Cognitive process mapping: Adapting cognitive task analysis to research and educational assessment of young children’s thinking skills in the classroom

by

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A thesis submitted to the University of Otago

in fulfilment of the requirements for the degree of

Doctor of Philosophy in Education

University of Otago

Dunedin

New Zealand

2011
Abstract

The question of how best to assess thinking skills is an issue keenly debated amongst researchers and educators ever since competencies such as problem-solving and thinking skills became universally recognised as essential for the 21st century. Tests and the use of rubrics in performance-based assessments to evaluate students’ thinking competence do not provide specific information on the ways they can still improve and teaching intervention that is needed to help them do so. Tests and rubrics also fail to take into consideration the situated and emergent nature of learning because they are constructed before learning takes place. This participant observation study was designed to explore how young children’s thinking processes and skills can be analysed, interpreted, and assessed through classroom observations. A parallel could be drawn between cognitive task analysis and the techniques employed for data collection and analysis in this study.

The purposefully selected research site was an urban primary classroom in New Zealand comprising 28 children aged between 7 to 8 years old. Opportunistic and intensity sampling strategies led to the gathering of data on 19 of the children. Data were gathered primarily through observations of the children that incorporate thinking conversations - informal conversations with children that focus on eliciting their thinking. Analysis of data was undertaken using two techniques developed in the course of the study – cognitive process maps and visual models.

This research revealed that the techniques used in the study can be effective tools for the observation and analysis of children’s thinking processes and skills. They can provide insights into the strengths and weaknesses in children’s domain knowledge, working theories, and thinking skills at a specific level needed for formative purposes. These techniques allow for open-ended observation and analysis of children’s learning needs because they take into
consideration the emergent nature of children’s thinking and are not necessarily focused on preconceived aspects of children’s performance. The study demonstrates the capacity of young children to adopt their own individual approaches to task performance, involving thinking processes that can be complex and varied across individuals and contexts. One implication is that we cannot fully appreciate their competence without prolonged conversations with them and careful observation in order to establish an accurate picture of their thinking performance.

Recommendations are offered for researchers and educators to consider adopting task analysis techniques developed and employed in this study in addition to their repertoire of existing tools for research and assessment purposes.
Acknowledgements

I am grateful to my supervisors for their unflagging intellectual support and personal encouragement. My principal supervisor, Professor Helen May, has been a source of valuable advice and much appreciated intellectual critique in the course of this study. Associate Professor Mary Simpson has provided me with a patient listening ear and helpful support throughout the project. I am also appreciative of the balance my supervisors have been able to achieve between supervisory guidance and the space I needed to explore my ideas.

It has been a great privilege for me to work with the children and the teacher who were involved in this study. This thesis would not have been possible without the opportunity and time that they have generously given me.

I express my appreciation to Dr Bill Anderson, Director of Distance Learning at the University of Otago, for the advice and time that he has given me during a period when I was learning the nuts and bolts of data analysis. I am thankful to Professor Lisa Smith, Associate Dean of Research at the College of Education, for her kind words and support. I am also appreciative of the time and assistance I received from several staff members of the College of Education and the Higher Education Development Centre (HEDC), as well as the opportunity to work with some of them, including Dr Sarah Stein, Co-ordinator of the Academic Staff Development Group and Senior Lecturer in HEDC, and Dr Karen Nairn, Senior Lecturer at the College of Education.

This study was supported by the award of a University of Otago scholarship from 2008 to 2011. The generosity of the university has provided me with helpful financial assistance during my study.
I offer thanks to my good friend, Garry, for his unceasing support, encouragement, and belief in me. Finally, I thank God for His faithfulness, provision, and grace throughout this journey.
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Chapter One

Introduction

The question of how best to assess thinking skills is an issue keenly debated amongst researchers and educators ever since competencies such as problem-solving and thinking skills became universally recognised as essential for the 21st century (Brookfield, 1997; Emerson, Boes, & Mosteller, 2002; Ennis, 1993; Ku, 2009; Nickerson, 1989; Norris, 1988b). Although research generally shows the effectiveness of instructions in thinking skills, most of the studies use measures that are designed for summative evaluation and may not provide specific information needed to determine what makes students better thinkers and in what ways they can still improve (Burke & Williams, 2008; Norris, 1985). Test instruments are the method of choice among researchers and educators because they are well established and efficient. Nevertheless, they pose the potential problem of a mismatch between what is being tested and what is taught, and between the contexts in which thinking skills are taught and the contexts used in testing (Burke & Williams, 2008; Emerson et al., 2002). Performance assessment using methods such as naturalistic observation and interviews provide for direct evidence and greater insights into the process of thinking for formative purposes, but their advantages and limitations need to be explored and understood (Costa and Kallick, 2001; Beyer, 2001a; Burke, 2001; Norris, 1988b).

Assessment reformers stress the need for greater integration between assessment and instruction (Shepard, 2000), including a more differentiated pedagogical approach that uses formative evaluation methods to adapt instruction to where students are in their progression toward mastery of learning (Tomlinson, 1999, 2005). There has also been a call for the use of more naturalistic methods of assessment such as classroom observations for young children (Gullo, 2006; McAfee, Leong, & Bodrova, 2004; Puckett & Black, 1994). Performance-based
or authentic assessment tasks, especially those that promote complex problem-solving and thinking, can be messy, involve uncertainty and complexity, and present difficulties for observation and assessment (Schmidt & Plue, 2000). The issue then is: How can classroom observational data of young children’s thinking processes and skills be systematically analysed and interpreted to provide meaningful insights to inform research and the teaching of thinking skills in young children?

Teachers’ sense-making of assessment data has been identified as a key problem in the implementation of formative assessment in the classroom (Even, 2005). In particular, the diversity and unpredictability of the processes and products of learning in learner-centred classrooms pose a challenge to classroom assessment (Evertson & Neal, 2006). Carless (2007) contends that formative assessment should 1) start from the student’s existing knowledge and abilities, 2) be timely, and 3) offer the potential for student action in correcting any misconceptions during task performance and not after. The use of rubrics in performance-based assessments to evaluate students’ competence may not provide specific information on the ways they can still improve and teaching intervention that is needed. Rubrics may not take into consideration the situated and emergent nature of learning because they are constructed before learning takes place (Hipkins, 2009). Rubrics can guide assessors to look for features of task performance that are similar to or different from the description contained in the rubrics and ignore the “patterns and connections that give it (the task performance) meaning and integrity” (Delandshere & Petrosky, 1998, p.21).

The motivation for this qualitative research study was the search for an alternative approach for the formative assessment young children’s thinking abilities, which takes into account the situated and emergent nature of learning. An alternative that is more “embedded in and accomplished through interaction” (Cowie, 2009, p.47) and, more importantly, an assessment tool that can provide specific insights into how children’s thinking skills can be
further improved is needed. In this thesis, I discuss how informal conversations with children, which I call *thinking conversations*, can elicit useful information on their thinking. I describe how two techniques developed in the course of this study - *cognitive process mapping* and *visual modelling* - can be used to analyse and interpret young children’s thinking processes and skills utilising data gathered through these thinking conversations. I present some research evidence to show:

- The capacity of young children to adapt their own individual approaches to thinking tasks, even though their strategies are not always effective and efficient.
- The diverse forms of reasoning processes that children engage in across different contexts.
- The unpredictable and emergent nature of the tasks and reasoning processes that children engage in when they perform open-ended and ill-structured tasks.

I present evidence of how cognitive process mapping and visual modelling can make evident and provide insights into the children’s thinking processes, as well as identify gaps in the children’s thinking abilities.

The study involved 28 children aged seven to eight years old in a Year 3 classroom of an urban primary school in New Zealand where children start school at age five. It was anticipated that the knowledge generated from this research would afford new insights and so inform research and education practice in terms of the teaching and assessment of young children’s thinking abilities. This first chapter of the thesis begins with description of the background of the study, the development of the competency movement internationally, the New Zealand context, and the pedagogical context of the study. This is followed by the problem statement and the purpose of the study, including the research goals and the related research questions. The last section of the chapter outlines the structure of the thesis.
1.1 **Background of the Study**

This study was carried out at a time when the teaching of thinking skills remained an issue despite a flourish of efforts in research and publications on this topic, and the adoption of educational policies by many countries to promote thinking skills since the 1980s. Despite the rhetoric about policy changes, the tradition of academic success that gives priority to literacy and numeracy skills remains entrenched (Abbott & Ryan, 2001; Blaustein, 2005). The increasing political pressure in many developed countries towards nationalised standards and testing causes schools to focus on knowledge acquisition and recall at the expense of complex thinking skills (Nelson, 2004). In fact, the movement in many schools in countries such as the United States (US), the United Kingdom (UK), Australia, New Zealand, and Singapore is primarily toward a greater emphasis on standards and academic performance. In New Zealand, National Standards were introduced in English-medium schools in 2010 to set clear expectations that students need to meet in reading, writing, and mathematics in the first eight years at school (Ministry of Education, 2009). Even early childhood educational programmes, in the US for example, began to adopt a more formal academic approach (Armstrong, 2006). The emphasis on standards and academic performance often leads to a crowded curriculum and less priority being given to developing competency in thinking and problem solving. In the US, Linda Mariotti, President of the Association for Supervision and Curriculum Development (ASCD) calls for a redesign of the American high school experience to include 21st century skills such as thinking and problem-solving, with the focus being on what students could do with knowledge rather than amassing of knowledge (Mariotti, 2009). Abbott and Ryan (2001) argue that successful education in the 21st century requires helping all children to move beyond simply the traditional goals of literacy and numeracy. The explosion of information due to the rapid changes and technological advances of today’s
world is one reason persistently put forth for the need to focus on thinking and learning processes rather than the acquisition of knowledge (Davis-Seaver, 2000; Fisher, 2003; Halpern 1994; Howie, 2003; Morgan, 1993). In the UK, a 2003 report by the Department for Education and Skills notes that young people still lack the thinking and problem-solving skills needed for the workplace even though they were better educated in numeracy, literacy and science (McGregor, 2007). As recent as 2007, business leaders in the US called for schools to do more to improve students’ critical thinking (Willingham, 2007). Given these developments, it is not surprising that the advocacy and teaching of thinking skills is a challenge and of key interest to educators today.

1.2 Development of the Competency Movement

The interest in thinking skills in education has historically been closely linked to the development of the competency movement because thinking skills have invariably been included as one of the competencies considered essential to school success and a competitive workforce in today’s world. The increasing complexity and international competition in knowledge-intensive economies since the 1980s led to recognition by some governments that human capital is a key competitive advantage in knowledge-intensive economies. As a result, educational reforms were introduced in these countries in late 1980s and 1990s that included a focus on developing generic competencies such as thinking and problem-solving skills (Eltis, 1997).

The competency movement first originated in the US and the UK in response to changing technology, increasing competition, declining profitability, and the search for competitive advantage and improved performance in the 1970s and early 1980s (Horton, 2000). There was also increasing dissatisfaction with the U.S. education system in its ability to respond to needs of the modern knowledge-based economy. The report What Work
Requires of Schools (Secretary's Commission on Achieving Necessary Skills, 1991) identifies a number of competencies necessary for the modern workplace: creative thinking, decision-making, problem-solving, learning how to learn, collaboration, and self-management. Many of the concepts of core competencies and capabilities developed in the US were transferred to the UK by management consultancy firms, educational institutions, and U.S. companies. In the 1980s, British policy-makers became increasingly concerned about the country’s poor economic performance, rising unemployment, growing skill gaps and the weakness of the education system. Following a review by McGuinness (1999), thinking skills were incorporated into the English National Curriculum. In 2001, the Department of Trade and Industry (DTI) and the Department for Education and Employment (DfEE) jointly issued a paper calling for school education to adapt and respond to the needs of business and industry by providing rounded education which fosters practical skills, creativity, enterprise, and innovation (Harlen, 2007). By the late 1990s, the competency movement has become an international movement, with initiatives by countries in the members of the Organisation for Economic Co-operation and Development (OECD), the European Union (EU), and Australasia.

The competency movement in the OECD placed emphasis on flexibility, entrepreneurship and personal responsibility with the view that individuals need to be adaptive, innovative, creative, self-directed, and self-motivated. The OECD also recognised the role of key competencies in going beyond the reproduction of knowledge to being able to tackle complex mental tasks. In 1997, OECD member countries launched the Programme for International Student Assessment (PISA), with the goal of assessing students’ knowledge and essential skills near the end of compulsory schooling. The OECD also initiated the Definition and Selection of Competencies (DeSeCo) project which provides a framework to guide curriculum development and assessments on key competencies, including thinking skills. The
DeSeCo project defines key competencies as those needed by people to function in a wide range of situations in order to live meaningfully in and contribute to society (Hipkins, 2006b). The global interest in the idea of competency was evident in the Third International Competency Conference in London in 1998 which was attended by 600 delegates from Europe, the USA, the Middle East, Asia, and Australasia, comprising academics, managers, consultants, and human resource people (Horton, 2000). There are two significant developments that resulted from the international competency movement. The first was the change in pedagogical approach brought about by the increasing dissatisfaction with traditional classroom instructional methods. The second was the interest in the teaching of thinking skills in the classroom.

1.3 The New Zealand Context

The OECD competencies provided a foundation for the key competencies proposed by the Ministry of Education in 2005 for the New Zealand school curriculum (Baker & Mackay, 2006). Developing the key competencies based on the OECD framework effectively aligns the New Zealand school curriculum (Appendix A: The New Zealand School Curriculum) with OECD’s monitoring programmes such as PISA, and enables the Ministry of Education to make use of valuable information from these programmes to evaluate its domestic educational policy initiatives (Hipkins, 2006b). The key competencies framework was a revision and development of the eight Essential Skills introduced in 1993 in the New Zealand curriculum framework (Ministry of Education, 1993), namely: communication skills; numeracy skills; information skills; problem-solving skills; self-management and competitive skills; social and co-operative skills; physical skills; and work and study skills (Boyd & Watson, 2006a). Other motivations for adopting the key competencies framework were the dissatisfaction with the marginalisation of the essential skills in school curriculums and the need to include attitudes.
and values with skills to better reflect what is needed to meet important demands and challenges across a variety of life contexts (Hipkins, 2006b).

The Ministry of Education of New Zealand revised the national curriculum in 2007 to include key competencies that are considered to be desirable and necessary capabilities for living and lifelong learning (Ministry of Education, 2007). These key competencies include thinking, using language, managing self, relating to others, and participating and contributing. According to the revised curriculum, students not only need to be literate and numerate, they also have to be critical and creative thinkers, active seekers, users and creators of knowledge, and informed decision-makers in order to be lifelong learners (p.8). Embedded in the text are many important concepts such as 1) the importance of both the process and end product of learning; 2) the importance of reflective, creative and critical thinking in learning; 3) the development of learning dispositions such as motivation and knowing when and how to apply key competencies, and why; 4) the need for opportunities and time to deepen understanding and achieving mastery; 5) the role of social contexts in developing key competencies; 6) the role of self-regulation and self-assessment in learning; 7) the benefits of peer learning, cooperation, and collaboration; 8) involvement in and of the community; and 9) assessment as necessarily an on-going process that involves timely gathering, analysis, interpretation, and use of information to make evident and monitor student progress. The revised curriculum also clearly states that certain values are to be promoted and modelled in New Zealand schools. In the key competency of thinking, students are encouraged to think critically, creatively, and reflectively in order to develop values such as innovation, inquiry, and curiosity (p.10).

