The rules of the classroom activity system emanate from the focus of instruction. This focus is established by the teacher during the front-end analysis of the prescribed curricula documentation (See Chapter 3 for details). Decisions regarding instructional strategies are made by the teacher at the macro-level to focus classroom activity towards certain outcomes. In other words, the rules of the activity system support the collective in attaining the object of the activity system through goal driven actions and automatic operations (See Chapter 2 for details). In this study, it was found that an Australian technology education class associated with higher-order thinking was concerned with outcomes that increased students’ understanding and knowledge of certain types of technological content. The actions of the teacher and students were governed by the division of labour which promoted single student to teacher interaction. Students’ goal driven actions occurred independently and without the teacher reducing the students’ responsibility for decisions made regarding the appropriateness of their actions relative to goal attainment. The teacher modelled individual problem-solving skills and facilitated the devising of solutions to problems that impeded student goal attainment without reducing the students’ perception of responsibility.
It would appear that the findings of this chapter support the conceptualisation of higher-order thinking as synthesised in this thesis. In this conceptualisation the behaviour setting program is argued to promote higher-order thinking through particular instructional strategy selection and implementation. The inanimate artefacts (i.e. psychological and technical tools) within the activity system mediate the actions of the teacher and students in a synomorphic relationship. The hierarchical cognitive structures of the individual acting within the activity system, responds to problems that inhibit personally important goal attainment by regulating individual cognitive processes in response to an understanding of self and to seek access to prior knowledge (i.e. memories) of similar problem situations. In terms of the activity system proposed in this chapter, it is the object of the students learning of technological content within a design-process framework that drives the system and mediates the actions of the teacher and the students that promotes students’ use of higher-order thinking within the behaviour setting (i.e. the technology education classroom).

The following chapter examines the implications of the results of Study 1 and Study 2 and present areas for further research because of the findings of this study.
CONCLUSIONS DRAWN FROM THE STUDY

7.1 Introduction

Two problems are addressed in this thesis: firstly, to understand the nature of higher-order thinking in technology education classrooms, and secondly, to understand the characteristics of classroom conditions that promote this kind of thinking. This study is the first to combine theories of cognition (Anderson, 1982; Fischer, 1980; Jones & Anderson, 1987; Newell & Simon, 1972; Scandura, 1981; Stevenson, 1984), behaviour settings (Barker, 1968, 1978; Wicker, 2002, 1991, 1984) and activity (Engeström, 2000; Engeström & Cole, 1997; Jonassen & Rohrer-Murphy, 1999; Virkkunen & Kuutti, 2000) to examine classroom activities (teaching strategies and tactics) that promote students’ use of higher-order thinking in technology education.

This thesis contributes to theory by advancing a conceptualisation of higher-order thinking, synthesised to incorporate influence from the behaviour setting, culturally mediated activity (i.e. actions using culturally significant technical and psychological tools), and the hierarchically controlled internal cognitive structures of a person. The synthesis of these theories (i.e. cognitive theory, behaviour setting theory and activity theory), as conceptualised in terms of higher-order thinking, infers meaning to classroom activity, classroom actions and decisions made relative to prescribed classroom learning outcomes and students’ use of higher-order thinking in the realisation of these outcomes (i.e. the object of the activity system).

Jonassen et al (1990) argue that teachers design instruction through a process of front-end analysis of the mandatory curriculum documentation, which results in the selection of teaching strategies at various levels and that these strategies are implemented using instructional tactics.
Jonassen, et al (1990), Leshin et al (1992) and Rothwell and Kazanas (1992) argue that these instructional aspects (strategies and tactics) formulate the instructional design framework of the learning environment (i.e. the technology education classroom in terms of this study), and create what is described in this thesis as the classroom program (See Section 3.3.2 for details). It is argued in this thesis that to promote student higher-order thinking, it is necessary to understand the decisions teachers make (i.e. strategy selection and implementation), the influence these decisions have on student learning activity (i.e. goal driven mediated actions) and the resulting influence these activities have on the types of thinking students use in technology education classrooms. In other words, it is necessary to identify the technology education classroom program that promotes students’ use of higher-order thinking.

It is predicted in this thesis that certain types of classroom program support student higher-order thinking in technology education classes (See Section 3.4 for details). The theories examined in this thesis, are used to establish a conceptualisation of higher-order thinking and to provide support for the predictions argued to promote higher-order thinking in technology education classes. That is, cognitive theory, behaviour setting theory and activity theory have been examined in this thesis, to conceptualise higher-order thinking in terms of these theories, and to establish a theoretical understanding of the types of mediated actions (i.e. classroom program) that promote higher-order thinking in technology education classes.

Two studies were undertaken to examine technology education classes in Australia (Study 1) and America (Study 2). The aim of these studies was two-fold: firstly, to establish the types of classroom program that supported different types of student thinking in two countries, and secondly, to examine the nature of higher-order thinking in terms of the conceptualisation advanced in the thesis. It is argued that these two areas are related and important because the identification of teacher and student activities (i.e. goal driven mediated actions) that promote higher-order thinking within technology education classrooms, supports an understanding of
the nature of higher-order thinking and of the instructional conditions necessary for its promotion.

This chapter is structured in the following way. Section 7.2 outlines the theories employed in this thesis and the predictions proposed based on the theories. Section 7.3 provides a summary of the results of the study and relates these to the literature reviewed in Chapters 2 and 3. Section 7.4 examines the contributions of the study to theory and the practice of teaching, learning and the promotion of higher-order thinking in technology education classes. Section 7.5 provides suggestions for areas that require further investigation.

7.2 Theories Outlined
7.2.1 Cognitive Theory
Stevenson’s (1984, 1986a, 1986b) and Barkley’s (2001) theories of cognitive adaptation support a conceptualisation of a hierarchical cognitive system that enables transformations to occur. Stevenson, (1986a) argues that transformations to existing lower-order specific procedures within the cognitive system allow the person to adapt to situations that appear to be novel or non-routine during goal attainment. Barkley’s (2001) Executive Functions (EFs) provide support for Stevenson’s (1984, 1986a, 1986) hierarchy of adaptive cognitive processes (See Section 2.3). In both Stevenson’s and Barkley’s theories, the activation and regulation of transformations are controlled by cognitive structures that exist at higher, more general levels.

7.2.2 Self Regulation
Student self-regulation involves learner autonomy and this is widely regarded as a desirable component of contemporary curriculum development and implementation (Boekaerts, 1997; Eshel & Kohavi, 2003; Paris & Paris, 2001; Perry, Phillips, & Dowler, 2004; Ryan, & Deci, 2000; Stefanou, Perencevich, DiCintio, & Turner, 2004; Veugelers, 2004). Stefanou, et al, (2004) argue that the self-regulated learner should possess a disposition for thinking or thoughtfulness. Boekaerts, (2002) argues that self-regulation is performed with reference to personal goals and these goals emanate from a person’s interpretation of self. Therefore, it is
argued in this thesis that personal goals are likened to Barkley’s (2001) desirable hypothetical futures and are the regulating mechanisms that determine how and when (i.e. higher-order procedures) lower-order procedures are compiled within the cognitive system. Lower-order procedures are used automatically in response to familiar situations, while higher-order procedures are used as a controlled response to unfamiliar situations (i.e. problems) (Stevenson, 1986a). In other words, self-regulation is argued in this thesis to be an essential characteristic of higher-order thinking and is activated with regards to problems that impede personally important goal attainment.

7.2.3 Behaviour Settings Theory
Barker’s (1968, 1978) theory of behaviour settings is argued in this thesis to be important in terms of conceptualising an individual’s use of higher-order thinking. Barker (1968) defines behaviour settings as complex systems of milieu-behaviour synomorphs (i.e. a synomorphic relationship between artefacts and behaviours) that support and maintain individual goal attainment through a socially maintained setting program. That is, behaviour settings are argued to have an ordered and socially maintained program that impacts, both negatively and positively, upon various individuals’ personal goal attainment within the setting, and thus influence the types of activities a person or persons may engage with during routine or non-routine situations in pursuit of their goals. In other words, the behaviour setting program is conceptualised in this thesis as influencing the thinking of setting inhabitants (i.e. students in terms of this study) through its propensity to promote certain types of activity (i.e. mediated actions) over others. In addition, other related settings also exert an influence on goal attainment because of the interrelationships experienced by setting inhabitants between and across these settings (Wicker, 2002, 1991).

7.2.4 Activity Theory
Susi and Ziemke (2001), Hacker (2001), Engeström (2000) and Jonassen and Rohrer-Murphy, (1999) argue that within activity theory, activities are considered to have a hierarchical structure. At the highest level, activities are undertaken as a result of a personally significant
motivating factor. This motivating factor or overall collective purpose is defined as the object of the activity. Transformations occur, which have a reciprocal influence on the object of the activity and the actions of individuals (Susi & Ziemke 2001; Jonassen & Rohrer-Murphy, 1999). Actions are directed at a more specific set of individual goals and it is the aggregation of these actions that support the activity and thus the object of the activity system. Operations are sub-units of actions that react automatically to environmental factors and constantly adjust a person’s actions relative to these factors (Susi & Ziemke, 2001). Additionally, it is the mediation by tools (i.e. psychological tools and technical tools) of actions that indicates that cognition exists and interrelates on two planes, one internal to the person and one external to the person, in order that goals are attained.

7.2.4 Instructional Theory
Jonassen, et al, (1990) argue that instructional design can be conceptualised as a process of front-end-analysis that results in the implementation of instructional strategies at various levels (i.e. the macro, intermediate, and micro levels). These implementations of strategies result in students’ engagement in activities (i.e. mediated actions) that support their displaying of an intended outcome or instructional objective (Jonassen, et al, 1990; Rothwell & Kazanas, 1992). Rothwell and Kazanas, (1992) argue that during student learning activity teachers facilitate particular outcomes or objectives using simple instructional tactics. An instructional tactic is defined as what teachers do as they interact with students during strategy implementation (Jonassen, et al, 1990; Leshin, et al, 1992; Rothwell & Kazanas, 1992).

In this thesis, the concept of classroom program (i.e. behaviour setting program) supports a conceptualisation of technology education classrooms that support certain types of activities over others. That is, it is argued that teachers select strategies and the tactics that support their implementation, based on an interpretation of the stipulated curriculum documentation through a process of front-end-analysis and that different strategies and tactics promote different types of teacher and student classroom activity (Jonassen, et al, 1990; Rothwell &
Kazanas, 1992). The conceptualisation of higher-order thinking presented in this thesis suggests that different types of student thinking are promoted by different types of student learning activity (i.e. mediated actions) (Stevenson, 1986a). In other words, different classroom programs support different types of student thinking because teachers select different types of instructional strategies. Thus, it is argued in this thesis that a relationship between teaching, learning and higher-order thinking can be conceptualised in terms of the theories reviewed in this thesis.

7.2.5 Theories Outlined Summary

This thesis examines literature associated with theories of cognition, behaviour setting and activity to support a conceptualisation of higher-order thinking. As a result of this examination, this thesis advances the conceptualisation of higher-order thinking as depicted in Figure 7.1. The conceptualised relationship across these theories and represented visually in Figure 7.1, suggests that higher-order thinking incorporates the notion of influence from the socially maintained and mutually beneficial behaviour setting (i.e. the program and various milieu-behaviour synomorphs), the self-regulated adaptive system that incorporates a hierarchy of cognitive transformations and the goal driven actions of individuals or groups of individuals acting in pursuit of culturally significant and collectively important objectives. In other words, it is argued in this thesis that higher-order thinking may be conceptualised as a system of hierarchically governed cognitive transformations that proceed in relation to goal attainment with reference to the physical, the social, and the contextual environments experienced by an individual.
Therefore, it is argued that teachers may promote student higher-order thinking in technology education classes by creating a classroom program (i.e. through teaching strategies and tactics) focused on key aspects of higher-order thinking, as defined in this thesis and displayed in Figure 7.1. That is, it is predicted in this thesis that particular teaching strategies and tactics (i.e. classroom program) should emphasise the students’ responsibility for learning (i.e. higher-order thinking is a self-regulated adaptive system), that learning situations need to
allow students to build on what they know (i.e. higher-order thinking incorporates a hierarchy of cognitive transformations) and that learning activities (i.e. goal driven actions) should be important and meaningful to students (i.e. higher-order thinking requires that the activities of an individual or group of individuals have collective purpose). The following section reviews the findings of the study with reference to the literature examined in Chapters 1 and 2.

7.3 Research Findings in Summary

7.3.1 Introduction: Research Questions

This thesis reports on a study that examined teaching and learning within technology education classes in two countries (i.e. Study 1: Australia; Study 2: America). The focus of this study was to examine the classroom actions of teachers and students to interpret the classroom factors that seemed to be associated with students’ use of higher-order thinking in technology education classes and to interpret these findings in terms of the conceptualisation of higher-order thinking advanced (i.e. Figure 7.1). The study addressed two related questions:

- How can higher-order thinking be conceptualised?
- In what ways can higher-order thinking be promoted in technology education classes?

The following sections address the findings of the study as identified in Study 1 (Chapter 5) and Study 2 (Chapter 6) in terms of the research questions posed in this thesis.

7.3.2 Summary of Findings from Study 1 and Study 2

Chapter 5 and Chapter 6 report the findings of Studies 1 and 2 respectively. Study 1 examined technology education classes in Southeast Queensland, Australia and Study 2 examined technology education classes in North Carolina, America. In each study, technology education classes were examined to ascertain the press for different types of thinking and the types of classroom actions that caused students to think in the manner they did. A summary of the findings for Studies 1 and 2 are provided in Table 6.7 and in Figure 6.2 and are examined with reference to the literature reviewed in Chapters 2 and 3 in this section within activity theory components.
The findings of Study 1 indicate that presenting information to students is associated with lower-order thinking. This finding is consistent with the literature and indicates that individual cognition is hierarchically structured and self-regulated towards goal attainment (Anderson, 1982; Stevenson, 1986a; Barkley, 2001). Therefore, teachers providing information to students, does not promote their use of higher-order thinking. This finding is consistent with the prediction in this thesis that for student learning activities to promote higher-order thinking, they should support students to construct knowledge based on what they already know and may need to know, so that they might solve problems that achieve goal attainment. As depicted in Figure 7.1, goal attainment is seen to be the focus and the regulating mechanism for higher-order thinking processes. It would seem that the results of this study support the argument that providing information to students reduces the relative importance of the goal of the activity and thus students’ use of higher-order thinking.

Thus, teaching strategies and tactics that involved presenting information to students and telling or showing students how to do things, resulted in less student responsibility for their learning activity and hence a lower probability of students’ use of higher-order thinking. Contemporary definitions for higher-order thinking, such as those provided by Lewis and Smith (1993), Ivie, (1998), Newmann (1990), and Young (1997) argue that information is transformed or manipulated so that problems may be solved and goals realised. Therefore, it would seem that lower levels of student responsibility for learning would equate to less student interest in the perceived goals of the learning and thus to less likely-hood of students’ use of higher-order thinking. Given the nature of higher-order thinking advanced in Figure 7.1, it is probable that learning activity without such student valued goals would be less likely to support higher-order thinking. Thus, technology education classes that support students’ use of higher-order thinking should promote activities that have as their fruition, outcomes (i.e. object) that are perceived by students as being important and relevant.
The findings of the study indicate that a technology education classroom setting supportive of students’ use of higher-order thinking encouraged students to devise solutions to problems and the teacher supported this activity through cueing, hinting and modelling based on an understanding of each individual student’s learning requirements. De Miranda (2004) argues that technology teachers require these supportive skills if they are to support students to think at higher-order levels. Students were involved in situations where their knowledge for dealing with the situation was inadequate. That is, the lower-order procedures that the students had available to solve their technological problems were inadequate for achieving the perceived goal of the activity. Therefore, it is assumed that the students were pressed to modify their existing specific lower-order procedures or to create new lower-order procedures by seeking new cognitive items relevant to characteristics of the new situation. The teacher supported this process by providing hints and cues relative to the needs of each individual student. This finding is consistent with what is understood regarding cognitive theory and the structure of cognition (e.g. Anderson, 1982; Barkley, 2001; Jones & Anderson, 1987; Newell & Simon, 1972; Stevenson, 1984). In addition, these findings support De Miranda’s (2004) argument that exemplary technology education classrooms (i.e. exemplary in that they support student higher-order thinking) typify instruction that supports teaching and learning methods that reflect research drawn from the cognitive sciences. Figure 7.1 indicates that individual cognition is structured to support goal attainment. However, a student’s theory of self and prior knowledge may support or impede goal attainment. If goal attainment is impeded, it would appear that teaching tactics (e.g. hinting and cueing) that support students to regulate and interpret their own understandings of problem situations promote a greater capacity to think at higher-order levels and thus to attain personally important goals.

The findings of this study indicate that students using known processes in American MTE classes were associated with support for higher-order thinking and that students’ using known processes in Australian technology education classes were associated with support for lower-order thinking. This result was not expected given the evidence of previous studies (e.g.
Stevenson & McKavanagh, 1991; Stevenson & Evans, 1994) and the conceptualisation of higher-order thinking presented in this thesis (i.e. Figure 7.1). A possible explanation for this different finding across countries could be the structure of the American modular technology education classroom. That is, that support for student learning and higher-order thinking is largely provided through multimedia, work booklets and computers and that known processes are interpreted by the students in terms of their ability to interact with the modular technology rather than as previously experienced operations, and are therefore associated with students’ use of higher-order thinking rather than lower-order thinking.

Subjects
The findings of Study 1 and Study 2 revealed that the teacher’s perception of how the students learned best (i.e. the characteristics of the learner) influenced the decisions teachers made regarding the classroom program. Figure 7.1 depicts the classroom program (i.e. setting program) as an important element of higher-order thinking that regulates individual and collective activity and actions. In other words, the setting program controls and promotes certain learning and teaching activities over others and thus promotes different types of student thinking as a result. The resources used to support student activity (i.e. the mediating of actions by cultural tools seen in Figure 7.1 within Individual Actions) indicated that real artefacts in Australian technology education classes and all forms of resource (i.e. real artefacts, images & written materials) in American MTE classes were associated with students’ use of higher-order thinking. This finding reflects MTE’s emphasis on students’ interaction with information, multimedia and modular technologies.

The findings of this study indicate that a design-process form of learning activity focused on the underlying technological content of instruction, rather than on product outcomes, is associated with promoting students’ use of higher-order thinking. That is, the classroom program of this form of design-process curriculum promoted higher-order thinking as conceptualised in Figure 7.1 by having a focus on self-regulation during personally
meaningful goal attainment with reference to student understanding of technological concepts. However, additional knowledge is required to understand the relative importance of the real artefact over images and written materials within design-process based technology education classes, in terms of support for student higher-order thinking. In other words, more understanding is required to assess the relative importance of various milieu-behaviour synomorphs during goal attainment and thus of support for students’ use of higher-order thinking. An explanation may be found in the ability of students and teachers to relate more readily to artefacts and of the relative importance of the goal of manufacturing a product as a result of the design-process activity. Given the nature of higher-order thinking advanced in this thesis and as displayed in Figure 7.1, it is argued that goal attainment is the primary focus of higher-order thinking and as such, goals must be personally and culturally significant. Therefore, it appears that support for higher-order thinking in Australian technology education classes is primarily in response to the importance of product outcomes (artefacts).

In Study 1, the perceived characteristics of the students caused the teacher to provide students with support to increase their success and reduce their experience of failure during their design activity (i.e. class 21). This strategy was implemented to increase student effort, self-esteem and grades, and to reduce behaviour problems, and was found to be associated with students’ use of lower-order thinking.