New Zealand’s implementation of key competencies appears to involve a national approach with a lot of room for local exploration and interpretation (Boyd & Watson, 2006a; Hipkins, 2009). Hipkins (2006a) identifies a number of implementation issues: the beliefs among some that they are not new to what is already being done in schools, the lack of room
in the curriculum for key competencies, and how to teach and assess key competencies. The first of these issues is particularly applicable to the key competency of thinking because it was very much part of the previous Essential Skills and schools were already using a number of thinking tools in their curriculum. Although schools are encouraged to adopt a dual approach of integrating thinking into subject areas and teaching it separately (Hipkins, 2006b), teachers typically use a combination of an integrated approach such as inquiry-based learning, an array of thinking tools, and one or more taxonomies to teach the key competency of thinking (Boyd & Watson, 2006a). Commonly used thinking tools include de Bono’s six thinking hats, Bloom’s taxonomy, Costa’s habits of mind, and Gardner’s theory of multiple intelligence (Hipkins, 2006b). This was certainly the case in five of the six primary schools that I visited in my search for school sites for my research.

Whether and how to assess key competencies is a subject of debate and constitutes one of the key challenges in the implementation of key competencies identified by the New Zealand school curriculum (Boyd & Watson, 2006a). Hipkins (2006b) notes the difficulty of assessing the progress students make in getting more proficient at using key competencies as one of the major challenges confronting teachers. As noted earlier, she contends that assessment of the key competencies has to take into account the situated and emergent nature of learning. Key competencies are complex in nature and how they are demonstrated could vary significantly according to context (Boyd & Watson, 2006b). In the New Zealand curriculum framework, contexts and situated learning are considered to be important aspects in the development of key competencies in students because of the underpinning philosophy and principles provided by the sociocultural theory of learning. Hipkins (2005) notes that it is implied in the OECD framework that the development of key competencies occurs in contexts which are challenging and meaningful to students, and which require them to actively engage in problem-solving. She argues that assessment of key competencies should be carried out by
performance assessment in “a real context” because of their holistic nature (p.6). The Ministry of Education offers several suggestions for documenting the development of key competencies, including learning logs or journals, portfolios, e-portfolios, and short narratives (Ministry of Education, n.d.). It also suggests several strategies to help teachers and students think about the development of key strategies, such as student reflections, discussion prompts, and peer sharing. However, the link between assessment and teaching is unclear because there is no information on whether and how these assessment methods can offer insights and strategies for improving students’ key competencies. This is one aspect of the assessment of young children’s thinking skills that I discuss in this thesis, particularly in Chapter Seven.

1.4 The Pedagogical Context

The importance of and the need for teaching thinking skills have been well articulated in research and literature in countries such as the US, the UK, Canada, Australia, New Zealand, Israel, Hong Kong, and Singapore (see for example Barak & Dori, 2009; Epstein, 2003; Fisher, 2003; Helm & Katz, 2001; Hipkins, 2006b; McGuinness, 1999; Murdoch & Wilson, 2008; Ong & Borich, 2006; Resnick, 2001; Sanz de Acedo Lizarraga, Sanz de Acedo Baquedano, Mangado, & Cardelle-Elawar, 2009; Zohar & Schwartzer, 2005). Unfortunately, educational assessment of thinking skills in the classroom is a much neglected area (Ennis, 1993; Ku, 2009; Stiggins & Bridgeford, 1989). In part, this is due to the fact that it is relatively easy to assess student’s content knowledge but much more difficult to assess thinking skills in the classroom (Bissell & Lemons, 2006). Testing is the most established and efficient method for assessing thinking skills but it poses certain problems, including the lack of comprehensiveness, artificial time constraint imposed by the duration of the test, risk of familiarity if pre-test and post-test are used, and failure to take into consideration factors such as differences in beliefs, culture, and assumptions (Ennis, 1993). The applicability of written
forms of assessment to young children is limited by the requirement of a certain requisite level of literacy or communication skills. Classroom observations, interviews and reflective dialogues are generally considered to be more suitable forms of assessment techniques for young children (Gullo, 2006; McAfee et al., 2004; Puckett & Black, 1994).

The ability to assess the thinking skills of learners may be an integral part of research into questions and issues related to the effectiveness of thinking skills instruction (Ennis, 1993). Ethnographic techniques such as classroom observations and interviews are commonly for qualitative research involving young children. The task of analysing and interpreting data collected through classroom observations and interviews in order to obtain insights into the children’s thinking processes and skills can be useful but methodologically challenging from the researcher’s perspective. In this study, valuable insights were obtained through ethnographic and task analysis techniques adapted and developed for the purposes of elicitation and analysis of the children’s thinking processes and skills. These include the concepts of thinking conversations, cognitive process mapping, and visual modelling which are elaborated in Chapters Four and Five of this thesis.

Using classroom observations, interviews, and reflective dialogues to assess young children’s thinking is no easy task because thinking processes are invisible and children are unlikely to express their thinking skills precisely (Davis-Seaver, 2000). Observers have to make inferences from children’s actions when using classroom observations to assess children’s thinking (Howie, 2003; Kassem, 2005). In interviews and reflective dialogues, interviewers have to contend with possible issues of accuracy and comprehensiveness in children’s feedback (Ennis, 1993; Winsler & Naglieri, 2003). Moreover, young children’s performance is sensitive to context and task unfamiliarity (Gullo, 2006). Researchers and teachers need to have good documentation and to observe children closely in order to accurately understand and assess children’s reasoning. They need to know what is being
assessed and how the data demonstrate the children’s thinking (Zan & Geiken, 2010). They need a clear description, an explicit vocabulary, and a frame of reference to describe aspects of young children’s thinking and dispositions (Beyer, 2001a; Fisher, 2001; McAfee et al., 2004; Moseley, Elliott, Gregson, & Higgins, 2005). The need for an interpretative tool has led to the use of rubrics in assessments, usually developed with the help of a particular taxonomy or framework. Rubrics are used as a guide or criteria to note a demonstration of a particular skill and may involve the assignment of a score or rating the performance according to a constructed range of proficiency in certain skills or sub-skills. In New Zealand, the use of rubrics is a common feature in the assessment of key competencies (Hipkins, 2009) – a practice that I observed in my visits to six primary schools. Hipkins (2009) contends that the use of rubrics in assessments may not provide sufficiently rich information for teachers to make the changes needed in classroom practice to support the development of key competences in students. Given that rubrics are typically constructed before learning takes place, Hipkins argues that:

The relationships and connections that emerge and evolve over the course of the learning experience are unlikely to be an assessment focus, and without this attention to context and action, instances when powerful new connections open up for individuals or groups could simply fade away unnoticed. (p.15)

Furthermore, the use of rubrics in assessments to report on a narrow range of performance does not take into account why a student may or may not perform well in certain situations and the impact of classroom dynamics and interactions (Hipkins, 2009). These aspects of
student performance need to be taken into consideration if scaffolding of students’ learning is to be effective.

Within the social constructivist framework, scaffolding is essential to guiding and supporting students as they construct their understanding and make sense of their experiences within a community of learners (Bonk & Cunningham, 1998). For scaffolding to be effective, the teaching support given must be timely and provided at the point of need (Hammond & Gibbons, 2001), and offered within the learner’s potential for development or what is known as the zone of proximal development (ZPD) (Bonk & Cunningham, 1998, Vygotsky, 1978). In the classroom, this means both tasks and support have to be differentiated according to the needs of different students. This requires teachers to have a good understanding of where the students are in terms of their abilities and understanding. In addition to identifying individual needs and abilities, assessment of young children’s thinking skills is necessary to monitor the progress in the development of their thinking skills as it forms an integral part of the teaching process. Careful and systematic collection of information about children’s skills and dispositions and reflection upon this information can provide teachers with useful evidence of children’s learning and growing competencies (Helm, Beneke, & Steinheimer, 1998; Helm & Gronlund, 2000).

In order to serve formative purposes, it is desirable that assessment is on-going and seamlessly integrated with the instructional procedure and classroom activity, providing important feedback to both teacher and learner. The goal of formative assessment is to inform decision-making and actions that support learning using information co-constructed by teachers and students in the course of on-going learning activities (Harlen, 2007). The information gathered has to be interpreted in relation to where the students are in their progress towards a set of learning goals or mastery of certain skills. Popham (2008) emphasises that adjustment decisions that teachers and students make must be based “not on
whim but on evidence of students’ current level of mastery with respect to certain skills or bodies of knowledge” (p.7). If the assessment of thinking skills is to be formative, then suitable methods must perform these functions. This thesis explores an assessment approach that provides specific insights into how children’s thinking skills can be further improved while taking into account the situated and emergent nature of learning.

1.5 The Problem Statement

The analysis and assessment of young children’s thinking processes and skills is critical to understanding their thinking abilities for both research and pedagogical purposes. While researchers and educators recognise that naturalistic or classroom observations offer the advantages of being broad-based and authentic, and are therefore more suited to young children, there is little research carried out on how observational data of young children’s thinking processes and skills can be analysed and interpreted. The problem statement may be summarised as follows:

Figure 1.1: The problem statement
1.6 Purpose Statement, Research Goals, and Research Questions

The purpose of this study was to explore how young children’s thinking processes and skills can be analysed, interpreted, and assessed through classroom observations that incorporate interviews and reflective dialogues. At the personal level, this research study was driven by my interest in understanding young children’s thinking and problem-solving skills. It represents a step forward in my desire to advocate young children’s independence and competence in terms of their learning, thinking and problem-solving. In my past working experience in strategic planning and policy formulation with the Singapore Economic Development Board (EDB) and the Monetary Authority of Singapore (MAS) from 1992 to 2003, one of my key concerns had been the surprising lack of creative and critical thinking among even the brightest and best that we were able to recruit. Having personally experienced and witnessed the negative impact of an educational system that emphasised academic achievement, direct instructions, and rote learning over thinking, I have an interest and desire to help children develop from an early age important life skills of creative thinking and critical thinking.

This became possible when I jointly set up an early childhood centre with a friend in 2002 and left my job two years later to become a full-time early childhood teacher. I completed a Master of Science programme in early childhood education conducted by the Wheelock College between September 2006 and March 2008, during which I carried out a qualitative research study on how the project approach can develop problem-solving skills in young children. I also took up a part-time lecturing job in 2008 to conduct training courses for preschool teachers. The many challenges that teachers face in supporting young children’s development of thinking and problem-solving skills became evident in my own work with young children, and in the experiences of my student teachers and some of the teachers in the New Zealand schools that I visited over several months prior to the
commencement of this research study. These challenges include, among others, observation and understanding of young children’s thinking, assessing and reporting on children’s thinking skills, as well as supporting and scaffolding the development of these skills.

Adopting an exploratory and generative approach, this study sought to gain insight into young children’s thinking skills by seeking to make evident the complex processes involved. Using data gathered through classroom observations, interviews and reflective dialogue, the aim of this qualitative research study was to explore how young children’s thinking processes and skills could be analysed and interpreted in order to understand and assess their thinking abilities. Over the course of my research, I developed the concept of thinking conversations with children to elicit information on their thinking, as well as the techniques of cognitive process mapping and visual modelling for the analysis of the data gathered. My research goals, which I modified as the study evolved in order to sharpen the focus and the direction of the study, were as follows:

1. Investigate how informal conversations with young children could be used to elicit information on their thinking processes and skills.

2. Examine how task analysis techniques could be used to analyse and interpret young children’s thinking processes and skills in order to obtain insights into their thinking abilities.

3. Explore the potential of task analysis techniques as research and assessment tools to provide an in-depth understanding of children’s thinking abilities and to inform the teaching of thinking skills.

4. Examine whether and how young children adopt their own approaches and engage in their own thinking processes when performing tasks that require them to exercise their creative and critical thinking skills.
My research question was: How do young children engage in tasks that require them to exercise creative and critical thinking skills in a classroom setting? More specifically, the following sub-questions were addressed in this study:

1. How can observational data on young children’s thinking processes and skills be gathered and analysed?
2. What can classroom observations, interviews, and reflective dialogues reveal about young children’s thinking processes and skills?
3. How can young children’s thinking abilities be formatively assessed using classroom observations, interviews, and reflective dialogues?

1.7 Summary

I began this chapter by providing the rationale for the study, followed by a brief description of the international and national contexts that situated and informed my research. I have also articulated the pedagogical context and the problem statement. I have contended that formative assessment is critical to the effectiveness of any approach to teaching thinking skills. I have argued that making evident children’s thinking processes holds the key to the adoption of a more differentiated approach to teaching children thinking skills, especially in identifying their ZPD, understanding their thinking, and respecting their individuality. Many existing methods of assessment thinking skills may not be suitable for young children because they are in the written forms, such as tests and essays. Observations that incorporate interviews and reflective dialogues offer another alternative but the analysis of data thus obtained is difficult. I have discussed the purpose and goals of the study, as well as the related research questions. The rest of this thesis adopts the following structure:

Chapter Two describes the theoretical framework that influenced the thesis both methodologically and philosophically. In particular, I highlight a number of constructs that
provided the impetus for this study, undergirded the argument in this thesis, and served as sensitising concepts for my interpretation of the data.

In Chapter Three, I provide a review of literature and research related to the topic of my study, including various approaches to teaching thinking skills in the classroom and the key issues related to the teaching of thinking skills. I also discuss the role of existing thinking frameworks and taxonomies in the context of research and pedagogy. The chapter concludes with a discussion of relevant development in educational assessment, with a focus on the assessment of thinking skills.

Chapter Four provides a detailed discussion of the research design and methodology. I start by describing the research approach, the participants, and the research setting. This is followed by a discussion of the role of the researcher and ethical considerations in relation to research with children. The subsequent sections of the chapter describe the development and refinement of research strategies, including the adoption of an evolving sampling strategy, the collection of data from multiple sources using multiple techniques (including the concept of thinking conversations with children), and the development of cognitive process mapping as an analytical tool.

The next three chapters discuss the findings and address the three research sub-questions listed above. In Chapter Five, I discuss the use of thinking conversations and informal interviews as data collection techniques to seek insights into children’s thinking processes and skills involved in their task performance. Cognitive process maps are described in detail in this chapter, including illustrative examples of how they can be used to analyse and represent children’s thinking processes and skills. I also explore in this chapter how visual models can be constructed from several cognitive process maps of a child’s task performance to give a larger picture of the child’s thinking abilities.
Chapters Six and Seven focus on the application aspects of cognitive process maps and visual models of children’s thinking processes and skills. In Chapter Six, I examine how cognitive process maps and visual models can be used to compare learner’s performance to theoretical models for certain task performances such as problem-solving and decision-making. In Chapter Seven, case examples are discussed to demonstrate that techniques developed and employed in this study - thinking conversations, cognitive process maps, and visual models - can provide insights into the strengths and weaknesses in children’s domain knowledge, working theories, and thinking skills at a specific level needed for formative purposes.