It was found that student learning activity that occurred within technology education classrooms that acknowledged success and failure as being equally important, in the context of successful learning, supported higher-order thinking (i.e. class 91). This finding is consistent with the conceptualisation of higher-order thinking as advanced in Figure 7.1 and with cognitive theory (e.g. Anderson, 1982; Barkley, 2001; Jones & Anderson, 1987; Newell & Simon, 1972; Stevenson, 1984) which argues that cognition has inherent structure and that for higher-orders of thinking to occur, students should modify their understandings to realise their goals, and that this process may result in both success and failure in terms of goal attainment.
In other words, mistakes are equally as important as successes, in regards to the restructuring of both psychological and physical activity in recognition of past and current learning experiences. Thus, it is argued in this thesis that technology education classes, which emphasise success over failure, may not promote the higher-order thinking processes of students, because of the nature of higher-order thinking as advanced in this thesis and displayed in Figure 7.1.

Division of Labour

Studies 1 and 2 found that technology education classes that emphasised teacher interaction with individual students, rather than with the whole class or groups of students, promoted higher-order thinking. This finding is consistent with previous studies that examined teachers and students classroom actions and the press of the learning environment for different types of student thinking (e.g. Stevenson & McKavanagh, 1991; Stevenson & Evans, 1994). In Stevenson and McKavanagh’s (1991) study it was found that FOCHP (i.e. lower-order thinking) was associated with teacher initiation of activities and larger group sizes and that SOCHP (i.e. higher-order thinking) was associated with student initiation of activities and smaller group sizes. Therefore, the findings of this study support those of previous research and suggest that learning environments that press for higher-order thinking are more likely to facilitate single student-to-teacher interactions. This finding provides support for the concept that individual action that occurs within a collective activity system (i.e. behaviour setting), should focus towards meaningful individual goals in order to promote students’ use of higher-order thinking. This feature of higher-order thinking is recognised in Figure 7.1 as the nesting of goal attainment, individual cognition and individual actions within the behaviour setting.

Student higher-order thinking was supported in both studies by individual learning activity that occurred independent of the teacher. Group learning and learning that relied on the teacher were associated with lower-order thinking. This finding supports the individual nature of higher-order thinking as advanced in this thesis (i.e. Figure 7.1) and is reflective of the
types of activities predicted to support students’ use of higher-order thinking in Chapter 3. In other words, the program of the technology education classroom emphasised individual learning activity rather than group learning and this was perceived by students as being separate from the direct influence of the teacher. McCormick (2004) argues that within technology education classes student collaboration exists at 3 levels:

1. Students work side by side on individual design projects.
2. Tasks are split and each student performs a component of the task.
3. Groups of students jointly design and construct projects.

The findings of this study and the conceptualisation of higher-order thinking presented in Figure 7.1, suggest that higher-order thinking is unlikely to be promoted by group learning activity that reduces individual responsibility for the outcomes of the learning (i.e. the activity system object). McCormick argues that in real world industrial situations people: ...share the products of their work, but not necessarily the process, and that: ...in the learning situation we want both (McCormick, 2004, p.30). However, the findings of this study suggest that higher-order thinking is supported by technology education classes in which students accept lone responsibility for their activity. That is, they do not share the process or outcomes (object) of the activity. This type of activity is reflected in industrial real world situations (McCormick, 2004). Therefore, as argued by De Miranda (2004), strategies such as peer tutoring may provide better support for individual student’s use of higher-order thinking, than would group work that may reduce individual student learning responsibility.

Eliciting information from students in Australian technology education classes was found to promote higher-order thinking, while in American classes this same program element (i.e. teaching tactic) did not. The Australian technology education classroom was focused on the students’ understanding of technological content through a design-process based strategy (i.e. the object of the activity system). The students were responsible for learning and applying this content during their designing activity (i.e. goal driven actions). The teacher’s responsibility within this process was to support the students and eliciting information from them was a
teaching tactic used to facilitate this support without diminishing the students’ perception of responsibility for the learning. This finding is consistent with the prediction in this thesis that higher-order thinking would be promoted by teaching strategies that influenced students to take responsibility for their own learning as displayed in Figure 7.1. Boekaerts (2002) agrees that students should be self-regulated in pursuit of personally meaningful goals.

In American MTE classrooms the reduced emphasis on the teacher’s role to facilitate modular activity may have influenced the finding that eliciting information from students was not associated with the promotion of higher-order thinking. The increased reliance on technological support (i.e. multimedia and computer programs) to facilitate student actions, as argued in Section 3.3.3, may explain why students seem to not interpret teacher support in this way as promoting their independence during their goal directed actions (i.e. learning activity).

Ryan and Deci (2000) argue that self-regulation requires that students must understand their learning activities, must have initiation and functional control of their learning activities, and must feel comfortable with and within the learning environment. It would appear that technology education teachers who elicit information from individual students in order to support their actions and understanding of the underlying technological content of the activity are maintaining student initiation, control and comfort within the collective activity of the classroom. It would seem that this teaching tactic (i.e. eliciting information from students to promote understanding of technological content) within the classroom program facilitates individual student and teacher actions in such a way as to promote students’ use of higher-order thinking. This association of teacher support and student self-regulation has been found to promote students’ use of higher-order thinking in Australian technology education classes and is conceptualised in Figure 7.1 as an important component of higher-order thinking. Given that American MTE classrooms do not provide the same level of teacher input and support as Australian technology education classrooms, it is unclear whether modular-facilitated self-
directed learning has the same association with self-regulation and the promotion of higher-order thinking as student responsibility for learning does.

Rules
The findings of this study indicate that a design-process form of learning activity focused on the underlying technological content of instruction, rather than on product outcomes, was associated with promoting students’ use of higher-order thinking. This focus indicated the object of the activity system and therefore, the rules of the activity system centred on facilitating this object. In terms of this study, the rules were selected through the teacher’s front-end analysis of the curricula documentation and were evident in the technology education classroom program (See Table 6.7).

The findings of this study appear to provide support for the conceptualisation of higher-order thinking as displayed in Figure 7.1. It would seem that aspects of the behaviour setting, in particular the setting program, the influence of other settings and the structure of the setting (i.e. milieu-behaviour synomorphs) promote certain teacher and student activities and actions over others. It has been found that different types of student activities, and teacher support for these activities, promote different types of student thinking. Additionally, it has been argued that for students to think at higher-order levels they should be involved in activity that results in the fulfilment of personally important and relevant goals. That is, when students perceive the outcomes of the activity (i.e. object of the activity) as important, they are more likely to take responsibility for understanding and controlling their activity. Self-regulation is argued to be an essential aspect of the cognitive processes involved in higher-order thinking.

7.4 Contributions of the Study
This section outlines the contribution of the study to theory in terms of understanding the nature of higher-order thinking and of the technology education classroom conditions necessary for its promotion. Additionally, this section outlines the contribution of the study to
research methods useful in the examination of technology education learning environments and students’ use of higher-order thinking.

This thesis makes a contribution to cognitive, behaviour setting and activity theories. This contribution is made in relation to synthesising a relationship between aspects of these theories in regards to conceptualising higher-order thinking. By examining the nature of support for student higher-order thinking in technology education classes in two countries, this thesis adds to our knowledge of higher-order thinking and its conditions of use.

Higher-order thinking, as conceptualised in this thesis (See Figure 7.1), empowers influence upon both the individual and the environment. This relationship is significant, because it recognises that higher-order thinking does not originate solely in the individual and that higher-order thinking is influenced by other factors. Importantly for technology education, it is argued that some of these factors can be controlled and modified by the teacher.

Current theories seem to relate higher-order thinking mainly with individuals and focus on heuristics or the conditions of use of higher-order thinking rather than on a holistic interpretation of the nature of higher-order thinking and how learning and the environment can be structured in its support. The findings reported in this thesis have contributed to an understanding of the breadth of support required to facilitate students’ use of higher-order thinking in technology education classrooms.

Additionally, support for students’ use of higher-order thinking in technology education is dependent on other related settings. For example, university training supports the skill and strategy acquisition of teachers in training and these have been found to have an influence on the higher-order thinking outcomes of students in technology education classes in this study. Therefore, this thesis contributes to understanding how university training of teachers can empower teachers and teacher trainers to make decisions regarding strategy selection and
implementation that promotes students’ use of higher-order thinking in technology education classes.

Additionally, technology education curriculum designed at the district or state level or commercially (e.g. MTE curriculum) should acknowledge the factors that promote student higher-order thinking. School and district administrations have the capacity to influence the structure of the environment. This is evident in the various orientations of the subject as discovered in Sanders’ (2001) study. Therefore, this thesis contributes to an understanding of how higher-order thinking in technology education classes can be influenced by educational stakeholders and decision makers, curriculum designers, university teacher training, classroom facilities, teachers through strategy selection and implementation and students. The personal characteristics of the students are also influenced by other related behaviour settings. Thus, this thesis contributes to an understanding of the complex nature of higher-order thinking as conceptualised in this thesis.

This thesis contributes to and expands upon Stevenson’s (1984, 1986a) concept of Cognitive Holding Power by conceptualising higher-order thinking as being promoted by the technology education classroom program. Cognitive Holding Power (CHP) is defined as the press exerted by an educational learning environment, which causes students to display certain levels of procedural knowledge (Stevenson, 1984, 1986a). That is, to engage in particular kinds of thinking. This study incorporates the Cognitive Holding Power concept to extend knowledge of technology education learning environments and to link aspects of cognitive theory, behaviour setting theory and activity theory with instructional theory. In other words, teachers design instruction at various levels and this instruction (teaching strategies and tactics) directs the types of activities (i.e. goal driven actions) with which students’ engage. It is argued in this thesis that certain types of classroom program support certain types of student thinking. Therefore, this study contributes to theory by advancing the concept of classroom program as an influence on the technology education classroom activities of students and thus as an
influence on different types of student thinking. That is, it is argued in this thesis that teachers promote students’ use of higher-order thinking in technology education classes through strategy selection and implementation (i.e. through a particular classroom program).

This study contributes to the validation of the Cognitive Holding Power Questionnaire (CHPQ) as a measure of the press of the learning environment for different types of student thinking. Classroom observations have supported the argument that different types of teacher and student actions and interactions are associated with different types of thinking (i.e. SOCHP and FOCHP). The scales of first order cognitive holding power (FOCHP) and second order cognitive holding power (SOCHP) are established as reliable measures of student thinking at the higher and lower-order levels. In addition, the international nature of this study has upheld the validity and reliability of the CHPQ across two countries.

This study has used qualitative methods relatively untested in technology education research studies. However, the methods are well established in other disciplines (e.g. mathematics and science education). This study has contributed to an understanding of video-data capture and video-stimulated interview techniques as they have been adapted by this study to the examination of technology education classrooms. In addition, this study has extended the video-data analysis technique developed by Stevenson and McKavanagh (1994). That is, this study has included the concept of background activity because of the specific nature of the technology education learning environments under investigation in this study. The study required the incorporation of background as well as foreground technology education classroom activities within the data analysis because of the need to acknowledge self-directed autonomous technology learning experiences said to be necessary in the support of student higher-order thinking (Perkins, 1993; Resnick, 1987)

The study makes a practical contribution to teaching and learning by providing an understanding of technology education classroom programs that promote students’ use of
higher-order thinking. That is, this study has provided new suggestions for the kinds of teaching strategies and tactics that promote student higher-order thinking. Importantly, the programs (i.e. Table 6.7) advanced in this thesis represent teaching and learning activity (i.e. goal driven action) as it actually occurs in technology education classrooms. Therefore, this study contributes to practice by recognising that technology education teachers have the potential to promote student higher-order thinking through particular strategy selection and implementation.

The following section provides suggestions for further research.

7.5 Areas for Further Research
The use of quantitative and qualitative research methods as applied in Studies 1 and 2 is argued to provide a useful direction for future research in technology education. Study 1 employed qualitative methods used extensively in mathematics and science education. Video-data capture and video-stimulated interviews with teacher and students has enabled this study to interpret what is happening in technology education classes and why. Importantly, the results of the quantitative analyses of technology education classes have supported an interpretation of the effect of classroom program on the types of thinking technology education students use. Study 2 supports an understanding of what is happening in American technology education classes and how this affects the types of thinking students use.

However, little is understood regarding the affect of modular technology education (MTE) learning experiences and support for student higher-order thinking. The comparison of Studies 1 and 2 has noted similarities and differences across the two countries, regarding technology education classroom programs that support student higher-order thinking. The American study (Study 2) has highlighted areas that require further research in relation to computer-based self-directed learning argued to be evident in MTE classes (See Table 6.7). The use of video and
video-stimulated recall interview research methods may prove useful in examining American MTE classroom settings.

Additional research is required to examine the use of images and written materials in Australian technology education classes, with respect to how these might be enhanced to support student higher-order thinking. In other words, in what ways can the design-process and supportive documentation (e.g. design folio) be used to effectively support student higher-order thinking in technology education classes? The findings of Study 2 indicate that American technology education classes use all forms of resource (i.e. real objects, written materials and images) in support of student higher-order thinking. A closer examination of American MTE classes may provide support for more effective resource use, in terms of the promotion of higher-order thinking, in Australian technology education classes.

Figure 7.1 depicts the nature of higher-order thinking as conceptualised in this thesis. In addition, Figure 6.2 presents the activity system of the behaviour setting (technology education classroom) that supports the setting program and advances an understanding of the classroom actions of the teacher and students that promote students’ use of higher-order thinking. The studies conducted in this thesis examined the conceptualisation of higher-order thinking with regards to the teaching strategies and tactics that appear to promote different types of student thinking. Future studies could examine the nature of the conceptualisation of higher-order thinking as advanced in this thesis, in terms of the influence of other related settings.

This study has examined quantitatively 52 technology education classes and collected and analysed 1235 responses to the Cognitive Holding Power Questionnaire across two countries. A smaller sample of these classes was examined qualitatively using case study methods. It would be beneficial to increase the sample size to include larger numbers of students and classes from within other countries, to examine the findings of this study and the
conceptualisation of higher-order thinking advanced in this thesis under different learning conditions.

The thesis is primarily concerned with teaching and learning and the conditions that promote higher-order thinking in technology education classes. Further exploration of the findings of this study in other subject areas may add to our understanding of higher-order thinking, to the validity and reliability of the conceptualisation advanced in this thesis and to the classroom conditions that promote students’ use of higher-order thinking.
Dear Principal / Teacher,
I am a research postgraduate student (PHD) at Griffith University. I am currently studying the effectiveness of the Technology Education / Industrial Technology and Design learning environment (Manual Arts) (year 9) in influencing students’ use of higher order thinking processes. This project is a requirement for completing my doctoral studies. To facilitate an understanding of these classrooms, a research study has been developed that progresses through five phases, within the one school year (2003). These phases are proposed to proceed as follows:

Phase 1. Survey consenting year 9 technology students. An information and consent package will be supplied to students, before administering the surveys. Note: The survey instruments and consent packages are attached for your perusal. Please note that the survey does not ask for information of a sensitive or personal nature, only for students’ own perceptions of the activities that occur in their technology classroom. The questionnaire requires approximately 20 minutes of class time to complete. Also Students will be required to answer a technological problem-solving pre-test. The pre-test is of a short duration and will be administered immediately after the survey instrument.
Phase 2. After analysing the results obtained in phase 1, four technology teachers and their classroom students, from within the original sample, will be approached for consent to observe their classroom activities. Two video cameras will be used to capture teacher-student interactions and student-student interactions (two lessons only). Teacher and student interviews will be required to support the video data. Interviews will be conducted at each class teacher’s convenience as soon as possible after the recorded lesson. Teacher Interviews will be approximately lesson length e.g. 70 minutes if double lesson. Student interviews (4 per class) will be approximately 15 minutes duration per student.

Phase 3. Teaching methods / strategies that appear to improve student thinking will be identified, based on the findings of phase 2. These teaching methods or strategies will be structured to promote classroom activities that are believed to improve student higher-order thinking in Technology Education. The content of the curriculum will not be modified; only the method of delivery to students will be adjusted, and as such will not involve students in learning activities outside normal educational practice. A number of technology teachers will be asked to modify slightly their teaching strategies for a 6-8 week delivery period. A random sample of classes (including the four classes involved in phase 2) will be taught using the modified delivery methods; the remaining classes will maintain studies as normal. Before delivery, discussions will be held with implementing teachers. These discussions will assist with consistency of delivery between classrooms and will be held when convenient for class teachers. (Note: At the completion of the study, all schools will be provided with copies of the revised methods of delivery and an executive summary of the research results).

Phase 4. Videotape classes as in phase 2 while teachers and students are still involved with the adjusted curriculum delivery methods. Interviews will be conducted with these teachers and students to support video data. The class time required will be as for Phase 2.

Phase 5. At the completion of phase 4, all 500 students will be surveyed as in phase 1. The problem-solving post-test will be slightly different from phase 1, to recognise the students’ increased experience in technological knowledge. The class time required will be as for Phase 1.

The study aims to consider the perceptions of 500 year 9 students through completion of the questionnaire and problem-solving questions, and a smaller number of teachers and students to contribute via classroom observations using video and interview data. It is expected that this research will assist in understanding how teachers should deliver technology curriculum that supports students in developing higher-order thinking skills. Knowledge of this aspect of instructional design contributes substantial direct benefits for Technology Education / Manual Arts students in particular, and considerable benefits for students in other disciplines. I would be pleased if your school could participate in this research project. The principal supervisor for this project is Dr. Howard Middleton, the director of the Centre for Technology Education Research.

Assurances:

All information provided through the various phases of this study, will be treated as confidential and no direct reference will be made to particular schools, teachers or students.

Your school would be a volunteer and as such will have the freedom to withdraw from the study at any time. A summary of the report findings will be supplied to you on completion of the study.
Parental consent:
As is necessary, students will be required to seek parental permission to participate in the survey and classroom observations (videotape and interviews). Information and consent forms, relating to the relevant section of the study, will be supplied to enable parental permission to be given. To minimize disruption to classes, it may be required that participating class teachers administer and collect the survey and consent forms. If this is the case, an introduction script will be provided to these teachers to ensure each class receives exactly the same information, before being asked to respond to the survey and technological problem-solving pre and post-tests. It is likely that 15-20 minutes should be sufficient class time for completion of the survey form and a small amount of additional time for the problem-solving test. The involvement of your school may be required in two or more phases of this study.

I would like the surveys to commence on ......................... with the final survey required for collection on .........................

Thank you for your assistance with this research project.
Please do not hesitate to contact me for clarification of any of the issues raised in this introductory letter.

I the under-signed will adhere fully to this list of assurances.

........................

Brad Walmsley

Should you have any complaints regarding the conduct of this research, please do not hesitate to contact either the Chief or Assistant Investigator or alternately, the universities Research Ethics Officer, Office of Research, Bray Centre, Griffith University, Kessels Road, Nathan, Qld 4111, Ph. 07 3875 6618.
APPENDIX 2

Parent and Student Information Document.
Technology Education / Manual Arts and Student Thinking.

Chief Investigator: Dr Howard Middleton
Director, Technology Education Research Unit (TERU)
School of Vocational, Technology and Arts Education
Faculty of Education
Griffith University
Nathan 4111 Queensland,
Ph: 3875 5724

Assistant Investigator: Brad Walmsley
Research Student, Doctor of Philosophy in the
School of Vocational, Technology and Arts Education
Faculty of Education
Griffith University
Nathan 4111 Queensland,
Ph: 3875 5662

Dear Parent /Carer and Student,
I am a research postgraduate student (PhD) at Griffith University. I am currently studying the effectiveness of the Technology Education / Industrial Technology and Design learning environment (Manual Arts) (year 9) in influencing students’ use of higher order thinking processes. This project is a requirement for completing my doctoral studies. To facilitate an understanding of these classrooms, a research study has been developed that progresses through five phases, within the one school year (2003). These phases are to proceed as follows:

Phase 1. Survey consenting year 9 technology students. Note: The consent package is attached for you to complete and return to your child’s technology / manual arts teacher. Please note that the survey does not ask for information of a sensitive or personal nature, only for students’ own perceptions of the activities that occur in their technology classroom. The questionnaire requires approximately 20 minutes of class time to complete.