In the last chapter, I recapitulate the key findings and relate them to the research questions set out at the beginning of this thesis. I conclude with recommendations for researchers and educators, as well as suggestions on areas for further investigation.

This first chapter of the thesis has introduced the research topic and provided a brief overview of the study, including the background, the rationale and purpose, as well as the research goals and questions.
Chapter Two

Theoretical Framework

My research approach and methodology were framed by constructivist and pragmatist principles. The research topic was developed in the context of the need for an assessment approach that could provide specific insights into children’s thinking skills and take into account the emergent nature of children’s learning. My goal was to understand and reconstruct the children’s thinking processes and strategies. The study approach was characterised by an emergent structure and an interpretive perspective. The choice of research methods was driven by the criteria of viability and usefulness. I adopted the researcher role of a participant and facilitator that involved close relationships with research participants and co-construction of meaning through interaction with the participants. In my study, I recognised the existence of a mutually influencing relationship between the researcher and the participants. I present my findings as a set of tentative conclusions that serve as a basis for future research and actions. The implications of the constructivist and pragmatic positions on selected methodological issues of the study are described in Appendix B: Implications of Constructivist and Pragmatic Positions on Selected Methodological Issues. In the following sections of this chapter, I discuss in greater detail the constructivist and pragmatist principles that influenced the design and conduct of my research.

According to Schram (2006), all research is informed by the researcher’s perspective, beliefs about the world and how it can be studied and understood. Hatch (2002) makes a distinction between methodological and substantive theories. Silverman (2005) calls the former “paradigms” and the latter “theories”. Methodological theory addresses the ontological and epistemological questions (Hatch, 2002), while substantive theory is used to describe and explain the phenomena being investigated (Hatch, 2002; Silverman, 2005). Some researchers
recommend that substantive theories be developed upfront, be it a research study that involves testing of a hypothesis or a research that is exploratory in nature (Yin, 2003). Yin argues that some level of assumptions and direction underlies even an exploratory research by providing the following analogy:

When Christopher Columbus went to Queen Isabella to ask for support for his ‘exploration’ of the New World, he had to have some reasons for asking for three ships (Why not one? Why not five?), and he had to have some rationale for going westward (Why not south? Why not south and then east?). He also had some (mistaken) criteria for recognising the Indies when he actually encountered it. In short, his exploration began with some rationale and direction, even if his initial assumptions might later have been proved wrong. (Yin, 2003, p.23)

On the other hand, proponents of grounded theory see generation of theory as an outcome of the research (Glaser, 1992; Strauss & Corbin, 1998). Taking a somewhat mid position, Hatch (2002) suggests that some form of substantive theory is important upfront to clarify and explain to others what the researcher is up to. While the context in which my study was situated is described in my literature review in Chapter Three, it is useful to draw attention to the theoretical lenses with which I determined the research focus, the problem statement, what data were collected, and how the data were interpreted. In this chapter, I first discuss the constructivist worldview that both framed my research methodology and influenced how and why I was positioned to view ideas, issues and relationships in the manner I did. I then describe how the research design and methodology were underpinned by the principles of
pragmatism. An in-depth discussion of the two schools of philosophy is beyond the scope of this thesis. As Malachowski (2010) puts it:

Philosophers are fond of saying that philosophy has no shallow end . . .
But it is nothing to either boast about or apologise for. And it does not mark out anything special about philosophy. Try diving into an introductory text on pure mathematics, corporate finance, literacy theory or, indeed, any subject around which a substantial body of literature and critical thought has been built; unless you are already familiar with some of the background material, you will soon find water flowing over your head.

(p.x)

Rather than indulge in a broad-based philosophical discourse, I focus my discussion solely on those theoretical aspects that have a direct influence and relevance in this study. My aim is to make a clear link between these theoretical aspects and the context of my study and the research approach.

2.1 Constructivism

The term constructivism came from the idea that we construct our meanings (Boghossian, 2006) and constructivism may be defined as a “theory of how individuals and communities of individuals (e.g. scientist) make sense of the world” (Bentley, 1998, p.237). In constructivism, “realities” can be seen only through a theory and value-based perspective (Guba, 1990). Realities exist in the form of multiple mental constructions that are socially, experientially, and contextually-based (Guba, 1990; Guba & Lincoln, 2004). Multiple constructions of reality cannot be interpreted and understood through universal laws
(Rodwell, 1998). Reality is socially constructed and individuals develop subjective meanings of their experience (Bloomberg & Volpe, 2008). In this sense, constructivism can be viewed as being respectful of individual autonomy and capacity (Rodwell, 1998). The corollary is that access to an objective reality is impossible since each person construct his or her version of it (Fosnot & Perry, 2005; Patton, 2002). According to Guba and Lincoln (2004), constructions of meanings “are not more or less ‘true’, in any absolute sense, but simply more or less informed and / or sophisticated” (p.26).

In constructivist research, the researcher’s role is to seek to understand the multiple realities from the perspectives of the participants (Bloomberg & Volpe, 2008). The goal of the constructivist researcher is to understand and reconstruct the phenomena being studied, including participants’ views and contextual setting (Creswell, 2007; Creswell & Clark, 2007; Guba & Lincoln, 2004). The research focus is not to identify causal links and an action “may be explainable in terms of multiple interacting factors, events, and processes that shape it and are part of it” (Rodwell, 1998, p. 17). Rodwell describes constructivist research as a research investigation where:

The researcher attempts to reach understanding about the phenomena under investigation by understanding the internal and intangible processes of the minds of the inquiry participants. Constructivists are interested in the structure of the construct systems, the schemas or cognitive maps, that individuals evolve for themselves that allow them to impose meaning on their individual experiences. Through the cognitive structure, individuals construct their own truth. Constructivists participate in the creation of that truth. (Rodwell, 1998, p.27)
This is only possible if the researcher locates himself or herself in the situation and enters into
dialogue with the participants (Bloomberg & Volpe, 2008; Guba & Lincoln, 2004; Hatch,
2002; Rodwell, 1998). The inquirer and the inquired interact to influence one another, and
both inquirer and participants are changed as a result of the research (Rodwell, 1998).
Constructivist research adopts an interpretive perspective that acknowledges that knowledge
construction is a mix of the rational, serendipitous, and intuitive (Creswell, 2007; Rodwell,
1998). The structure of the research is necessarily emergent since the form and process of
research are dependent on interaction with participants and the context (Rodwell, 1998).
There are always multiple interpretations that can be made in any research because
interpretation is influenced by the inquirer’s theoretical framework, experience, and values
(Guba, 1990; Guba & Lincoln, 2004; Larochelle & Bednarz, 1998). “Truth” is a matter of
consensus among informed and sophisticated constructors (Patton, 2002). The aim of
constructivist research, therefore, is to generate a consensus construction “that is more
informed and sophisticated than any of the predecessor constructions” (Guba & Lincoln,
2004, p.27). The aim of interpretive research is to “develop a characteristic body of
knowledge . . . in the form of a series of tentative suppositions that describe the individual
case” (Rodwell, 1998, p.17). The phenomena being studied can only be understood within the
context in which they are studied and findings from one context cannot be generalised to
another (Patton, 2002; Rodwell, 1998).

There can be many interpretations of constructivism, including cognitive, socio-
cultural, radical, and pragmatic constructivism (Bentley, 1998; Boghossian, 2006; Cobb,
2005; Garrison, 1998; Reich, 2009; von Glasersfeld, 1998). I briefly discuss aspects of the
first three versions that are relevant to this study and address pragmatic constructivism in the
section on pragmatism.
Cognitive constructivism draws significantly on Piaget’s work and looks at individual cognitive structuring process (Bentley, 1998; Cobb, 2005; Fosnot & Perry, 2005; Reich, 2009). Cognitive constructivists analyse thought in terms of conceptual and cognitive processes located in the individual (Cobb, 2005; Reich, 2009). Cognitive theorists are interested in the individual’s interpretive activity and adaptation in response to the actions of others and the environment (Cobb, 2005).

Unlike cognitive constructivists, socio-cultural theorists emphasise the social and cultural effects on cognitive development (Bentley, 1998; Cobb, 2005; Fosnot & Perry, 2005; Reich, 2009). These social constructivists, as they are sometimes called, view learning as a process of enculturation through participation in culturally organized practices (Cobb, 2005). Some of them view the role of the teacher as mediating between the student’s own conceptual understanding and culturally established concepts of the wider society (Cobb, 2005). Knowledge is seen as socially constructed but the active construction on the part of the individual is implicitly acknowledged (Cobb, 2005; Reich, 2009). Socio-cultural theorists analyse individual’s cognitive structure by observing it interacting within a social and cultural context (Cobb, 2005; Fosnot & Perry, 2005). To socio-cultural theorists, research into human thinking and learning must necessarily be situated:

A primary tenet of Vygotskian psychology is that individual functioning is inherently situated in social interactional, cultural, institutional, and historical contexts. Therefore, to understand human thinking and learning, one must examine the context and setting in which that thinking and learning occurs. (Bonk & Cunningham, 1998, p.35)
Cobb (2005) argues for a pragmatic approach that recognises the complementary roles of the cognitive and socio-cultural theories:

I suggest that the socio-cultural perspective gives rise to theories of the conditions for the possibility of learning . . . whereas theory developed from the cognitive perspective focus on both what students learn and the processes by which they do so. (p.52)

Cobb proposes that the decision to adopt one or other perspectives should be determined by its suitability for resolving educational and research issues. Adopting such a pragmatic approach to theorising, I describe my focus on the participants’ cognitive processes as reflective of the cognitive constructivist approach, while the attention paid to the socio-cultural interactions and conditions that facilitated and provided the context for the research is reflective of the socio-cultural theory. Both perspectives played an equally important role in the conduct of this study.

In his version of radical constructivism, von Glasersfeld (1998) observes that knowledge is always related to our experience and to our desire to derive abstractions in the forms of concepts, theories, models which we construct “in the attempt to create a more or less regular predictable world” (p.25). He states that this “quest for model with predictive capacity is based on the belief that future experience will be similar to past experience” (p.25). A key thought in von Glasersfeld’s radical constructivism is that direct access to an external reality is not possible even though it may exist:

The leading scientists themselves have, I believe without exception, come to share the view that Einstein expressed by a brilliant metaphor. He
compared the scientist to a man who, faced with a clock he cannot possibly open, invents mechanisms that might explain the movements of the hands and the ticking he perceives – knowing full well that he will never be able to check his model against what ‘really’ goes on inside the clock. (von Glasersfeld, 1996, pp.3-4)

Likewise, we cannot look into the children’s heads to examine what and how they think, but can only infer from the conversations we have with them, what they say, and their behaviour. In the words of Larochelle and Bednarz (1998), a map can never be taken to be the territory it represents and what particularities and distinctions featured in the map are inevitably dependent on the decisions and experiences of the maker. Maps are nonetheless very useful devices for representing and communicating certain information about a territory. Different maps serve different purposes and are often essential for charting unfamiliar territory. In a similar vein, my study explored the use of cognitive process maps and visual models to represent the constructions of children’s thinking processes and strategies, without claiming that they correspond to objective reality (the concepts of cognitive process maps and visual models are elaborated in Chapters Four and Five of this thesis).

My research approach and methodology were framed by the constructivist principles described above. My goal was to understand and reconstruct the children’s thinking processes and strategies. I established close relationships with research participants and my role as a researcher was that of a participant and facilitator. I adopted an emergent structure of research where the process was a mix of the rational, serendipitous, and intuitive. Multiple realities were co-constructed through interaction between the researcher and the participants. Meanings were constructed through conversations, interviews, and open-ended questioning. I
adopted an interpretive perspective and interpretation was influenced by my personal values, experiences, and theoretical background.

2.2 Constructivism in Teaching and Learning

It is necessary at this stage to discuss the influence of constructivism on teaching practices given that the focus, the problem statement, and the findings of this research study were developed through the lenses of the constructivist perspective of learning. I have argued in Chapter One that scaffolding is essential to guiding students as they construct their understanding and make sense of their experiences. I also contended that the assessment of individual abilities would be crucial to effective scaffolding and the differentiated teaching of thinking skills. An important position adopted by constructivists is that students “are neither tabula rasa nor some as yet unmolded putty . . . they are both actors and authors of their cognition: they compare, translate, symbolize, and transform” (Desautels, 1998, p.127). Von Glasersfeld (1998) observes that six year-olds come with their own subjective perceptions and experiences which influence the way in which they interpret the actions and words of their teachers. The teacher cannot make the assumption that knowledge and ideas can be transmitted to students through the words of language alone given that the meanings of words have to be constructed by each person individually and this construction is dependent on the subjective experience of the particular person (von Glasersfeld, 1998). Teachers need to have some notion of their students’ knowledge and thinking in order to “speak in such a way as to ‘orient’ students’ efforts at construction” (von Glasersfeld, 1998, p.27). By providing students with the opportunity to explain the process which they took to solve a given problem and analyzing that process, teachers can seek a better understanding of the students’ conceptual understanding and mental operations (von Glasersfeld, 1998). Von Glasersfeld argues that children are capable of seeing for themselves where they had gone wrong and capable of
becoming “aware that it is they who are capable of constructing solutions to problems and that they themselves can decide whether something works or does not” (p.28). An illustrative example of this can be found in the experiments conducted in India with slum children, who were observed to be able to understand and use technology when provided with Internet access on-site in their settlement within the first month of unsupervised and unguided access (Mitra & Rana, 2001).

One key concept in constructivism is the notion of cognitive equilibration which Piaget describes as a dynamic process involving two complementary activities: assimilation and accommodation (Fosnot & Perry, 2005). In assimilation, the individual uses his or her current schemes of understanding to organize experience, to interpret the external world, and to act (Berk, 2003; Fosnot & Perry, 2005). In accommodation, the individual searches for new knowledge, creates new schemes, or adjusts current ones when he or she encounters contradictions to current understandings which make them insufficient and cause cognitive disequilibrium (Berk, 2003; Fosnot & Perry, 2005). Contradictions could arise when actions on objects are not working or when there are two conflicting theories (Fosnot & Perry, 2005). Furthermore, information and data by themselves are not contradictory – “they are contradictory only in relation to the meaning that the learner . . . attributes to them” (Fosnot & Perry, 2005, p.19). Taken in this sense, students in the classroom have to have the opportunity to explore the meaning of their experiences and engage in assimilation and accommodation, in order for deep learning (including learning how to be better thinkers) to occur. It can be said that cognitive constructivists focus on building on students’ prior knowledge, extending their learning by posing contradictions, and addressing misconceptions (Bonk & Cunningham, 1998; von Glasersfeld, 2001). It should be noted that Piaget himself did not deny the role of social context in the construction of knowledge even though it is not in the foreground of his theory (Bentley, 1998; Fosnot & Perry, 2005; Reich, 2009). For example,
contradictions that challenge an individual’s understanding could arise as a result of interaction with the social environment (Cobb, 2005).