Phase 2. After analysing the results obtained in phase 1, four technology teachers and their classroom students, from within the original sample, will be approached for consent to observe their classroom activities. Two video cameras will be used to capture teacher-student interactions and student-student interactions (two lessons only). Teacher and student interviews will be required to support the video data. Interviews will be conducted at each class teacher’s convenience as soon as possible after the recorded
lesson. Teacher Interviews will be approximately lesson length e.g. 70 minutes if double lesson. Student interviews (4 per class) will be approximately 15 minutes duration per student.

Phase 3. Teaching methods that appear to improve student thinking will be identified, based on the findings of phase 2. These teaching methods or strategies will be structured to promote classroom activities that are believed to improve student higher-order thinking in Technology Education. The content of the curriculum will not be modified; only the method of delivery to students will be adjusted, and as such will not involve students in learning activities outside normal educational practice. A number of technology teachers will be asked to modify slightly their teaching strategies for a 6-8 week delivery period. A random sample of classes (including the four classes involved in phase 2) will be taught using the modified delivery methods; the remaining classes will maintain studies as normal. Before delivery, discussions will be held with implementing teachers. These discussions will assist with consistency of delivery between classrooms and will be held when convenient for class teachers. (Note: At the completion of the study, all schools will be provided with copies of the revised methods of delivery and an executive summary of the research results).

Phase 4. Videotape classes as in phase 2 while teachers and students are still involved with the adjusted curriculum delivery methods. Interviews will be conducted with these teachers and students to support video data. The class time required will be as for Phase 2.

Phase 5. At the completion of phase 4, all 500 students will be surveyed as in phase 1. The class time required will be as for Phase 1.

The study aims to consider the perceptions of 500 year 9 students through completion of the questionnaire and problem-solving questions, and a smaller number of teachers and students to contribute via classroom observations using video and interview data. It is expected that this research will assist in understanding how teachers should deliver technology curriculum that supports students in developing higher-order thinking skills. Knowledge of this aspect of instructional design contributes substantial direct benefits for Technology Education / Manual Arts students in particular, and considerable benefits for students in other disciplines. It would be of benefit if your child could participate in this research project. The principal supervisor for this project is Dr. Howard Middleton, the director of the Technology Education Research Unit.

Assurances:

All information provided through the various phases of this study, will be treated as confidential and no direct reference will be made to particular schools, teachers or students.

Your child would be a volunteer and as such will have the freedom to withdraw from the study at any time. A summary of the report findings will be supplied to your child’s school on completion of the study.

Parental consent:

As is necessary, students will be required to seek parental permission to participate in the survey and classroom observations (videotape and interviews). Information and consent forms, relating to the relevant section of the study, will be supplied to enable parental permission to be given. To minimize disruption to classes, it may be required that participating class teachers administer and collect the survey and consent forms. If this is the case, an introduction script will be provided to these teachers to ensure each class receives exactly the same information, before being asked to respond to the survey and technological
problem-solving pre and post-tests. It is likely that 15-20 minutes should be sufficient class time for completion of the survey form and a small amount of additional time for the problem-solving test. The involvement of your child may be required in two or more phases of this study. The surveys will commence during late March 2003 with the final survey required for collection during October 2003.

Thank you for your assistance with this research project.

Please do not hesitate to contact me for clarification of any of the issues raised in this introductory letter.

I the under-signed will adhere fully to this list of assurances.

Brad Walmsley

Should you have any complaints regarding the conduct of this research, please do not hesitate to contact either the Chief or Assistant Investigator or alternately, the universities Research Ethics Officer, Office of Research, Bray Centre, Griffith University, Kessels Road, Nathan, Qld 4111, Ph. 07 3875 6618.
Technology Education and Student Thinking.
Survey Consent Form.

Dear Parent/Carer,

I am a research higher-degree (PhD) student at Griffith University. As part of the requirements for completing my degree, I am studying the effectiveness of the Technology Education learning environment (Year 9). As one component of this study, year 9 students will be surveyed using a questionnaire. Dr. Howard Middleton the Director of the Centre for Technology Education Research Griffith University is in supervision of this project.

Students will be asked to respond to questions related to their learning in Technology Education. The questionnaire does not contain questions of a sensitive or personal nature. There are no right or wrong answers and all student responses will remain anonymous and strictly confidential. The surveying method meets all the relevant ethical standards. Students can withdraw from the survey at any time and there is no penalty for choosing not to contribute to the survey. The survey does not form any part of normal school curriculum for your child.

It would be appreciated if your Daughter/Son could contribute to this survey.

It is requested that you discuss the survey with your Son/Daughter and, if you are willing for them to complete the survey that you read and sign the section below and return this form to their Technology Education teacher.

Many thanks for considering this request.

Brad Walmsley

I have read the information sheet and the consent form. I agree to allow my child to participate in the Technology Education and Student Thinking Study and give my consent freely. I understand that the study will proceed as described in the information statement, a copy of which I have retained. I realise that whether or not I decide to allow my child to participate is my decision and will not affect my child’s studies. I also realise that my child can withdraw from the study at any time and that I do not have to give any reasons for withdrawing. I have had all my questions answered to my satisfaction.

Please indicate your response by signing one of statements below.

I do give permission for my son/daughter to participate in this survey

Signed Parent/ Carer……………………………Signed/ Student……………………………

I do not give permission for my son/daughter to participate in this survey

Signed Parent/ Carer……………………………Signed/ Student……………………………

244
Dear Parent/ Carer and Student,

I am a research higher-degree (PhD) student at Griffith University. As part of the requirements for completing my degree, I am studying the effectiveness of the Technology Education / Manual Arts learning environment (Year 9). As one component of this study, a number of year 9 students and their teachers will be observed during their normal Technology classroom activities. These activities will be videotaped during one or two class lessons. After completing classroom observations, interviews will be held with teachers and students to provide support for videotape data. Dr. Howard Middleton the director of the Centre for Technology Education Research Griffith University supervises this project. It would be appreciated if your Daughter/ Son could contribute to this component of the study.

During the observations, students will engage with their learning as they normally would in Technology Education / Manual Arts. The appropriate governing bodies have approved the research design. The observation and interview method meets all the relevant ethical standards. All the video and interview data collected will be kept confidential and maintain student and teacher anonymity. Students can withdraw from observations and interviews at any time and there is no penalty for choosing not to contribute to the study. The study will form part of the normal school curriculum for your child. It is requested that you discuss the study with your Son/Daughter and, if you both agree to contribute to classroom observations and interviews, that you both read and sign the section below and return this form to their Technology Education / Manual Arts teacher.

Many thanks for considering this request.

Brad Walmsley

I have read the information sheet and the consent form. I agree to allow my child to participate in the Technology Education / Manual Arts and Student Thinking study and give my consent freely. I understand that the study will proceed as described in the information statement, a copy of which I have retained. I realise that whether or not I decide to allow my child to participate is my decision and will not affect my child’s studies. I also realise that my child can withdraw from the study at any time and that I do not have to give any reasons for withdrawing. I have had all my questions answered to my satisfaction.

Please indicate your response by signing one of statements below.

I do give permission for my son/daughter to participate in the observations and interviews.

Signed Parent/ Carer……………………………Signed/ Student……………………………

I do not give permission for my son/daughter to participate in the observations and interviews.

Signed Parent/ Carer……………………………Signed/ Student……………………………

245
APPENDIX 5

Cognitive Holding Power Questionnaire

TECHNOLOGY ENVIRONMENT RESPONSE FORM

Cross out the one which does “NOT” apply

Grade 9 / 10
Male / Female

Please answer every question......Tick the ONE box which best answers each of the questions below

IN THIS CLASS...........

1. I ask questions to check my results..................Almost never □ Seldom □ Sometimes □ Often □ Very Often □
2. I feel I have to try out new ideas..................Almost never □ Seldom □ Sometimes □ Often □ Very Often □
3. The teacher encourages students to find links between the things they learn..................Almost never □ Seldom □ Sometimes □ Often □ Very Often □
4. I feel I have to find out information for myself..................Almost never □ Seldom □ Sometimes □ Often □ Very Often □
5. I let the teacher tell me what to do..................Almost never □ Seldom □ Sometimes □ Often □ Very Often □
6. I feel I have to copy what the teacher does..................Almost never □ Seldom □ Sometimes □ Often □ Very Often □
7. I check my results against things I know..................Almost never □ Seldom □ Sometimes □ Often □ Very Often □
8. I get all my information from the teacher..................Almost never □ Seldom □ Sometimes □ Often □ Very Often □
9. Teacher encourages students to copy what he or she does..................Almost never □ Seldom □ Sometimes □ Often □ Very Often □
10. I feel I have to ask questions to check my results..................Almost never □ Seldom □ Sometimes □ Often □ Very Often □
11. The teacher encourages students to try out new ideas..................Almost never □ Seldom □ Sometimes □ Often □ Very Often □
12. I feel I have to check my results against things I know..................Almost never □ Seldom □ Sometimes □ Often □ Very Often □
13. I find links between the things I learn..................Almost never □ Seldom □ Sometimes □ Often □ Very Often □
14. I do what I want to do..................Almost never □ Seldom □ Sometimes □ Often □ Very Often □

PLEASE TURN OVER
The teacher encourages students to find out things for themselves.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

The teacher encourages the students to do what they are told.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

I feel I have to work exactly as I am shown.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

I rely on the teacher to show me the links between things.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

I try out new ideas.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

I copy what the teacher does.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

The teacher encourages students to ask questions to check their results.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

I feel I have to find links between the things.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

I learn.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

I accept my results without question.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

I feel I have to do what the teacher tells me.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

I do things my own way.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

The teacher encourages students to do their own work exactly as they are shown.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

I find information out for myself.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

I rely on the teacher for new ideas.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

The teacher encourages students to check their results against things they know.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

I work exactly as I am shown.