Although social constructivists generally emphasise interaction and collaboration, the importance of the learner actively constructing his or own meaning is also underscored by the Vygotskian theory of learning (Bonk & Cunningham, 1998). In adult mediated learning, cognitive development depends on the child’s ability to comprehend the adult’s model (Fosnot & Perry, 2005). Vygotsky describes the process as the child’s spontaneous concepts working their way up to meet the knowledge concepts that work their way down in the process of classroom instruction, and the place where this occurs is called the zone of proximal development (Fosnot & Perry, 2005). This suggests that Vygotsky is also of the view that knowledge cannot be transmitted by language alone.

Scaffolding is an important educational concept commonly attributed to social constructivism (Berk, 2003; Bonk & Cunningham, 1998; Fosnot & Perry, 2005). Fosnot and Perry (2005) observe that there are two different versions of scaffolding. One involves adult modelling and provision of hints and props that guide the child in next steps until the child is capable of independent performance. I see this in the teaching strategy that utilises thinking maps to guide students through various thinking processes (Burke & Williams, 2008; Swartz, 2008). This scaffolding approach is akin to step-by-step guidance, which is not significantly different from didactic instruction. In practice, the learner could quickly become dependent on the hints and props, focusing on each step of the way and losing sight of the whole. The other version of scaffolding focuses more on the “constructive nature of learning” (Fosnot & Perry, 2005, p.25), which involves actions “such as . . . 1) focusing on a learner’s conception; 2) extending or challenging the conception; 3) refocusing by encouraging clarification; and 4) redirecting by offering new possibilities for consideration” (p.25). While not denying the usefulness of the first approach, I subscribe more to the second version because the tenets of
constructivism require the learner to enter a state of disequilibrium through an encounter with a challenge and actively reconcile his or her own conceptions with those that brought about the challenge.

In constructivism, the goal of instruction is focused on cognitive development and deep understanding (Fosnot & Perry, 2005). The precepts of constructivism necessarily imply that students must construct their own concepts and learning is not a mere matter of transmission of information from teacher to students (Fosnot & Perry, 2005; Garrison, 1998; von Glasersfeld, 2001). The constructivist model of learning perceives cognitive development as “constructions of active learner reorganization” (Fosnot & Perry, 2005, p.11). Fosnot and Perry identify four teaching principles derived from the constructivist theory of learning:

- Teachers need to provide opportunities for learners to “raise their own questions, generate their own hypotheses and models as possibilities, test them out for viability and defend and discuss them in communities of discourse and practice” (p.34).
- Learning is facilitated by disequilibrium caused by learners’ mistakes and misconceptions, engendered by challenging open-ended investigations, and provoked by contradictions.
- Reflective abstraction helps learners to better grasp key principles and concepts, and to organize and generalize learning across experiences.
- Dialogue within a community of learners generates further learning and thinking.

Constructivist principles have led to teaching practices such as the use of open-ended inquiry and problem-solving in the classroom, learning in cooperative groups, and reflective learning (Bentley, 1998). Students’ knowledge and points of view are taken into account and emphasis is placed on encouraging students’ participation and responsibility for their learning (Larochelle & Bednarz, 1998). The metaphor of the classroom as workshop has also been
forwarded - students and teachers working together in authentic inquiry instead of transmission of knowledge from teacher to students (Bentley, 1998).

These constructivist principles have led me to adopt the view that, while students can be taught to be better thinkers, teachers need to eschew a prescriptive approach to teaching thinking skills. Opportunities should be provided for students to explore their own solutions and apply their own thinking processes in order to figure out for themselves, albeit with some help from adults, what works and what does not. This implies that both educational researchers and teachers need to have a means to achieve good understanding of where the students are in terms of their thinking abilities. “Workshop” is a useful metaphor for a constructivist learner-centred classroom and it should be noted that workshops are often messy. An approach to assessing children’s thinking skills must necessarily take into consideration the diversity and unpredictability of students’ thinking processes in a learner-centred classroom. Naturally, the assessment model must also be able to identify students’ current thinking abilities and needs so as to inform decisions on appropriate teaching strategies.

2.3 Pragmatism

As noted in the beginning of the chapter, my research approach and methodology was also framed by pragmatist principles. Like many philosophical movements, there are forms and interpretation of pragmatism (Biesta & Burbules, 2003; Creswell, 2007; Misak, 2007). Pragmatism arises from the work of several philosophers such as Charles Sanders Peirce, William James, George Herbert Mead, and John Dewey (Bloomberg & Volpe, 2008; Garrison, 1998). The adoption of the dual frameworks of constructivism and pragmatism for this study is not conflicting because of the connections between constructivism and pragmatism (Reich, 2009). To some, constructivism is a form of pragmatism centred on how
people construct knowledge and meanings that enable them to cope with the world around them (Bentley, 1998; Rodwell, 1998). In this regard, John Dewey’s classical pragmatism is consistent with constructivism in many aspects although he did not use the term “constructivism” in his work (Bentley, 1998; Rodwell, 1998). In Dewey’s view, truth is constructed in the process of solving problems (Hickman, 2009a). He is also of the view that thinking is a goal-directed construction: for example a person would not think unless there is a problem to solve (Rodwell, 1998).

There is also a parallel between emphasis of pragmatism on “what works” and the notion of viability in von Glasersfeld’s (1998) radical constructivism:

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\ldots \text{an action, operation, conceptual structure, or even a theory, is considered ‘viable’ as long as it is useful in accomplishing a task or in achieving a goal that one has set for oneself. Thus, instead of claiming that knowledge is capable of representing the world outside of our experience, we would say, as did the pragmatists, that knowledge is a tool within the realm of experience. (p.24)}
\]

Von Glasersfeld argues that the choice of a knowledge model in science, for example, should be based on its viability and usefulness as a tool, not how “true” it is in an ontological sense. This is consistent with the pragmatist’s concern with the practical and “what works” (Biesta & Burbules, 2003).

There are also some similarities between the constructivist and pragmatist view of human learning. Piaget’s concept of cognitive equilibration has been described earlier in this chapter. In von Glasersfeld’s instrumentalist approach to cognitive development, learning is characterised as a self-organisation in which the learner “reorganises his or her activity in
order to eliminate perturbations” brought about by the learning process and through interaction with others in the community (Cobb, 2005, p.42). Both Piaget’s and von Glasersfeld’s models are generally consistent with the pragmatist theory of learning.

Inspired by Darwin’s *Origin of Species*, Dewey combines the idea of the tendency of organism to constantly adapt with the concept of the existence of living organisms alternating between phases of disequilibrium and equilibrium (Hickman, 2009a). In Dewey’s reflex arc model (Hickman, 2009a), learning begins with a stimulus that engenders a disequilibrium in a child’s mental state and triggers an emotional response. This is followed by the child’s intellectual response at defining the problem and forming a hypothesis based on lessons learned from the past. The child then explores the new situation in order to test the hypothesis. The results of the experience are then applied by the child to adjust his or her understanding of the world. The problematic situation is resolved and the child is once again in a state of equilibrium. The implications of the reflex arc model is that learning occurs in the child’s interaction with the environment, and the child is not a blank slate but an active learner with his or her experiences, ideas, interests, needs, and abilities (Hickman, 2009a). While opposed to a didactic approach to teaching that ignores the interests and abilities of the learner, Dewey rejects the idea of an extreme child-centred approach that is dictated by the child’s interests and impulses (Hickman, 2009a). This position is in line with current practice and research findings that suggest that effective classrooms are those that have a balance of adults-led and child-initiated activities (Epstein, 2007; Siraj-Blatchford, Sylvia, Muttock, Gilden, & Bell, 2002). Dewey’s educational views are largely consistent with the constructivist approach described in the preceding section of this chapter.

Having noted the affinities between pragmatism and constructivism, I now discuss the pragmatist perspective of the process of research (or, to use Dewey’s term, inquiry) that informed my research approach. Most of my discussion centres on the ideas of Dewey
because of the significant role he plays in explicating the process of inquiry (Biesta & Burbules, 2003). According to Malachowski (2010), Dewey endorses the scientific attitude which:

. . . involves the application of critical intelligence to the practical problems that human beings need to resolve in order to lead better lives. This kind of intelligence involves a willingness to try things out and to revise previously accepted beliefs in the light of the results of such experimentation, while, all the time, keeping in close touch with practical human concerns. (p.23)

Dewey’s notion of inquiry is associated with problem-solving (Biesta & Burbules, 2003). Dewey states all inquiry begins with an unsettled, indeterminate, or problematic situation (Biesta & Burbules, 2003; Garrison, 2009). The purpose of inquiry is to arrive at a resolution of that indeterminate or problematic situation (Garrison, 2009). The process of inquiry involves *existential operations* (actions, exploration, or experimentation) and *conceptual operations* (reflection or thinking) - which distinguishes the inquiry from pure trial and error where no conceptual operations are involved, and pure mental process where no existential operations are involved (Biesta & Burbules, 2003).

To Dewey, there is a close relationship between knowledge and action because reality is experienced and knowledge is constructed through the interaction between the individual and the environment (Biesta & Burbules, 2003). This interaction is “an active, adaptive, and adjustive process” in which the individual continuously attempts to maintain a dynamic balance with a changing environment (Biesta & Burbules, 2003, p.10). Dewey describes this interaction as a mutually influencing relationship in the sense that the individual who acts on the environment is in turn affected by the resulting changes in the environment (Biesta &
Burbules, 2003). Pragmatists do not subscribe to the notion of causal, law-like relations between stimuli and response that are commonly held in western psychology and behaviourist theory:

We do not know which is which [stimuli or response] until the completion of the act. This is because the actions of the agent construct the stimulus object as much as the stimulus object constructs the agent’s response. The organism is as active in constructing its environment as the environment is active in constructing the organism . . . When two events interact in an evolving universe, what is already fully actualized in the first event actualizes the potential of the second event, and conversely. (Garrison, 1998, pp. 46-47)

In the context of research, I take this to mean that the behaviour of the researcher affects the participants as much as the participants’ actions affect the response of the researcher. Likewise, the interactions between the teacher (or researcher) and students in the classroom are affected by the relationships between them. The nature of the interactions has a bearing on the process of knowledge construction and meaning making.

Pragmatists tend to reject the relativist view of truth, nor do they hold that truth is objective and absolute (Hickman, 2009a; Misak, 2007). The objectivist believes in the existence of reality that is independent of the human mind. The relativist believes that there is no independent reality waiting to be discovered and sees knowledge as subjective constructions. Some constructivists assume this relativist and post-modernistic position while others adopt a more pragmatic approach (Boghossian, 2006; Hickman, 2009b). The pragmatist, according to Golding (2007), sees “knowledge or meaning as the vehicle of
adapting to an independent reality. Meaning is what works to solve the problems we face, given the constraints of the external reality” (p.6). Pragmatists recognise that the standards of objectivity evolve over time but hold “facts” to be objectively true until new and conflicting data arise (Hickman, 2009a; Misak, 2007). By the same virtue, pragmatists hold the view that all beliefs, no matter how strongly held, are fallible (Misak, 2007). One does not need to look very far for examples: scientists once regarded the constancy of the speed of light as a physical law or believed that they had conclusive proof that light was wave or particle-like in nature.

For Dewey, this uncertainty of knowledge stems from the notion that there can be no assurance that past knowledge will be applicable to future problems (Biesta & Burbules, 2003). Dewey holds the view that we must always be open to new experiences and inquiry if our knowledge is to grow (Hickman, 2009a). Dewey argues that carefully designed experimental inquiry can produce objective truths, but inquiry may lead to different truths in different situations because every inquiry is situated (Garrison, 2009; Hickman, 2009a). Dewey prefers the term warranted assertion to describe the outcome of inquiry instead of “truth” or “knowledge” because the conclusion is always related to the specific context in which it was achieved and there is no guarantee that it will always hold in the future, in every situation, or in other inquiries (Biesta & Burbules, 2003). The conclusion is warranted as far as the inquiry that gave rise to it is concerned and on the basis of inferential evidence constructed in the course of inquiry (Biesta & Burbules, 2003; Hickman, 2009b). It is an assertion because it serves as a reliable basis (for the time being until proven otherwise) for future judgments, actions, or inquiry (Hickman, 2009b).

The pragmatist principles described above guided various aspects of this research. I adopted a pragmatic interpretation of the theoretical framework. I crafted the topic of my research in the form of a problem statement. Knowledge was co-constructed in the
interactions between researcher and participants (the “human environment”). In the process of research, a mutually influencing relationship was evident in the interactions between the researcher and the participants, and both researcher and participants were changed as a result of the research. What was observed and how the data was interpreted was a consequence of the interactions between each individual (including the researcher) and the socio-cultural environment of the classroom. Viability and usefulness were part of the criteria in the selection of the multiple methods employed in the research. The findings were described as a set of tentative suppositions that serve as a basis for future research and actions, while being subject to future revision in face of new insights and knowledge. I recognised that there was no guarantee that the conclusions of the study would always hold in every situation or in other studies.

2.4 Cognitive Task Analysis (CTA)

In my search for a theoretical base to anchor my approach to data collection and analysis, I became interested in the parallel between cognitive task analysis (CTA) theories and the techniques of thinking conversations and cognitive process. It is helpful to explain my data collection and analysis approach from the perspective of CTA because my research involved studying the cognitive processes and thinking skills of the participants as they engaged in various tasks. CTA is defined as a “broad area consisting of tools and techniques for describing the knowledge and strategies required for task performance” (Schraagen, Chipman, & Shalin, 2000, p. viii). Hoffman and Militello (2008) define CTA as “the determination of the cognitive skills, strategies and the knowledge required to perform tasks” (p.58). CTA has been described as involving three main components (Crandall, Klein, & Hoffman, 2006; Lee & Reigeluth, 2003):

- Knowledge elicitation
• Knowledge analysis

• Knowledge representation

A review of literature in relation to knowledge elicitation and CTA reveals that the term “knowledge” was used variously to include domain knowledge, procedures, problem-solving strategies, skills, thought processes, decisions, guidelines, and mental models (Clark, Feldon, Yates, & Early, 2007; Cooke, 1994; Lee & Reigeluth, 2003; Olson & Rueter, 1987; Rowe & Cooke, 1995; Wei & Salvendy, 2004).

CTA is used to seek out information about knowledge, thought processes, decision-making, and problem-solving and information processing strategies that underlie observable task performance (Wei & Salvendy, 2004). The outcome of CTA could be a description of the cognitive skills involved in performing tasks such as decision-making and problem-solving (Wei & Salvendy, 2004). CTA is used to analyse real-world problem-solving and task performance, and has roots in constructivism (Cooke, 1994; Dehoney, 1995). According to Cooke (1994), many researchers adopt the constructivist view that “knowledge is not viewed as a resource to be mined”, but as constructed by the expert and reconstructed by the researcher (p.802). CTA methods attempt to identify individual differences and “problem-solving strategies that may be manifest in variable sequences of actions depending on the environmental dynamics in each task” (Wei & Salvendy, 2004, p.274). CTA has been used to develop expert systems (Clark et al., 2007; Dehoney, 1995; Wei & Salvendy, 2004), to develop decision aids (Hoffman, Crandall, & Shadbolt, 1998), and to establish competence models for task performance assessment purposes (Dehoney, 1995). CTA has also been used to analyse and identify knowledge, skills or mental models in expert performance in order to inform instructional design (Clark & Estes, 1996; Clark et al., 2007; Dehoney, 1995; Hoffman et al., 1998; Jonassen & Hernandez-Serrano, 2002; Lajoie, 2003; Ryder & Redding, 1993), as well as to assess novice-to-expert progression in training (Carley & Palmquist, 1992; Lajoie,
Researchers have identified over 100 types of CTA methods currently being used (Clark et al., 2007).

Similarities exist between CTA and social science research: for example, observations and interviews are commonly used knowledge elicitation techniques and data transcripts from these methods are analysed and coded in a similar fashion (Clark et al., 2007; Cooke, 1994; Crandall et al., 2006; Pidgeon, Turner, & Blockley, 1991). In CTA, different techniques tap different knowledge (Lee & Reigeluth, 2003; Wei & Salvendy, 2004) and a combination of methods is generally recommended given that a single technique is unlikely to be adequate (Cooke, 1994; Crandall et al., 2006; Wei & Salvendy, 2004). Observations of task performance are used to discover how experts make judgments or decisions, perform diagnosis, and carry out complex tasks (Cooke, 1994; Wei & Salvendy, 2004). Interviews and questionnaires are used to engage experts in conversations aimed at revealing their thinking and processes undertaken in making judgments, solving a problem, or deciding a course of action (Cooke, 1994; Dehoney, 1995; Hoffman & Militello, 2008; Wei & Salvendy, 2004). The use of probe questions or interruption analysis involves interrupting the expert during observation of task performance in order to clarify what is observed or to solicit insights that cannot be obtained through silent observation (Cooke, 1994; Crandall et al., 2006; Olson & Rueter, 1987). Process tracing typically involves asking the expert either to self-report or to think aloud while performing the task and protocol analysis is carried out with the transcripts in order to draw inferences on what the expert sees and the thinking processes undertaken (Cooke, 1994; Dehoney, 1995; Hoffman & Militello, 2008; Wei & Salvendy, 2004). In a variation of think-aloud protocols, specific probe questions may be asked during the process (Ryder & Redding, 1993). Observations, interviews, process tracing, and protocol analysis are well-suited for analysis of tasks that are skill-based (Hoffman & Militello, 2008). In particular, observations and interviews are useful where specific task performance are not
well-defined (Hoffman & Militello, 2008). Process-tracing is useful when it is important to evaluate task performance (Hoffman & Militello, 2008).

CTA using students’ verbal reports has also been used to develop cognitive diagnostic assessment (Leighton & Gierl, 2007). Leighton and Gierl describe cognitive diagnostic assessment as a type of test designed to measure specific knowledge (such as concepts, procedures, and rules in mathematics) and processing skills in applying those knowledge. The aim of cognitive diagnostic assessment is to provide information on the depth of students’ understanding within a content domain. Collection of data using verbal reports may involve asking the student to think aloud while solving a test question, using concurrent interviews while the student is engaged with the task, and retrospective interviews after completion of the task (Leighton & Gierl, 2007). The data are subsequently analysed to validate a cognitive model of task performance that has been previously developed from a review of theoretical literature. Test questions are then developed from the cognitive model of task performance to ensure that they are designed to provide information on students’ cognitive strengths and to “pinpoint the knowledge and processing skills the examinee may be lacking or where, in their thinking, students lost their way” (p.149). Cognitive diagnostic assessment is purportedly useful for formative (as well as summative) purpose because the information can be used to inform teaching intervention.

I describe the data collection and analysis approach employed in my study as an adapted form of CTA because the methods employed are similar to several CTA techniques such as observation, interview, interruption analysis, process tracing, and protocol analysis. The goal was to gain insights into children’s thought processes, skills, and problem-solving strategies. Observations with interviews were used in combination (which I call thinking conversations) to gather information while the children were actively working on tasks or about the work that they had completed in the natural setting of their classroom. Unstructured
and semi-structured interviews were employed “off-line” in a separate room to engage in conversation with children in relation to their work and experience after the fact. The techniques which I call cognitive process maps and visual models were developed in the course of the study to analyse and represent the data collected. Throughout the study, children were viewed as the experts in their own lives (Stephenson, 2009), including their own learning and thinking. This perspective of children as experts is a recurring theme in:

- The socio-constructivist framework adopted for the study which sees children as social actors with their own perspectives and co-constructors of the meaning of their own learning (Smith, Duncan, & Marshall, 2005).
- This researcher’s stance in interacting with the children.
- The study’s ethical considerations and respect for children’s rights.
- The choice of data collection and analysis methods akin to those used in elicitation of expert knowledge and CTA.

2.5 Summary

The constructivist framework provided the basis for adopting the qualitative approach of a participant observation study involving close relationship and interactions with the participants. Multiple meanings were co-constructed with the participants and an interpretive approach was adopted in data analysis, with the understanding that alternative interpretations were always possible. The pragmatic theoretical framework led to the adoption of a flexible approach that involved both deductive and inductive thinking, as well as multiple methods of data collection and analysis.

Constructivist principles influenced the research focus, the development of the problem statement, what data were collected, and how the data were interpreted. In my study, I sought to observe and document the diversity of the children’s own approaches and
strategies across a variety of contexts and as they respond to interactions with others. My aim was to make evident and to make sense of the children’s thinking processes and skills as they engaged in various activities and problem-solving. I was interested in what they did, how they did it, why they did it that way, and any thoughts they might have on the process they adopted. Pragmatic constructivism provided the justification for 1) the adaptation of cognitive task analysis (CTA) to study the cognitive processes and thinking skills of the participants as they engaged in various tasks; and 2) the cognitive process mapping approach to representing children’s thinking processes and strategies, on the basis that the cognitive process maps constituted useful representation but not correspondence to objective reality.

In order to stay focused and concise, I have left out many significant concepts in constructivism and pragmatism in my discussion because they are either peripheral or irrelevant to this study. I empathise with Hacking (2007) when he says, tongue in cheek or otherwise: “I once tried valiantly to read John Dewey, but it did not click. He goes on and on.” (p.45). I have endeavoured to be succinct in my discussion of the philosophical paradigms that underpinned this study. In the last section of the chapter, I discussed how a parallel can be drawn between CTA theories and my approach to data collection and analysis. On the basis of the theoretical framework described in this chapter, I next discuss the research and literature related to the study and the methodology that was adopted for my research in the next two chapters.
Chapter Three

Literature Review

The motivation for this qualitative research study was to explore the potential of thinking conversations, cognitive process maps, and visual models as research and assessment tools that can provide an in-depth understanding of children’s thinking abilities and to inform the teaching of thinking skills. The aim of the study was to investigate how task analysis techniques - thinking conversations with young children, cognitive process maps, and visual models - could be used to observe, analyse and interpret young children’s thinking processes and skills in order to obtain insights into their thinking abilities. The purpose of this chapter is to provide a literature review in order to situate this study within a conceptual framework of existing research and literature. In this chapter, I provide an overview of some of the commonly used methods to teaching thinking skills and discuss a number of issues in relation to transferability and the adoption of a teacher-directed approach to the teaching of thinking skills. Since this study involved the exploration of an alternative approach for assessing young children’s thinking abilities that can inform researchers and educators, it is necessary to discuss some of the developments and issues in relation to various methods for assessing thinking skills. I also discuss the observation, analysis, and interpretation of young children’s thinking processes and skills, which was the focus of this study.

3.1 Teaching Thinking Skills in the Classroom

Researchers, philosophers, and educators have come to the view that the traditional educational model of transmission-reception of knowledge is inadequate in today’s increasingly complex and fast-changing world, and that educating students to learn how to learn and think is crucial (Barak & Dori, 2009; Costa, 2001b; Fisher, 2003; Howie, 2003;
Moseley, Elliott, et al., 2005; Wells & Claxton, 2002). Educational reforms in the countries such as the US, the UK, Australia, Hong Kong and Japan advocate the critical thinking instruction in schools (Ku, 2009). In New Zealand, thinking is one of five competencies in the New Zealand curriculum introduced in 2007 and remains a feature of the curriculum even after introduction of the National Standards in 2010 which focus on literacy and numeracy (Ministry of Education, 2007, 2009).

Concerns over students’ poor thinking abilities are based on evidence that good thinking is not widespread and a significant proportion of secondary school and university students do not possess the thinking skills necessary for success in tertiary education or in the work place (Anderson, Howe, Soden, Halliday, & Low, 2001; Arter & Salmon, 1987; Beyer, 2001b; Kuhn, 1991). Research suggests that most high school and undergraduate students in the US do not perform well on critical thinking tests (Beyer, 2001b; Norris, 1985). A US study published in 1988 showed that 80% of third graders (7 to 8 years old), over half of seventh graders (12 to 13 years old), and 36% of eleventh graders (17 to 18 years old) scored minimally or inadequately in critical reading assessment (Follman, Lavely, & Berger, 1997). Students’ deficiency in problem-solving and critical thinking abilities was also reported in results of national, state, and local testing programmes in the US (Blumberg, Epstein, MacDonald, & Mullis, 1986; Cano, 1993; Norris, 1988a; Stiggins et al., 1989). A study on 256 Scottish and Australian university students showed that critical thinking was not being developed in their tertiary education (Pithers & Soden, 2000). In a follow-up study, Pithers and Soden (2000) found that instances of critical thinking were rare in university students’ essays and there was a high frequency of assertions without justifications. In 2005, the Association of American Colleges and Universities’ report stated that only six per cent of college seniors (final-year university students) were considered proficient in critical thinking (Ku, 2009).
Researchers and educators are generally of the view that thinking skills do not automatically develop as a result of maturation or standard instruction in a core subject area (Angelo, 1995; Baker, 1981; Beyer, 2001b; Halpern, 1994, 2007b). From New Zealand, Hipkins (2006b) contends there is a need for an explicit focus on the development of thinking skills in the classroom because it cannot be assumed that providing situations where students could think means they will think, nor can one assume that thinking will develop automatically when content is taught even though subject-specific knowledge can contribute to higher order thinking. There is some research evidence that critical thinking abilities do not develop as a result of general education, including courses that value the development of critical thinking abilities (Beyer, 2001b; Blattner & Frazier, 2002; Orion & Kali, 2005).

Researchers, psychologists and educators take the view that thinking skills can be taught and students can improve their thinking abilities as a result of instruction (Arter & Salmon, 1987; Beyer, 2008; Halpern, 2007b; Higgins et al., 2004; Higgins, Hall, Baumfield, & Moseley, 2005; McGuinness, 1999; Topping & Trickey, 2007). Even young children appear to benefit from critical thinking instruction (ten Dam & Volman, 2004). The American Philosophical Association 1990 Delphi Report, which is based on the views of forty six experts in critical thinking, suggests that critical thinking skills:

... can be taught in a variety of ways, such as by making the procedures explicit, describing how they are to be applied and executed, explaining and modelling their correct use, and justifying their application. Teaching cognitive skills also involves exposing students to situations where there are good reasons to exercise the desired procedures, judging their performance, and providing the students with constructive feedback regarding their proficiency and ways to improve it. (Facione, 1990b, p.28)
Research shows that enhanced thinking skills can improve subject-learning and the mastery of skills, such as comparing, classifying, sequencing, and predicting, has been found to be helpful to students in becoming effective readers, writers, and learners (Beyer, 2008). In a meta-analysis of 29 studies from a range of countries with half set in the US and the UK, Higgins et al. (2005) note that effect of thinking skills programmes in improving students’ cognitive performance was greater than that of most other educational programmes. In the US, Halpern (1994) cites seven research studies involving undergraduate students and adults, which found that thinking skills could be improved through instruction that was specifically adapted to promote critical thinking. A review of 23 research studies set mostly in the US (34%) and the UK (27%) on thinking skills instruction by Higgins et al. (2004) found that the majority reported positive effects in a range of non-curriculum measures such as reasoning and problem-solving, some evidence of benefits from explicit training in thinking skills, and some evidence of transfer to other contexts. A review commissioned by the Department for Education and Employment in the UK showed that approaches to developing children’s thinking can be effective if well implemented (McGuinness, 1999). Several decades of research demonstrate that creative abilities are amenable to further development (Esquivel, 1995; Feldhusen & Goh, 1995). Feldhusen and Goh (1995) note that teaching interventions can only facilitate creative thinking processes but “do not guarantee successful, real-life production” (p.241).

The review by Higgins et al. (2004) showed that impact of thinking skills programmes was uneven across different groups of students, suggesting a more targeted approach may be necessary to match the types of intervention that focus on improving specific thinking skills to students’ needs. The review also showed that there could also be a delay as long as two years before results of improvement became evident (Higgins et al., 2004).
There are many existing pedagogical programmes and techniques that promote students’ thinking in the classroom (Baumfield, Butterworth, & Edwards, 2005; Dewey & Bento, 2009; McGuinness, 1999). In the US alone, there are over 100 commercially available programmes that teach specific thinking strategies apart from the normal curriculum (Nisbet, 1993). Nisbet provides a listing of major initiatives in countries such as the Netherlands, Belgium, France, Germany, Spain, Portugal, Sweden, Finland, Greece, Britain, and Australia. Blagg (1991) provides a summary of a wide range of cognitive theories underlying the development of thinking skills. In an extensive review of research into thinking skills instruction commissioned by the Department for Education and Employment in the U.K., McGuinness (1999) reports that there was sufficient accumulated research and practice to identify key elements for the development of thinking skills:

- The need to make thinking skills explicit in the curriculum.
- The teaching of thinking skills through coaching.
- The importance of metacognitive skills, dispositions, and habits of good thinking.
- The impact of collaborative learning on the development of thinking skills.
- The extension beyond a narrow focus on thinking skills to include thinking curricula, thinking classrooms, and thinking schools.

Not all approaches are equally successful and mixed results have been reported for some thinking skills programmes (McGuinness, 1999; McMillan, 1987; Sternberg & Bhana, 1986; ten Dam & Volman, 2004). Successful thinking skills approaches tend to have “a strong theoretical underpinning, well-designed and contextualised materials, explicit pedagogy and good teacher support” (McGuinness, 1999, p.1). The report by McGuinness also highlights a number of factors crucial to the success of thinking skills instruction, such as the role of teachers, and the professional development and support needed for teachers.
There is the question of whether a constructivist approach or didactic teaching of thinking skills is preferable (Beyer, 2008). In either approach, Beyer advocates a new thinking skill be selected and introduced by the teacher at the beginning – the difference being the level of subsequent guidance and the manner in which the students are allowed to apply the new skill. According to Beyer (2008), research suggests that the former is more suited to average and above average students and the latter for less able students or when the skill being taught is highly complex and difficult to master. In the following sections, I have classified approaches to teaching thinking skills that have been used in the classroom into two main categories: broad-based integrated learning approaches and explicit approaches that target specific thinking skills.