Almost never □  Seldom □  Sometimes □  Often □  Very often □

PLEASE CHECK THAT YOU HAVE ANSWERED EVERY QUESTION.
APPENDIX 6

CHPQ Introduction

Date: ..................  Time: ..................  (Administered)

TECHNOLOGY ENVIRONMENT RESPONSE FORM
INSTRUCTION PAPER and INTRODUCTION SCRIPT

Each student to receive one response form before beginning the introduction.
Please do not alter the scripted introduction as this will influence research validity.

At the beginning of this lesson today you are each being asked to fill out a questionnaire. This questionnaire seeks to understand the types of activities that occur in this class. Just indicate your impression of what actually happens. There are no right or wrong answers. Do not put your name on the questionnaire, as your answers are completely anonymous and confidential. At the top of the form, you indicate your gender and grade level by crossing out the response that does not apply. In giving your response to each question, you are asked to think about how much the listed activity occurs and to tick the box after the question which you feel best matches your answer. It is important to make sure you answer each question only once. Make sure you answer all the questions. If you make a mistake, just cross it out and tick another box. Again, there are no right or wrong answers. Your honesty and thoughtfulness in answering these questions is greatly appreciated.

Any questions. You may now begin.

For administering teacher information only.
The correct response for a male student in a grade 10 class would be:

Cross out the one which does "NOT" apply  Grade \( \times 10 \)  Male / Female

Please answer every question.....Tick the ONE box that best answers each of the questions below.

A correct response is shown in the two questions below:

IN THIS CLASS...........
1 I ask questions to check my results. Almost never \( \checkmark \)  Seldom  \( \square \)  Sometimes  \( \square \)  Often  \( \square \)  Very often  \( \square \)

If you wish to change your answer cross the tick as below and enter the new response.

2 I feel I have to try out new ideas.....Almost never \( \times \)  Seldom  \( \square \)  Sometimes  \( \checkmark \)  Often  \( \square \)  Very often  \( \square \)

Answer each question only once
APPENDIX 7

Scoring the CHPQ

1. Transfer student responses to the scoring key below.

2. Items which are answered invalidly e.g. no response or more than one response, are given a score of 3.

3. Item numbers listed in the first column of the key refer to items associated with Second Order CHP. To obtain the SOCHP score, total these scores and divide by 13 (the number of items).

4. Similarly, to obtain the FOCHP (First Order Cognitive Holding Power) score, total the scores in the second column and divide by 12.

5. Items 10, 14, 15, 23 and 25 do not appear on the scoring key since responses to these items are not used to calculate FOCHP or SOCHP.

<table>
<thead>
<tr>
<th>SOCHP Questions</th>
<th>Score</th>
<th>FOCHP Questions</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>5</td>
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<td>Total</td>
<td></td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>SOCHP=Total/13</td>
<td></td>
<td>FOCHP=Total/12</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX 8

**Video Research Package**

<table>
<thead>
<tr>
<th>Product Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x JVC GR-DVL320EA DV camera</td>
</tr>
<tr>
<td>1 x JVC GR-DVL320EA DV camera</td>
</tr>
<tr>
<td>1 x (14”) Panasonic television monitor</td>
</tr>
<tr>
<td>1 x Panasonic DMR-HS2 Hard Drive DVD Recorder</td>
</tr>
<tr>
<td>1 x Panasonic Vision Mixer WJ- AVE55</td>
</tr>
<tr>
<td>1 x Behringer EuroRack UB 1002 Audio Mixer</td>
</tr>
<tr>
<td>1 x Savannah Tripod FT6902</td>
</tr>
<tr>
<td>1 x Manfrotto Tripod ART 144</td>
</tr>
<tr>
<td>1 x Shotgun Microphone Savannah Bardi ECK-716</td>
</tr>
<tr>
<td>1 x AKG PR81PT Body Pack System</td>
</tr>
<tr>
<td>1 x AKG C417L Lavalier Microphone</td>
</tr>
<tr>
<td>2 x 25mt BNC cable</td>
</tr>
<tr>
<td>2 x 10mt BNC cable</td>
</tr>
<tr>
<td>4 x Y/C Breakout Boxes</td>
</tr>
<tr>
<td>Various cabling as required to connect equipment</td>
</tr>
<tr>
<td>2 x Cannon to RCA Audio</td>
</tr>
<tr>
<td>1 x BNC to BNC Vision Cable</td>
</tr>
<tr>
<td>2 x BNC to RCA Vision</td>
</tr>
<tr>
<td>1 x Savannah MB Field Monitor soft carry bag (blue)</td>
</tr>
<tr>
<td>1 x Savannah DV soft carry bag (green)</td>
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<tr>
<td>1 x Savannah in transit soft carry bag (green)</td>
</tr>
<tr>
<td>1 x Dazzle/Snazzi Digital Video Creator USB MPEG-1 encoder</td>
</tr>
<tr>
<td>1 x Headphones Digitor Pro-M6</td>
</tr>
</tbody>
</table>
APPENDIX 9

Video Stimulated Recall Interview Procedure
Teacher

The interview will be held informally and you are free to comment at anytime. The details of your responses will be kept completely anonymous and no reference will be kept which connects you to any of the comments you make during this or any other interview for this project.

Interviewer dialogue:
I am interested in the teaching strategies you used during your lesson --- especially what you believe are the effects of your strategies on student learning.
As the lesson is played back, please stop the footage at points in the lesson where you see yourself using a particular teaching strategy. At that point I would like you to explain:
How you describe the strategy?
Why you decided to use the strategy?
What effect do you believe the strategy has on student learning?

In each case, I may ask you to elaborate on your responses to gain further clarification. Please be careful to distinguish between your reasoning for using particular strategies during the lesson and any subsequent thoughts you may now have as you observe the lesson, and to explain these differences to the researcher. Please be aware that there are no right or wrong answers and you are free to comment on any aspect of the video footage that you wish.

As the interviewer I may choose to stop the footage at certain times, when you do not, for you to comment on aspects of the lesson that are interesting in terms of the strategies noted.

For the Researcher: At the completion of the interview ask the interviewee to respond to the following:

Could you please provide some details of your background, in terms of prior and post teaching experience?
If you were to provide an analogy (in a few words) of your teaching role in this lesson or with this particular class of students, what would it be?
APPENDIX 10

Video Stimulated Recall Interview Procedure
Students

The interview will be held informally and you are free to comment at anytime. The details of your responses will be kept completely anonymous and no reference will be kept which connects you to any of the comments you make during this or any other interview for this project.

Interviewer dialogue:
I am interested in what happened at particular times during your lesson --- especially how you reacted to things your teacher did and said during the lesson.
The lesson will be played back at certain points in the lesson and you will be asked to explain,
What were you thinking about during or immediately after this point in the lesson?
What did you do as a result of what the teacher did at this point in the lesson?
What do you think the teacher is trying to achieve at this point in the lesson?

In each case, I may ask you to elaborate on your responses to gain further clarification. Please be aware that there are no right or wrong answers and you are free to comment on any aspect of the video footage that you wish.
# APPENDIX 11

**Researcher Observation Sheet Study1-Phase 2**

<table>
<thead>
<tr>
<th>Strategy Number</th>
<th>Strategy / Logged Time during lesson</th>
<th>Strategy Description</th>
<th>Researcher</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
## Lesson Coding of Teacher and Student Activities