### 3.1.1 Integrated learning approaches to teaching thinking skills.

Integrated learning approaches attempt to offer challenging and thought-provoking open-ended learning experiences within contexts that are meaningful to students. Examples include inquiry-based learning, problem-based learning, case-based learning, and project approach (Ong & Borich, 2006). Such approaches are broad-based in terms of their coverage of general skills and cut across traditional disciplinary or subject areas. They are designed to be learner-centred and to provide a certain degree of authenticity in learning which is characterised by open-ended, complex tasks that require students to engage in problem-solving, decision-making, and investigation. Students are usually assessed not only on their knowledge but also on their thinking and problem-solving skills, dispositions, communication skills, and ability to work cooperatively with others (Ong & Borich, 2006). The open-ended nature of the learning activities in such approaches renders it difficult to teach specific thinking skills and cover subject content comprehensively. Helm and Gronlund (2000) note the difficulty in assessing the outcomes of open-ended activities that require young children to
apply their developing thinking skills in meaningful contexts. The difficulty in assessing student learning in problem-based learning because of its open-ended nature has also been highlighted by Ertmer and Simons (2006).

There is limited research evidence that shows the effectiveness of these approaches in developing specific thinking skills in students. In a study in Australia, Oliver (2001) found that university students enrolled in a web-based programme on critical thinking and problem-solving chose to focus on content knowledge and failed to see the opportunity or the need to exercise critical thinking even though the problem-based learning setting provided many opportunities for the advancement of student’s critical thinking skills through problem-solving. The students did not reflect on the processes they undertook, solutions they developed, or strategies for improvement even though a number of reflective components were built into the problem-based learning setting. The results showed that the development of thinking skills was not a necessary outcome of the problem-based learning course and that some deliberate interventions may be needed if thinking skills are to be part of the learning outcomes (Oliver, 2001). There is some research evidence that the project approach is effective in teaching problem-solving and decision-making (David, 2008). In a study of the impact of problem-based learning on 79 undergraduate nursing students at a Hong Kong university, Tiwari, Lai, So, and Kwan (2006) found significant differences in the development of critical thinking dispositions between those who undertook problem-based learning and those that attended lecture courses.

### 3.1.2 Explicit methods of teaching thinking skills.

Explicit methods of teaching thinking skills are based on the principle and research findings that there is a need to be explicit about what is meant by good thinking and to teach students directly how to be better thinkers (Beyer, 2008; Burke & Williams, 2008;
McGuinness, 1999). McGuinness (1999) identifies three broad categories of approaches: discrete approaches where students are taught to practise specific thinking skills in a programme that is additional to the normal curriculum, programmes that are subject-specific, and interventions that are infused across the curriculum.

There is considerable debate over whether it is more effective to adopt a discrete programme or an infused approach (ten Dam & Volman, 2004). Underlying this debate is the question of whether thinking skills are generic and applicable across disciplines (Ennis, 1989; Siegel, 1992; Wegerif, 2004) or domain and task-specific (Baer, 1998; Brown, 1997; Feldhusen & Goh, 1995; Haylock, 1987; Hu & Adey, 2002; McPeck, 1981, 1990; Perkins & Salomon, 1989; Swartz, 2001; Swartz & Parks, 1994). There is also the related question of whether thinking skills are transferable across contexts (Glevey, 2008; McGuinness, 1993). There are evidently some aspects of thinking that are general while others are domain-specific (Perkins, Jay, & Tishman, 1994; Sternberg, 2006b) and both discrete and infused approaches have their advantages and disadvantages (Baron & Sternberg, 1987; Nisbet, 1993).

Comparison of the effectiveness and merits of the different approaches is difficult because evaluative studies tend focus on one particular thinking skills programme at a time (Burke & Williams, 2008; Higgins et al., 2004). According to Willingham (2007), evaluative studies of critical thinking programmes can be limited by a number of methodological issues: 1) students are evaluated only once and endurance of observed effects is unclear; 2) there is no control group, so it is unclear whether the gains are due to other factors; 3) the control group does not have a comparison intervention, so that the gains may be due to the teacher’s enthusiasm and not the programme itself; and 4) there is no measure of transferability to other contexts and materials that differ from that of the programme.

One of the most popular discrete approaches is de Bono’s CoRT (Cognitive Research Trust; De Bono, 1976) which provides a number of thinking tools as strategies for individual
thinking, group discussion, and problem-solving. Evaluation studies on the effectiveness of the programme show mixed results (Adams, 1989; Nisbet & Davies, 1990). The Instrumental Enrichment programme is another approach adopted internationally for teaching general thinking skills (Feuerstein, Rand, Hoffman, & Miller, 1980). The programme purports to individualise instruction through the use of dynamic assessment typically in the form of pre-test, intervention, and post-test format. Evaluation studies showed positive effects such as improvement in non-verbal reasoning (Blagg, 1991; Dewey & Bento, 2009; McGuinness, 1999; Shayer & Beasley, 1987). There are concerns over transferability because of the abstract nature of the tasks, the need for substantial training for teachers, and the lengthy duration of the programme (Sternberg & Bhana, 1986).

Another widely used programme is Philosophy for Children, several versions of which have been developed for children from three to over 16 years old (Cleghorn, 2002; Fisher, 2003; Haynes, 2002; Lipman, Sharp, & Oscanyan, 1980). The programme is aimed at improving children’s thinking abilities such as evaluating, reasoning, analysing, justifying, classifying, and hypothesising (Fisher, 2003). The programme also seeks to develop certain intellectual dispositions such as curiosity, thoughtfulness, perseverance in seeking truth, openness to the views of others, willingness to judge and self correct, and readiness to speculate and analyse (Fisher, 2003). It also aims to develop self-awareness, self-regulation, resilience, and empathy in addition to social and metacognitive skills (Fisher, 2007). In the UK, Fisher has adapted the Philosophy for Children programme to be used in literacy lessons and across curriculum (Fisher, 1999; Fisher, 2001). Numerous evaluation studies have been carried out in different countries with different age groups of children (Trickey & Topping, 2004). Positive effects include improvement in the quality of children’s discussion and argumentative skills, reasoning skills, and ability to pose questions and provide justifications for their views (McGuinness, 1999; Topping & Trickey, 2007; Trickey & Topping, 2004).
The Odyssey programme is designed based on schema theory with an emphasis on helping students develop the ability to transfer their skills across different domains (Adams, 1989). The programme provides both abstract and content-specific teaching materials focusing on four broad processes of classification, hierarchical classification, sequencing, and analogical reasoning. Evaluation using a number of standardised tests showed cognitive gains in seventh grade (12 to 13 years old) students (Adams, 1989).

A number of programmes that teach creative thinking are based on the creative problem-solving (CPS) model. Building on the original Osborn-Parnes approach to creative problem-solving (Parnes, 1967), Isaken and Treffinger (2004) developed several versions of their model for CPS. In versions 5 and 6 of their CPS model, Isaken and Treffinger identified the need for a more flexible approach in an effort to espouse constructivist principles (Treffinger & Isaken, 2005). In particular, they recognise that the phases of CPS may be used in different sequences, not all the steps are always necessary, and there is a need to build in a phase where the user considers whether CPS is appropriate and whether modifications are needed. In failing to recognise that their CPS model may be one of many approaches to problem-solving and in attempting to make their model all encompassing and flexible, they produce an abstract representation that is perhaps far too complex and difficult to put into classroom practice.

Other programmes that target specifically creative thinking skills include the Purdue Creativity programme (Feldhusen & Clinkenbeard, 1986), the Productive Thinking programme (Covington, Crutchfield, Davies, & Olton, 1974), the AUTA (awareness, understanding, techniques, and actualisation) model (Davis, 1982), and Sternberg and Williams’ (1996) approach. De Bono’s Six Thinking Hats (De Bono, 1999) is frequently associated with the development of ‘lateral thinking’ and encourages examining issues from multiple perspectives. At the MIT Media Lab, Resnick (2007) adapted “kindergarten-style”
learning to develop technologies for teaching creative thinking. Sternberg and Lubart (1991) propose a model for fostering creativity in children and adults that involves six “resources”: intelligence, knowledge, intellectual style, personality, motivation, and environmental context. Reviews focusing on creative thinking programmes show that creativity can be taught by employing various techniques addressing key elements such as domain knowledge, cognitive process skills, metacognitive skills, social and physical environment, and personality factors (Craft, 2001; Davis & Rimm, 1985; Feldhusen & Goh, 1995; Sternberg, 2003; Torrance, 1987). According to Craft (2001), studies show creative thinking programmes “are much less successful than is sometimes maintained” and there is little evidence of transfer (p.16). There is also a lack of systematic evaluation of some of the programmes (Craft, 2001).

A number of programmes target subject-specific thinking skills through a series of structured lessons. Examples are CASE (Cognitive Acceleration through Science Education), CAME (Cognitive Acceleration through Mathematics Education), Thinking through Geography, and History of Science (Adey, Shayer, & Yates, 2001; Leat, 1998; Malamitsa, Kasoutas, & Kokkotas, 2009; McGuinness, 1999). In a two-year longitudinal UK-based study of 11 to 14 year-old students enrolled in the CASE programme, Adey and Shayer (1994) reported gains in student achievement in science, mathematics and English. In a UK-based study involving five to seven year-olds enrolled in the CASE programme, Cattle and Howie (2008) found some limited evidence of positive effects. In Israel, the Thinking in Science Classrooms (TSC) project makes use of learning activities, open-ended inquiry, and guided discussions to systematically develop critical thinking, scientific inquiry, and metacognitive skills in multiple science topics (Zohar, 1996; Zohar & Dori, 2003; Zohar & Schwartz, 2005). Evaluation results showed significant gains in junior high school (12 to 15 year-old) students’ reasoning skills and science knowledge (Zohar & Dori, 2003). The potential for
fostering critical thinking through physical education is demonstrated in a US-based study by McBride and Bonnette (1995), who found positive effects in a group of 43 at-risk male students aged between 10 and 11 years old.

Unlike discrete or subject-specific programmes, the infusion approach does not have a prescribed set of lessons (Dewey & Bento, 2009). McGuinness (2000) lists a number of benefits of the infusion approach to teaching thinking skills: matching thinking skills to curriculum subject areas, and promoting thoughtfulness and deep learning in curriculum content. Several approaches infuse the teaching of thinking skills into the curriculum. One example is the ACTS (Activating Children’s Thinking Skills; McGuinness, 2000) programme which is modelled on the infusion approach and taxonomy of thinking skills of Swartz and Parks (1994). The programme identifies metacognition, critical thinking, creative thinking, searching for meaning, problem-solving, and decision-making as important processes and skills to be taught explicitly across existing curriculum areas. An evaluative study in the UK of 404 children aged between seven years six months and nine years eight months from eight primary schools by Dewey and Bento (2009) found positive effects in terms of cognitive gains, and awareness and use of thinking skills. Wallace’s (2009) Thinking Actively in Social Context (TASC) approach provides an eight-stage process to develop skills in research, investigation, and problem-solving that can be used across the curriculum for four to seven year-olds. There is some research evidence that the approach improved students’ reasoning skills in a Spanish study of 58 students aged between 11 and 13 years old (Sanz de Acedo Lizarraga, Sanz de Acedo Baquedano, & Oliver, 2010). Another school-wide infusion approach to implementing critical thinking instruction is the CRTA (Culture-Review-Teach-Assess) model that targets the four areas of knowledge, habits of mind, thinking processes, and metacognitive strategies (Kassem, 2005). A number of teaching strategies are used including graphic organisers, reciprocal teaching, teacher’s questioning, and modelling
(Kassem, 2000; Kassem, 2005). An evaluative study involving a US-based secondary school was limited to qualitative feedback from teachers and students (Kassem, 2000). Talents Unlimited (TU) is an infusion programme that focuses on developing students’ skills in the areas of productive thinking, decision-making, planning, forecasting, and communication (Newman, 2008; Schlichter, 1979, 1986). Evaluation studies showed improvements in grades one to six (six to 12 years old) students’ academic achievement, and creative and critical thinking skills (Chism & McLean, 1980; Schlichter, 1979).

Thinking tools, thinking maps or graphic organisers are commonly employed as part of the teaching strategies to guide students through various thinking processes (Burke & Williams, 2008; Swartz, 2008). These are techniques that typically help students approach a task in a certain manner by drawing their attention to specific aspects of the task and guiding them through specific procedures to complete the task. An example of thinking tools is Durham’s (2006) Handy Thinking Tools designed “to help students focus on, unpack, understand, and develop issues and ideas” (p.184). Murdoch and Wilson (2008) provide a comprehensive list of thinking tools commonly used by teachers in the primary classroom to teach students thinking skills. Thinking maps are commonly used in infusion approaches and involves a sequence of questions to guide students in a particular cognitive process (Melville Jones & Haynes, 1999, December; Ong, 2006; Swartz, 2008). A list of sequential questions is designed for a thinking process such as decision-making, or a thinking skill such as compare and contrast. Proponents of thinking maps claim that the use of questioning in the classroom alone is inadequate and “it is necessary to provide them (the students) with questions that are structured according to thinking procedures” (Ong, 2006, p.243). Graphic organisers are also frequently used in teaching thinking skills in the classroom (Clarke, 1991; Ong, 2006). They are typically used to help students visualise the thinking process and guide them through steps in applying certain thinking skills.
The Visible Thinking programme uses more than 30 thinking routines developed based on work carried out in primary to university settings in the US, the Netherlands, Sweden, Belgium, and Australia (Ritchhart & Perkins, 2008). The aim of the Visible Thinking programme is to deepen learning and foster thinking skills and dispositions in students. The thinking routines are used by teachers as classroom learning tools to promote certain forms of thinking according to a variety of predetermined learning objectives such as helping students to develop the abilities to evaluate ideas, offer evidence-based explanation, and make connections between new ideas and prior knowledge. Relevant thinking routines are selected and incorporated by the teachers into their classroom lessons based on their pedagogical planning decisions or students’ learning needs that they have identified. Teachers are encouraged to review and assess where the students are in terms of their conceptual understanding and their ability to engage in the thinking routines selected by the teachers. Assessment makes use of any form of documentation that reveals “learners’ unfolding ideas as they think through an issue, problem or topic”, including mind maps, charts and lists, diagrams, and worksheets (Tishman & Plamer, 2005, p. 1). It is unclear whether the assessment examines student’s conceptual understanding or their abilities in exercising specific thinking skills. Teachers collaborate as a group to review documented students’ work, “speculating about students’ thinking”, raising questions, and exploring implications for teaching” according to a protocol recommended by the programme (Ritchhart & Perkins, 2008, p.3). The protocol does not specify how students’ thinking skills can be identified nor does it provide a means to do so.