### APPENDIX 12

### LESSON CODING / STUDENT AND TEACHER ACTIVITIES – (1MINUTE INTERVALS)

<table>
<thead>
<tr>
<th>TIME</th>
<th>FG/CODE</th>
<th>FG/DESCRIPTION</th>
<th>BG/CODE</th>
<th>BG/DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.30-3.40</td>
<td>PLVXT</td>
<td>T introducing lesson to S’ outside class</td>
<td>NO / BG</td>
<td></td>
</tr>
<tr>
<td>3.40-4.40</td>
<td>PLVXT</td>
<td>T introducing lesson to S’ inside class around front bench</td>
<td>NO / BG</td>
<td></td>
</tr>
<tr>
<td>4.40-5.40</td>
<td>ELVCA</td>
<td>T using demo object questioning S’ about processes</td>
<td>NO / BG</td>
<td></td>
</tr>
<tr>
<td>5.40-6.40</td>
<td>ELVCA</td>
<td>T using demo object questioning S’ about processes</td>
<td>NO / BG</td>
<td></td>
</tr>
<tr>
<td>6.40-7.40</td>
<td>ELVCA</td>
<td>T using demo object questioning S’ about processes</td>
<td>NO / BG</td>
<td></td>
</tr>
<tr>
<td>7.40-8.40</td>
<td>ELVCA</td>
<td>T using demo object questioning S’ about processes</td>
<td>NO / BG</td>
<td></td>
</tr>
<tr>
<td>8.40-9.40</td>
<td>ELVCA</td>
<td>T using demo object questioning S’ about processes</td>
<td>NO / BG</td>
<td></td>
</tr>
<tr>
<td>9.40-10.40</td>
<td>ELFXM</td>
<td>S’ taking out their projects T Monit’g</td>
<td>NO / BG</td>
<td></td>
</tr>
<tr>
<td>10.40-11.40</td>
<td>PLOCA</td>
<td>T showing how to do a process to S NROCY</td>
<td>S’ using processes on project</td>
<td></td>
</tr>
<tr>
<td>11.40-12.40</td>
<td>PLOCM</td>
<td>T monit’g &amp; correcting processes NROCY</td>
<td>S’ using processes on project</td>
<td></td>
</tr>
<tr>
<td>12.40-13.40</td>
<td>PLOCM</td>
<td>T monit’g &amp; correcting processes NROCY</td>
<td>S’ using processes on project</td>
<td></td>
</tr>
<tr>
<td>13.40-14.40</td>
<td>PLOCM</td>
<td>T monit’g &amp; correcting processes NROCY</td>
<td>S’ using processes on project</td>
<td></td>
</tr>
<tr>
<td>14.40-15.40</td>
<td>PLVCT</td>
<td>T using observ of S’ prob to question S’ for correct processes</td>
<td>NO / BG</td>
<td></td>
</tr>
<tr>
<td>15.40-16.40</td>
<td>PLOCM</td>
<td>T monit’g &amp; correcting processes NROCY</td>
<td>S’ using processes on project</td>
<td></td>
</tr>
<tr>
<td>16.40-17.40</td>
<td>PSOCY</td>
<td>T showing how to perform a skill to S NROCY</td>
<td>S’ using processes on project</td>
<td></td>
</tr>
<tr>
<td>17.40-18.40</td>
<td>PLOCM</td>
<td>T monit’g &amp; correcting processes NROCY</td>
<td>S’ using processes on project</td>
<td></td>
</tr>
<tr>
<td>18.40-19.40</td>
<td>PLOCM</td>
<td>T monit’g &amp; correcting processes NROCY</td>
<td>S’ using processes on project</td>
<td></td>
</tr>
<tr>
<td>19.40-20.40</td>
<td>PLOCM</td>
<td>T monit’g &amp; correcting processes NROCY</td>
<td>S’ using processes on project</td>
<td></td>
</tr>
<tr>
<td>20.40-21.40</td>
<td>PLOCM</td>
<td>T monit’g &amp; correcting processes NROCY</td>
<td>S’ using processes on project</td>
<td></td>
</tr>
<tr>
<td>21.40-22.40</td>
<td>PLOCM</td>
<td>T monit’g &amp; correcting processes NROCY</td>
<td>S’ using processes on project</td>
<td></td>
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<tr>
<td>22.40-23.40</td>
<td>PLOCM</td>
<td>T monit’g &amp; correcting processes NROCY</td>
<td>S’ using processes on project</td>
<td></td>
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<tr>
<td>23.40-24.40</td>
<td>PLOCM</td>
<td>T monit’g &amp; correcting processes NROCY</td>
<td>S’ using processes on project</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Type</td>
<td>Action</td>
<td>Action 1</td>
<td>Action 2</td>
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<td>-----------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>24.40-25.40</td>
<td>PSOCA</td>
<td>T telling how without doing for S</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
<tr>
<td>25.40-26.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
<tr>
<td>26.40-27.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
<tr>
<td>27.40-28.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
<tr>
<td>28.40-29.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
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<tr>
<td>29.40-30.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
<tr>
<td>30.40-31.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
<tr>
<td>31.40-32.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
<tr>
<td>32.40-33.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
<tr>
<td>33.40-34.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
<tr>
<td>34.40-35.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
<tr>
<td>35.40-36.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
<tr>
<td>36.40-37.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
<tr>
<td>37.40-38.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
<tr>
<td>38.40-39.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
<tr>
<td>39.40-40.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
</tr>
<tr>
<td>40.40-41.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>NROCY</td>
<td>S' using processes on project</td>
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<tr>
<td>41.40-42.40</td>
<td>ELVXY</td>
<td>T asking S' to pack up</td>
<td>DXOCY</td>
<td>S' performing T assigned task</td>
</tr>
<tr>
<td>42.40-43.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>DXOCY</td>
<td>S' performing T assigned task</td>
</tr>
<tr>
<td>43.40-44.40</td>
<td>PLOCM</td>
<td>T monit'g &amp;correcting processes</td>
<td>DXOCY</td>
<td>S' performing T assigned task</td>
</tr>
<tr>
<td>44.40-45.40</td>
<td>PLVXX</td>
<td>T marking roll at end of lesson</td>
<td>NO / BG</td>
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</tr>
<tr>
<td>45.40-46.40</td>
<td>ELVXT</td>
<td>T questioning S' about processes</td>
<td>NO / BG</td>
<td></td>
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<tr>
<td>46.40-47.40</td>
<td>ELVXT</td>
<td>T questioning S' about processes</td>
<td>NO / BG</td>
<td></td>
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<tr>
<td>47.40-48.40</td>
<td>ELVXT</td>
<td>T questioning S' about processes</td>
<td>NO / BG</td>
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Video Master Code descriptions

<table>
<thead>
<tr>
<th>CODE</th>
<th>CODE DESCRIPTION</th>
</tr>
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<tbody>
<tr>
<td>FOREGROUND CODES</td>
<td></td>
</tr>
<tr>
<td>NXXXX</td>
<td>No foreground activity.</td>
</tr>
<tr>
<td>PLVXT</td>
<td>The teacher presents information to the whole class using knowledge about things.</td>
</tr>
<tr>
<td>PLVCM</td>
<td>The teacher presents information about a real object to the whole class while monitoring performance and progress.</td>
</tr>
<tr>
<td>PLVCT</td>
<td>The teacher providing information about a real object to the whole class.</td>
</tr>
<tr>
<td>PS/LVCT</td>
<td>A student, with teacher support, presenting information to the whole class about a real object (project).</td>
</tr>
<tr>
<td>PLVWT</td>
<td>The teacher presents written information to the whole class using knowledge about things.</td>
</tr>
<tr>
<td>PLVIT</td>
<td>The teacher provides information about images to the whole class.</td>
</tr>
<tr>
<td>PLVCY</td>
<td>The teacher demonstrating a skill using real objects to the whole class.</td>
</tr>
<tr>
<td>PLVCA</td>
<td>The teacher providing information about how to perform a skill using real objects to the whole class.</td>
</tr>
<tr>
<td>PLOXT</td>
<td>The teacher presents information about things to a single student.</td>
</tr>
<tr>
<td>PLOCT</td>
<td>The teacher presents information to a single student about a real object (project).</td>
</tr>
<tr>
<td>PLOCA</td>
<td>The teacher providing information about how to perform a skill using real objects to a student.</td>
</tr>
<tr>
<td>PROCY</td>
<td>The teacher demonstrating a process with a real object for a single student.</td>
</tr>
<tr>
<td>PLOCY</td>
<td>The teacher demonstrating a specific process for a single student on a real object (project).</td>
</tr>
<tr>
<td>PLFCA</td>
<td>The teacher presenting information to a group of students about how to perform a skill using a real object.</td>
</tr>
<tr>
<td>PSOCA</td>
<td>A student asking the teacher to how to perform a skill using a real object.</td>
</tr>
<tr>
<td>ELVXT</td>
<td>The teacher elicits information from the whole class.</td>
</tr>
<tr>
<td>ELVO/VXT</td>
<td>The teacher elicits information from single students and the whole class.</td>
</tr>
<tr>
<td>ELVXA</td>
<td>The teacher elicits an explained (how to) action from the whole class.</td>
</tr>
<tr>
<td>ELVXY</td>
<td>The teacher elicits a known action from the whole class.</td>
</tr>
<tr>
<td>ELVXM</td>
<td>The teacher elicits a response from the whole class in order to monitor their performance and progress.</td>
</tr>
<tr>
<td>ELVXX</td>
<td>The teacher elicits a response from the whole class.</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>ELVCY</td>
<td>The teacher elicits a known action from the whole class in relation to real objects (project related).</td>
</tr>
<tr>
<td>ELVCT</td>
<td>The teacher elicits information from the whole class about real objects (project related).</td>
</tr>
<tr>
<td>ELVCM</td>
<td>The teacher elicits information from the whole class about real objects (project related) in order to monitor their performance and progress.</td>
</tr>
<tr>
<td>ELOCT</td>
<td>The teacher elicits information about a real object from a single student.</td>
</tr>
<tr>
<td>ELOCA</td>
<td>The teacher elicits an action from a single student by telling them how using a real object.</td>
</tr>
<tr>
<td>ELOCM</td>
<td>The teacher elicits a verbal explanation of a real object (project) from a single student to check student progress and understanding.</td>
</tr>
<tr>
<td>ELOCG</td>
<td>The teacher elicits a single student’s deeper understanding (higher-order knowledge) of a real object’s (project) function and design.</td>
</tr>
<tr>
<td>ELFCM</td>
<td>The teacher elicits a response from a group of students about a real object in order to monitor their performance and progress.</td>
</tr>
<tr>
<td>ESOCM</td>
<td>A student elicits a response from the teacher about a real object in order to gain ideas and the teacher responds by monitoring their progress and performance.</td>
</tr>
<tr>
<td>ESOCT</td>
<td>A student elicits information about a real object from the teacher.</td>
</tr>
<tr>
<td>ESOCG</td>
<td>A student elicits a response from the teacher by explaining a higher-order procedure they have used or devised using a real object.</td>
</tr>
<tr>
<td>ESFCM</td>
<td>A group of students elicits information about a real object from the teacher and the teacher responds by monitoring their progress and performance.</td>
</tr>
<tr>
<td>ESFCA</td>
<td>A group of students elicits information from the teacher about how to perform a skill using a real object.</td>
</tr>
<tr>
<td>ESVWT</td>
<td>A student elicits information about written material from the teacher in front of the whole class.</td>
</tr>
<tr>
<td>ESVXT</td>
<td>A student elicits information about things from the teacher in front of the whole class.</td>
</tr>
<tr>
<td>EROCG</td>
<td>A resource (project fault) initiates a problem-solving response from the teacher with a single student.</td>
</tr>
</tbody>
</table>

**BACKGROUND CODES**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO / BG</td>
<td>No background activity.</td>
</tr>
<tr>
<td>DROCY</td>
<td>The class doing as instructed by the teacher and individual students performing known procedures as initiated by a real object (project).</td>
</tr>
<tr>
<td>NROCY</td>
<td>Students working independent of the teacher on their own using known procedures in response to the specific requirements of a real object (project).</td>
</tr>
<tr>
<td>NROCG</td>
<td>Students working independent of the teacher on their own and devising procedures in response to the specific requirements of a real object (project).</td>
</tr>
<tr>
<td>NRFCG</td>
<td>Students working independent of the teacher in a group and devising procedures in response to the specific requirements of a real object (project).</td>
</tr>
</tbody>
</table>
Cognitive Holding Power questionnaire Validation Current Study

Eight components were extracted as a result of the initial principle component analysis. Field (2000) states that for analysis where the number of variables is under 30, the sample size is greater than 250 and the communalities are less than 0.6 it is advisable to use the scree plot of the principle component solution to determine the number of components to retain. For this sample containing 30 questions and 441 responses communalities ranged from 0.392 to 0.660 with a mean result of 0.534.