To make thinking skills explicit, importance is placed in some of the thinking skills programmes on developing the language of thinking in the classrooms so that students can relate thinking words such as compare, predict, reason, summarise, conclude, estimate, classify, and imply to their cognitive processes (Costa & Marzano, 2001; Fisher, 2003;
Tishman & Perkins, 1997). Proponents claim that making thinking explicit through classroom interaction and effective patterns of talk can help make thinking skills programmes effective (Higgins et al., 2004; Nelson, 2004). Various questioning tactics, including the use of Socratic questioning technique, are employed to promote thinking skills in the classroom (Nelson, 2004; Paul, 1993; Walker, 2003). Dialogical discussion forms a key component in several thinking skills programmes such as Philosophy for Children, Topping’s (2001) Paired Thinking strategy, Dawes, Mercer, and Wegerif’s (2000) Thinking Together, Paul’s dialogical thinking approach (Paul, 1986), and Berntein’s negotiation model for teaching critical thinking (Bernstein, 1995). Some approaches explicitly teach argumentative skills (Anderson et al., 2001; Hernandez, Kaplan, & Schwartz, 2006; Kuhn, 1991) or analysis of arguments (Swartz, 2006) in order to develop students’ critical thinking. Collaborative group work and learning have also been found to be beneficial toward enhancing students’ thinking skills (Burke & Williams, 2008; Higgins et al., 2004).

Metacognition is considered an important component of teaching students to be effective thinkers, especially in helping students to reflect on their thinking, be aware of the cognitive procedures they employ, and transfer their thinking skills to different contexts (Beyer, 2008; Burke & Williams, 2008; Costa, 2008; Feldhusen & Goh, 1995; Kuhn, 1999; Moseley, Elliott, et al., 2005; Pithers & Soden, 2000; Swartz, 2008). Researchers, theoreticians and practitioners also recognise that thinking is more than process skills and students need to have the necessary dispositions to be able to recognise when a skill is needed and be willing to apply it – in other words, to be self-directed thinkers (Bailin, Case, Coombs, & Daniels, 1999; Costa & Kallick, 2000; Ennis, 1987; Facione, 1990b; Fisher, 2007; Halpern, 1996; Norris, 2003; Paul, 1992; Resnick & Klopfer, 1989; Ritchart & Perkins, 2000; Sternberg, 2006a; Tishman, 2001; Weil, 2004). Despite general consensus on the importance of adopting a dispositional perspective, different and often overlapping types of dispositions
have been proposed and these are reflected in various thinking frameworks, definitions, and thinking skills programmes. Adult modelling, scaffolding, cognitive apprenticeship, and cooperative learning have been proposed as ways of developing appropriate thinking dispositions (Perkins, Jay, & Tishman, 1993).

Very few research studies have been carried out to investigate whether dispositions can be learned or how they can be effectively taught (Perkins, Tishman, Ritchart, Donis, & Andrade, 2000). A US-based study by Ritchart and Perkins (2000) involving university students showed that certain classroom practices could increase students’ mindfulness toward learning and thinking. There is also limited research that examines the impact of dispositions on thinking and problem-solving. A series of US-based studies of sixth and eighth graders (11 to 14 year-olds) by Perkins et al. (2000) showed that low sensitivity to shortcomings or problematic areas in thinking appeared to be the larger obstacle to good thinking than a lack of ability or motivation. The same series of studies also revealed that a person’s sensitivity was likely to improve as ability level increased. In the US, Stanovich and West’s (1997) study on university students’ performance on argument evaluation tasks showed that cognitive ability and thinking dispositions were separable predictors of performance. Oliver’s (2001) previously mentioned Australian study showed that students’ avoidance of critical and reflective thinking tasks could render the problem-based learning setting ineffective in engaging students in such thinking skills. More than 15 years’ of research into the related construct of self-regulation showed that the ability to self-regulate one’s learning can be a major contributor to the differences between high and low-achieving students (Bronson, 2000), although there is no evidence of direct link to specific thinking skills.

Models, taxonomies, and thinking frameworks have been developed to guide instruction and assessment (Burke & Williams, 2008; McGuinness, 1999; Moseley, Elliott, et al., 2005). McGuinness (1999) notes that several taxonomies “include some reference to
sequencing and sorting, classifying, comparing, making predictions, relating cause and effect, drawing conclusions, generating new ideas, problem-solving, testing solutions, making decisions and so on” (p.2). Some of the better known examples in education include Bloom’s taxonomy (Bloom, 1956), Anderson and Krathwohl’s (2001) revision of Bloom’s taxonomy, Costa’s habits of mind (Costa, 2009; Costa & Kallick, 2000), Swartz and Parks’s (1994) framework, Marzano’s dimensions of thinking (Marzano et al., 1988), and the Structure of Observed Learning Outcomes (SOLO) taxonomy (Biggs & Collis, 1982). Moseley, Elliott, et al. (2005) conducted a review of 55 frameworks which involve various aspects of thinking, including metacognition, creative thinking, critical thinking, dispositions for effective thinking, as well as cognitive processes such as problem-solving and decision-making. Moseley, Elliott, et al. note that frameworks for thinking “can provide shared understandings which can help improve the quality of instructional design, course and lesson planning, teaching, learning and assessment” (p.1). They observe that:

- The usefulness of the frameworks depends on their nature, how exhaustive they are, their relevance to the task at hand, and how well they relate to the observed world.
- There are varying degrees of overlap between frameworks and among the categories within a given framework.
- Definitions of the categories or components within the frameworks may be vague.
- Simpler and linear frameworks with fewer categories provide easy comprehension and ease of use at the expense of content validity.
- Large, complex frameworks provide better representation at the expense of meaningfulness and ease of use.

The work of Moseley, Elliot, et al. shows that frameworks provide structures that could be useful for practitioners and researchers to organise thoughts and ideas, but could equally
cause confusion by virtue of their diversities, overlapping scope, unclear definitions, and differences in terminology.

In summary, explicit methods of teaching thinking skills offer the advantage of being focused and direct in promoting specific thinking skills amongst students. They offer the advantage of guiding students step-by-step so that they can be effective and productive in their thinking. In so doing, they direct students to use strategy in a systematic manner to address a task and help prevent quick and impulsive responses (Swartz, 2008). Many of them have been found to have positive effects on students’ learning and thinking abilities in the classroom (Halpern, 1994; Higgins et al., 2004; Higgins et al., 2005; McGuinness, 1999). The successful implementation of thinking skills programmes depend on many variables, including the role of the teacher as a coach and model, professional development, course content, context, and culture (Burke & Williams, 2008; Costa, 2008; Higgins et al., 2004; Leat, 1999; McGuinness, 1999; Orion & Kali, 2005; Pithers & Soden, 2000). Evaluation studies of many of the instructional approaches produced evidence of positive effects in some cases and mixed results in others. Such results are as much a reflection of the question over the effectiveness of these approaches as the methodological issues, appropriateness of the evaluation instrument, and multiple variables involved in the evaluation studies (Burke & Williams, 2008; Dewey & Bento, 2009; McMillan, 1987). The review of literature suggests that the explicit approaches to teaching thinking skills appear to be more or less teacher-directed because the thinking approach or the types of thinking tools are inevitably predetermined and introduced by the teacher, without consideration and opportunities for children to exercise and explore their own thinking approach. The focus of this study is to explore how the assessment of thinking skills in young children can take into consideration 1) the situated and emergent nature of their learning; 2) their own approaches to task
performance; and 3) their thinking abilities as well as gaps in their thinking abilities. I discuss issues related to the teaching of thinking skills in the next section of this chapter.

3.1.3 Issues in relation to teaching of thinking skills.

The first issue is the transferability of thinking skills. Specific thinking skills taught in certain contexts are not easily transferable to novel and different contexts, students tend to fail to activate thinking skills that they possess when confronted with novel problems, and active teaching for transfer is necessary (Adams, 1989; Beyer, 2008; Glevey, 2008; McGuinness, 1993; McGuinness, 1999; Nelson, 2004; Nisbet, 1993; Perkins & Salomon, 1988, 1989, 2001; Pithers & Soden, 2000). Halpern (1998) describes this as the “Achilles heel” of thinking skills instruction (p.435). In a sense, this echoes the point made by Hipkins (2009) concerning the situated and contextualised nature of learning which was mentioned in the Introduction Chapter of this thesis. This is a serious problem because the inability of students to apply what they learned to real-life situations beyond the classroom defeats the very purpose of teaching thinking skills (Glevey, 2008; Perkins & Salomon, 2001).

There is research evidence showing that transfer is possible under certain specific conditions (Atkinson, 1997). A strategy to address the issue of transfer is to teach across a variety of contexts in the hope that general principles and strategies of critical thinking become transferable across domains (Adams, 1989; Baron & Sternberg, 1987; Nisbet & Davies, 1990; Norris, 1988b). Another strategy to help students transfer their thinking skills to other contexts is to get them to engage in various metacognitive activities: reflect on and identify the type of thinking they engaged in, describe how they did it, evaluate the process, and think of whether and how it can be modified (Baron & Sternberg, 1987; Nisbet & Davies, 1990; Swartz, 2008). Halpern (1998) proposes a four-part model for teaching critical thinking for transfer with a focus on certain dispositions necessary for effortful thinking, thinking skills
that are “teachable and generalisable” (p.452), training in recognising underlying structure of problems or arguments, and metacognitive monitoring skills. Research is needed to investigate the effectiveness of strategies for teaching transfer, especially in the case of young children given the stage of their cognitive development.

The second issue is related to my argument in this thesis that current approaches to teaching thinking skills do not provide sufficient opportunities for children to exercise and explore their own thinking approach, and that a better appreciation and understanding of young children’s thinking skills is needed. Proponents of explicit teaching of thinking skills typically advocate the direct-instructional model where specific thinking skills are introduced to students, followed by extended period of practice (Beyer, 2008; Hagevik & Swartz, 2010). Explicit teaching of thinking skills generally does not allow the students to explore using their own approach. Yet students are likely, given their own choice, to approach each thinking task differently and use their own thinking framework to make sense of their experiences (Meyers, 1986). In a US-based study on how people describe their approach to solving problems, Pershyn (Douglas, 2002; Isaksen & Treffinger, 2004) found that people’s natural approaches to problem-solving took a wide variety of forms after examining more than 150 cases and came to the conclusion that no one model can describe all the variations of creative problem-solving for all people.

With a few exceptions such as the Instrumental Enrichment programme, explicit methods of teaching thinking skills typically do not consider the Vygotskian concept of ZPD (Vygotsky, 1978) to assess and identify gaps in individual’s thinking abilities in order to respond with appropriate scaffolding in a timely manner and differentiate the teaching of thinking skills according to individual needs, preferences, and abilities. A common pattern can be identified in many of the approaches to teaching thinking skills: the teacher makes the decision on which approach to adopt and children are typically taught to think using a number
of tools or routines without the possibility of exploring their own approaches. Pithers and Soden (2000) observe that “too often it seems to be the teacher or lecturer who sets the problem(s) and shows the student how to pose it and solve it and then leaves the student to solve similar problems” (p.243).

The approach of achieving a commonly agreed methodology and mastery of a set of recognised conceptual tools is appealing because it seems efficient and offers a sense of competence to both teachers and students. A case in point is the Jersey critical skills initiative in the UK which adopts the approach of experiential learning that promotes critical thinking through problem-solving tasks among students ranging from seven to 15 years old (Crossouard, 2009). Students are taught thinking tools such as brainstorming and how to listen and contribute effectively in a group. The teacher sets a problem task as a challenge and students decide among themselves to take up predefined roles such as materials coordinator, artist, facilitator, timekeeper, or scribe. On completion of the task, each group presents its work to the class and the teacher for review. While there is shared responsibility between teacher and students, there is a certain level of rigidity in approach in terms of predefined thinking tools and roles that students employ. The structure and protocols become well assimilated by the students so much so that the approach to any problem-solving has become standardised and necessarily involve a challenge and a recognised division of labour according to familiar roles (Crossouard, 2009). On one occasion, a teacher reportedly quoted an example of how the roles had become such a common currency in the classroom that when she said “facilitate”, the students would immediately respond accordingly because “they’re so familiar with that” (Crossouard, 2009, p.84). The Visible Thinking programme (Ritchhart & Perkins, 2008) adopts a more learner-centred approach where teachers engage students in conversations that promote thinking, document students’ work, and encourage student initiatives and self-reflection. However, the teacher predetermines what specific thinking
skills to teach using predesigned lesson modules and selects relevant thinking routines to plan
learning activities for the students.

Teacher-directedness has been identified as a potential obstacle to students’ ability to
exercise their thinking skills in a self-directed manner (Hudgins & Edelman, 1986).
According to Costa (2001a), students’ performance may be impaired when problem-solving
strategies are imposed by the teacher rather than generated by the students themselves.
Furthermore, there is a risk of mindless learning of procedures if explicit approaches to
teaching of thinking skills are implemented in a highly structured and prescriptive manner.
Black, McCormick, James, and Pedder (2006) highlight the danger of “doing tasks” with
students applying procedures without full conceptual understanding. The previously
mentioned US-based study by Ritchart and Perkins (2000) showed that students, when
provided with absolute instruction, were significantly less flexible and creative and they were
prone to mindlessly misapply procedures that they learned. The same study also demonstrated
that students had a far better understanding of what they were doing when they were not given
any instruction and had to devise their own procedure in problem-solving. Researchers found
that students that learned mathematics procedurally encountered difficulty in generalising
skills to other contexts and demonstrated inability to use conceptual and flexible methods to
problem-solving (Leinwand & Fleischman, 2004). Teacher-directed teaching of thinking
skills may risk causing students to use the approach they have been taught only because the
teacher requires and helps them to.

According to Snow (1989), research shows that good learners develop multiple
strategies and change strategies when performing a task. On this basis, Snow argues that that
the objective of instruction in metacognitive and learning strategies should be to achieve
effective independent learning by helping students develop the ability to employ a repertoire
of multiple strategies and the flexibility to adapt to learning opportunities and demands.
Pithers and Soden (2000) contend that students “must learn to teach themselves to reflect and refine the strategies, to develop their metacognitive knowledge and skills . . . The school teacher . . . can only facilitate this individual process” (p.243). Willingham (2007) posits that “teaching students to think critically probably lies in small part in showing them new ways of thinking, and in large part in enabling them to deploy the right type of thinking at the right time” (p.15). According to Ritchart and Perkins (2000), the hallmark of effective transfer of learning to new contexts is the active role the learner plays in abstracting their own principles and processes within what is perceived as ambiguous situations where information and instruction are open-ended rather than absolute. Riesenmy, Mitchell, Hudgins, and Ebel (1991) emphasise the importance of self-directed critical thinking which “includes not only the ability to think critically . . . but to do it independently of adult authority . . . as well as spontaneously” (p.16).