Therefore, the scree plot was consulted (See Figure 1) and because the curve begins to flatten at seven components the decision was taken to progressively extract components starting from an initial number of six (Field, 2000). Questionnaire items would also be removed until the principal component analysis is found to load items positively to components that are conceptually equivalent. In the case of the CHPQ, the items (i.e. individual questions) should load in the component solution as either FOCHP or SOCHP.
Table 1
Principle component Analysis with Varimax Rotation
Conceptual Matrix Six Components Extracted: 30 Items.

<table>
<thead>
<tr>
<th>CHPQ Item Number</th>
<th>Component</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Quest 1 SO</td>
<td></td>
</tr>
<tr>
<td>Quest 2 SO</td>
<td></td>
</tr>
<tr>
<td>Quest 3 SO</td>
<td></td>
</tr>
<tr>
<td>Quest 4 SO</td>
<td></td>
</tr>
<tr>
<td>Quest 5 FO</td>
<td>FO</td>
</tr>
<tr>
<td>Quest 6 FO</td>
<td>FO</td>
</tr>
<tr>
<td>Quest 7 SO</td>
<td></td>
</tr>
<tr>
<td>Quest 8 FO</td>
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<td>Quest 9 FO</td>
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<td>Quest 10 RE</td>
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<td>Quest 11 SO</td>
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<td>Quest 12 SO</td>
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<td>Quest 14 RE</td>
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<tr>
<td>Quest 16 FO</td>
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<td>Quest 30 FO</td>
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</table>

Components that load for each question above 0.3 are highlighted (Quest 29 loaded at 0.283)
RE represents remove as for the original validation of the questionnaire.
SO = SOCHP & FO = FOCHP

The principle component analysis with a Varimax rotation for six components indicates that two
components (1 & 2) loaded items indicating a press for FOCHP and four components (3, 4, 5 & 6) loaded
items indicating a press for SOCHP. Table 1 displays the results of this analysis using a matrix that permits common item loading to be identified within particular concepts. Components that load items more than once and are conceptually linked to other components (i.e. two components strongly associated with either FOCHP or SOCHP), and items that are loaded incorrectly will be discarded (i.e. items that should load together within a FOCHP or SOCHP component and do not).

Items that loaded within components with a result greater than 0.3 are highlighted in the conceptual matrix. Question 29 displayed a result of 0.283 for loading to component 3 and was included as the sample size is sufficient to warrant its inclusion at this degree of component loading (Field, 2000). Because of the original validation of the CHPQ in previous studies, questions 10, 14 and 25 were discarded from the questionnaire construct (Stevenson & Ryan, 1994).

The positive loading of questions 14 (I do what I want to do) and 25 (I do things my own way) to component 5 without other questions (Note: question 15 (The teacher encourages students to find out things for themselves) is more positively loaded to component 3) indicates that these two items should be considered as specific to this component and not related to other items.

Question 10 (I feel I have to ask questions to check my results) is positively loaded to two different components that indicate both FOCHP and SOCHP. This result is in agreement with prior research (Walmsley, 2001). Therefore, component 5 and questions 10, 14 and 25 are discarded from the analysis.

Although Question 27 is cross-loaded into component 2 (FOCHP), it is strongly loaded to component 6 (SOCHP) and will remain in the analysis. Components 1 and 2 share many of the items representing FOCHP indicating a strong conceptual connection between these two components. Several questions were also loaded across components 3, 4 and 6 indicating a conceptual connection between these components.

A principle component analysis with Varimax rotation for five components (with questions 10, 14 and 25 removed) indicates that two components (1 & 2) loaded items indicating FOCHP and three components (3, 4 & 5) loaded items indicating SOCHP. Question 23 (I accept my results without question) loaded to component 5 indicating that this item is not indicative of FOCHP and therefore is discarded. Table 2 displays the results of the five component principle component analysis.

Components 1 and 2 each contain a mix of items representing teacher direction (FOCHP). Four items loaded to both components and contain the words; I work exactly as I am shown (quest 30); I feel I have to work exactly as I am shown (quest 17); I feel I have to do what the teacher tells me (quest 24); and I let the teacher tell me what to do (quest 5).
## Table 2
Principle component Analysis with Varimax Rotation
Conceptual Matrix Five Components Extracted: 27 Items.

<table>
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</tbody>
</table>

Components that load for each question above 0.3 are highlighted
SO = SOCHP & FO = FOCHP

Two items loaded to component 2 only and contain the words; *The teacher encourages students to do their own work exactly as they are shown* (quest26); and *The teacher encourages the students to do what they are told* (quest 16). Component 1 also contains an item with the wording; *The teacher encourages students to copy what he or she does* (quest 9), and other items that indicate students are either copying or relying on the teacher. This result indicates a strong link between these two components (i.e. the cross loading of several FOCHP questions).
Component 5 contains three items (questions 12, 13 & 15) common to components 3 and 4. In addition, items that have loaded to component 5 alone have a strong conceptual link with items that have loaded to component 3. That is, component 5 only items contain the words; I feel (questions 4 & 22); and I find out (quest 27) and component 3 only items contain the words; I feel (quest 2); I ask (quest 1); I check (quest 7); and I try out (quest 19) indicating a high degree of similarity in the underlying construct of these two components. Therefore, components 3 and 5 will be merged resulting in two components remaining in the analysis to represent SOCHP.

Because of the result of the five component principle components analysis one component (merged components 3 and 5) and question 23 (incorrect loading) are discarded. Therefore, a principle component analysis with Varimax rotation extracting four components was applied to the data. This analysis extracted two components (1 & 4) that loaded items primarily indicative of FOCHP and two components (2 & 3) that loaded items solely indicative of SOCHP. Question 15 loaded into components 3 (SOCHP) and 4 (FOCHP). The loading was found to be more positive towards component 4 (FOCHP) and therefore question 15 is discarded (incorrect loading). Alternately, question 27 is loaded more positively to component 2 (SOCHP) than it is to component 4 (FOCHP) and is retained in the analysis.

Table 3 displays the result of the principle component analysis for four components extracted. The conceptual matrix provided in Table 3 indicates that components 1 and 4 have three of four commonly loaded items. Although question 16 (The teacher encourages the students to do what they are told) has loaded to component 4 only, the similarity of its wording to that of question 26 (The teacher encourages students to do their own work exactly as they are shown), which was also loaded to components 1 and 4, supports its cautious inclusion in the analysis. Therefore, components 1 and 4 will be merged because of the common loading of the aforementioned items.

Components 2 and 3 have loaded items that are indicative of SOCHP. However, Component 2 has loaded items indicative of student self-initiative and use of higher-order thinking, while component 3 has mostly loaded items indicative of teacher encouragement towards student use of higher-order procedures. Table 4 displays the wording of questions loaded into components 2 and 3. Although questions 1 and 13 have loaded into both components 2 and 3, in each case the question has loaded more positively into component 2.

Therefore, it would seem appropriate that a learning environment that presses for higher-order thinking would involve both forms of activity. That is, students being encouraged to be autonomous higher-order thinkers and students being actually involved in these forms of autonomous higher-order thinking activities. Because of the logical link between students use and teacher encouragement to use higher-order thinking, these two components (2 & 3) are merged for this analysis.
Table 3
Principle component Analysis with Varimax Rotation
Conceptual Matrix Five Components Extracted: 26 Items

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<tr>
<th>CHPQ Item Number</th>
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Components that load for each question above 0.3 are highlighted
SO = SOCHP & FO = FOCHP

263
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<td>I ask questions to check my results</td>
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<td>Quest 2 SO</td>
<td>I feel I have to try out new ideas</td>
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<tr>
<td>Quest 3 SO</td>
<td>The teacher encourages students to find links between the things they learn</td>
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</tr>
<tr>
<td>Quest 4 SO</td>
<td>I feel I have to find out information for myself</td>
<td></td>
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<tr>
<td>Quest 7 SO</td>
<td>I check my results against things I know</td>
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<tr>
<td>Quest 11 SO</td>
<td>The teacher encourages students to try out new ideas</td>
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<td>I feel I have to check my results against things I know</td>
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<tr>
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<td>I find links between the things I learn</td>
<td>I find links between the things I learn</td>
</tr>
<tr>
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<td>I try out new ideas</td>
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<td>The teacher encourages students to ask questions to check their results</td>
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<tr>
<td>Quest 29 SO</td>
<td>The teacher encourages students to check their results against things they know</td>
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Therefore, this analysis has upheld the validity of the CHPQ and has supported the reliability of the two scales of FOCHP and SOCHP in terms of their ability to differentiate between different forms of student classroom thinking activity.
### Shapiro-Wilk Tests of Normality

#### Study 1-Phase 1 Pre-test

Technology Class Means FOCHP & SOCHP

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<th>Shapiro-Wilk Normality Test</th>
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*indicates non-normal mean distributions <.05
APPENDIX 16

Study 2-Phase 2 Researcher Classroom Observation Sheet

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<th>Cognitive Activity Comments</th>
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LIST OF REFERENCES


268


277