The teacher-directed approach to teaching thinking skills is challenged by the constructivist theory of learning. Learning that occurs in the interaction between individuals and the socio-cultural contexts would require the learner to have some control over the direction and procedure of learning (Bonk & Cunningham, 1998) – a process that could potentially be impeded by the teacher predetermining what approach children should adopt and what repertoire of thinking tools they should use. According to constructivist theorists, learners should be given plenty of opportunities to explore personal interests and expand on prior experience in a manner that makes sense to them (Bonk & Cunningham, 1998; Roehler & Cantlon, 1997). Constructivist theorists argue that learners should be given the opportunity to engage in meaning making and knowledge negotiation by seeking alternative perspectives and offering personal insights (Duffy & Cunningham, 1996). Brown, Collins, and Duguid (1989) emphasise the need to allow students to generate their own strategies and solutions to
problems, and to stress the point that heuristics are not absolute but to be evaluated with respect to the task at hand.

From the social constructivist perspective, teaching should be responsive and assisting learning rather than directing and fostering standard practices and teaching support should be provided on a just-in-time basis (Hmelo-Silver, Duncan, & Chinn, 2007). Pithers and Soden (2000) note that scaffolding involves prior assessment through dialogue of students’ level of competence before teaching intervention. To Hmelo-Silver et al. (2007), one of the goals of scaffolding is to help students learn not just how to do a task, but also why the task should be done that way. To do so, the teacher needs to be wary of mindless progression through tasks and challenge key aspects of students’ approach in order to encourage them to think deeply, explore alternatives, explain and justify their responses, monitor their progress, evaluate the outcome of their efforts, and reflect on their performance (Brown et al., 1989; Hmelo-Silver & Barrows, 2006; Reiser, 2004). According to Tanner and Jones (2000), scaffolding that transfers the responsibility for identifying strategies and making decisions will ensure that students “do not rely on the teacher to regulate and instigate thinking but are able instead to generalise particular learning experiences to more general thinking strategies” (p.21). The nature of learning in the constructivist classroom entails necessarily diversity of approaches, tasks and learning situations. Brown et al. (1989) point out that when teaching approaches ignore the creative processes that student bring to the classroom, they devalue the whole process of creative problem-solving. Research shows that some students disguised their own effective strategies in order to mislead teachers into believing that problems have been solved in the approved way (Lave, 1993).

In the light of these findings, there appears to be a need to have a better appreciation of students’ existing skills in order help them think better by improving on how they already think in addition to introducing thinking skills that are new to students. It also seems to make
sense to help students develop the ability to employ a variety of thinking processes and skills, know when to use what approaches, evaluate the effectiveness of a chosen approach and the outcome achieved, and have the flexibility and good sense to change an approach when it is inadequate or fails to work. The principle of adjusting instruction to the learner would require teachers to be prepared to respond to students’ needs by adapting relevant thinking models to each individual’s own thinking approach. In order for scaffolding to be effective, teachers need to seek insights into students’ thinking to find out where they are “at” as they work on thinking tasks so that they can respond to the needs of students on a just-in-time basis. The focus of this thesis is therefore to discuss how we can assess young children’s self-directed thinking approaches in order to:

- provide a better appreciation of their existing thinking skills;
- obtain specific insights into how their thinking skills can be further improved; and
- take into consideration the situated and emergent nature of their learning and thinking abilities.

I contend that these considerations are important in moving away from a teacher-directed approach and empowering the teaching of thinking skills to be responsive to the individual child’s abilities.

3.2 Methods of Assessing Thinking Skills

Assessment of thinking skills is crucial to determining students’ level of thinking skills, identifying learning needs, and providing feedback to students (Brookfield, 1997; Facione, 1990b; Ku, 2009). It is needed to provide evidence of students’ progress in developing their thinking skills (Bissell & Lemons, 2006; Glevey, 2008). Assessment of thinking skills is necessary to inform teaching and determine the effectiveness of instructional strategies (Angelo, 1995; Brookfield, 1997; Ku, 2009; Norris, 1985).
While researchers and educators tend to agree on the importance of thinking skills, there is little consensus on how they can be assessed (Cook et al., 1996; Glevey, 2008). Glevey (2008) highlights the difficulty in assessing progress in students’ thinking skills and raises the question of whether informal or formal methods should be used. In their previously mentioned meta-analysis of 29 studies, Higgins et al. (2005) note that it is often hard to determine which specific aspects of a thinking skills programme are the most effective, in what ways and in what areas. Research into effectiveness of critical thinking instruction typically involve the use of a general or customised critical thinking test on students after they have gone through a certain period of the instructional programme. Such test scores do not provide the fine-grained information on the effects of instructions in thinking skills that is necessary to assess and remedy specific flaws in students’ reasoning given that they are mainly focused on summative evaluation of students’ abilities or learning (Beyer, 2001a; Norris, 1985). Furthermore, assessment needs to be aligned with teaching in order to ensure that students are assessed on the particular skills that they are taught in the classroom (Beyer, 2001a). Burke and Williams (2008) argue that the use of standardised tests for evaluating thinking skills programmes are too broad to generate meaningful information because they do not relate specifically to the skills acquired by students, and they do not involve the active application of those skills. In a review of 27 studies on the effect of instructional courses on students’ critical thinking, McMillan (1987) concludes that “what is needed is a stronger set of studies with more sensitive instrumentation to begin to draw conclusions about the types of instructional methods, curriculum materials, and courses that enhance critical thinking” and “it may be necessary that the measurement of critical thinking coincide closely with what the intervention seeks to change” in order to reveal why and how critical thinking has improved as a result of intervention (p.15).
The APA 1990 Delphi Report on critical thinking suggests several ways to assess critical thinking skills, including the use of observation over time of a person performing activities that require the person to exercise thinking skills, evaluate the outcome of an execution of a given thinking skill against a set of criteria, and asking the person for description of the processes and judgments used (Facione, 1990b). Halpern (1994) lists several methods including naturalistic observation, open-ended test questions, multiple choice and multiple rating tests, portfolios, structured interviews, thought process protocols, and performance assessments. In the next section, I will discuss briefly some of the commonly used methods for assessing students’ thinking. They range from highly structured methods such as multiple-choice tests to loosely structured, open-ended forms such as classroom observations (Borich, 2006; Ennis, 1993). Structured methods are labour intensive to design and offer greater assurance that specific thinking skills will be assessed, while open-ended methods require greater effort during the process of assessment, provides less assurance that specific thinking skills will be assessed, and can be problematic in terms of interpretation (Ennis, 1993).

3.2.1 Tests.

It is not surprising that testing is the frequently used method for assessing thinking skills given the predominance and long history of tests being used for evaluating intelligence, learning and development (Boake, 2002; Janesick, 2001; Wortham, 2008). Multiple choice tests which focus on specific isolated skills are commonly used by both researchers and teachers for assessing students’ thinking abilities (Quelmalz, 1985; ten Dam & Volman, 2004). Many of these tests are general tests and not subject-specific. Critical thinking tests are considered more efficient because they are easy to administer and can be used on a large scale (Asp, 2001; Ennis, 1993; Halpern, 1994; Norris, 1990). Ennis (1993) lists several purposes for
which critical thinking tests can be used, including assessing critical thinking abilities and
giving feedback to students; informing teachers about the effectiveness of their instruction;
and researching questions and issues related to the teaching of thinking skills. Critical
thinking tests are also used for making enrolment decisions such as admission to medicine,
nursing, law, and graduate schools.

Tests may be aimed at a single or multiple aspects of thinking (Ennis, 1993). Tests for
assessing critical thinking skills have been developed, mainly for high school and
undergraduate students, to examine for example, inductive and deductive reasoning,
prediction and experimentation, arguments, fallacies, definition, identification of assumptions,
and evaluating of conclusions (ten Dam & Volman, 2004). Tests have been developed for
problem-solving, creativity and critical thinking for children as young as 7 to 8 years old
(Blumberg et al., 1986). Divergent thinking tests have been found to be problematic for
kindergarten children because they are unable to apply their divergent thinking to the tasks
involved in such tests (Runco, 1992). In a review of ten commonly used critical thinking tests,
Cook et al. (1996) found that they were all written tests, with a few both written and oral, and
all requiring reading, comprehension and writing skills. Cook et al. found that all ten tests
were designed according to different definitions of critical thinking and all tested components
or some part of critical thinking, and some targeted both thinking and general knowledge.
Some tests appear not to be linked directly to what is being taught and do not provide
formative information (Beyer, 2001a; Cook et al., 1996).

The validity and fairness of multiple choice tests are questioned because they may not
take into account the possibility of difference in the test-takers’ background beliefs from those
of the examiner (Norris, 1988a). A test-taker unfamiliar with the mode of delivery, for
example computer simulations, may be penalised for lack of familiarity rather than the ability
to think (Cook et al., 1996). Likewise, the test-taker may be assessed for knowledge rather
than thinking skills if the questions are phrased in a way that require both knowledge and
thinking skills or if the test situation is no longer novel to the test-taker (Arter & Salmon,
1987; Norris, 1988a; Runco, Dow, & Smith, 2006). Test-takers may be alerted to test
questions if the same test is used for pre-test and post-test (Ennis, 1993).

Because of the criticism of earlier tests that require only one correct answer, test
developers have added multiple-ratings items to multiple choice tests (Halpern, 1994).
Multiple-choice tests do not provide information on the thinking processes of the respondents,
which are important to differentiating between deficiencies in thinking and differences in
background beliefs and assumptions (Arter & Salmon, 1987; Ennis, 1993; Norris, 1990). Test
developers have attempted to alleviate this by asking respondents to provide reasons for their
answers, incorporate open-ended free response questions or using essay form of tests instead
(Ennis, 1993; Halpern, 1994). Another method is to ask the respondents to think aloud as they
work on the test questions and use the results to adjust the test items for any problems
identified through information gathered (Norris, 1985). In a Canada-based study on effects of
eliciting verbal reports on critical thinking test performance, Norris (1990) claims that such a
method of data collection does not alter test-takers’ thinking and performance. Test-takers can
also be asked to write a description of their thought processes as they work on a problem or
respond to a question (Halpern, 1994). Such vocal or written thought-process protocols can
potentially provide insights into underlying thought processes, help identify gaps in thinking,
and reveal metacognitive abilities but they are dependent on the spontaneous information
provided by the test-takers and face similar issue of reliability as in the case of open-ended
questions and essays.

Validity of a test can be threatened by decontextualisation when students are asked to
think in ways removed from the everyday world of making decisions, formulating plans, and
solving problems. Research on critical thinking tests reveals that responses to test items can
be highly sensitive to contexts. For example, a test-taker’s response to an item in the Watson-Glaser Test was found to vary according to the assumptions made by the person - one set of assumptions would lead to the “correct” keyed answer, and another set of assumptions would lead to an “incorrect” answer (Ennis, 1994; as cited in Norris, 1985). Harlen (2007) cites the example of surveys carried out by the Assessment of Performance Unit (APU) in the UK in 1980s which provided evidence that student performance can be highly dependent on the choice of content: students that perform well in one test item do not necessarily do so in another item testing the same skills but in a different context. According to Haylock (1987), several studies showed that divergent thinking in mathematics was unrelated to performance on general divergent thinking tests. Research also shows that people reason better deductively when dealing with contexts that relate to their personal experiences and when they do not have presumptions about the truth (Norris, 1985). Craft (2001) contends that tests such as the popular Torrance’s tests of creativity can de-contextualise creative thinking and ‘in situ’ assessment is preferred.

It is difficult to design multiple-choice tests that take into consideration the test-takers’ ability to think critically in unprompted contexts and that reflect the complexity of real-life problems which requires the use of several skills at the same time and strategic selection of appropriate skills to be applied to different situations (Halpern, 2003). Multiple choice tests that require only one-correct answer do not reflect the real world where there could be no one right answer, more than one solution to a problem, and many possible approaches to solving problems (Cook et al., 1996; Norris, 1988a). Researchers and educators generally agree that critical thinking is complex, involving not one discrete skill but is the sum of many cognitive processes (Cook et al., 1996; Facione, 1990b). Test developers have attempted to address some of these issues by adopting various strategies. One approach to critical thinking tests involves the use of context-dependent items where introductory information is provided.
without directing thinking followed by questions that assess not only responses made but also
the thought processes used to arrive at those responses (Oermann, Truesdell, & Ziolkowski,
2000). Another approach is to try to use questions that draw from real-world contexts so as to
improve face validity and improve test-taker motivation and engagement (Halpern, 1994). An
example that uses both multiple-choice and open-ended questions formulated in contexts that
resemble more closely real life is the Halpern Critical Thinking Assessment Using Everyday
Situations (Halpern, 2007a).

Multiple-choice tests generally do not provide information on dispositions (Ku, 2009).
Ennis (1996) points out that people who do not have the disposition can still give the correct
response to a multiple choice test item. Testing may assess what students know how to do and
what is required of them in a test but not necessarily what they do of their own volition
(Golding, 2010). Some tests such as the Ennis-Weir Critical Thinking Essay Test (Ennis &
Weir, 1985) and the California Critical Thinking Disposition Inventory (CCTDI) (Facione &
Facione, 1992) have been developed to assess the dispositional aspects of critical thinking.
The Ennis-Weir Critical Thinking Essay Test has been criticised for not being able to
discriminate between the influence of disposition and ability on performance (Ng, 2006).
Because of its use of self-reported measures, one criticism of the CCTDI is that it does not
take into account the possible gap between what test-takers claim they would do and what
they actually do (Ku, 2009). Creativity tests using questionnaires have also been developed
for assessing interests and attitudes (Clapham, 2004). The validity and appropriate use of self-
reports and questionnaires are being questioned because self-report data are difficult to verify
and they are dependent on variables such as individual differences in style of response (Baer,
1998). Ng (2006) notes that respondents could fake dispositions or choose socially desirable
responses in questionnaires and surveys that rely on self-reporting. In view of these findings,
testing was not adopted in this study to assess young children’s thinking skills because of the disadvantages that renders it inappropriate for young children, including:

- Reliance on writing and reading skills.
- Issue of decontextualisation.
- Failure to reflect the complexity of real-life problems / contexts.
- Inability to account for dispositional aspects.

3.2.2 Performance assessments.

Performance assessment is defined as assessment that allows the student to demonstrate his or her knowledge and abilities through performance of a task (Wortham, 2008). They generally require students to apply their knowledge and skills, construct their responses, explain the processes that they adopt in the performance of a task, provide the reasoning behind their decisions, and to work either individually or in groups (Khattri, Reeve, & Kane, 1998; Moon & Callahan, 2001).

Costa and Kallick (2001) argue that assessing growth in thinking abilities requires forms of assessment other than testing because “we cannot evaluate process-oriented outcomes exclusively through product-oriented assessment strategies” (p.517). Beyer (2001a) posits that tests may be the least useful way of assessing thinking skills because they measure discrete skills in isolation and therefore do not adequately measure student’s processes in critical thinking and problem-solving. Beyer contends that the “best measure of students’ ability to think may be their behaviour as they sift through data to arrive at a conclusion or as they go about solving a problem” (p.40).

Performance assessment may involve real or simulated tasks, usually involves open-ended problems, and may also take the form of essays (Linn, Baker, & Dunbar, 1991; Moon & Callahan, 2001). Simulated tasks using computer technology offer the advantage of
keeping detailed records of moment-by-moment students’ actions and decisions for the purposes of assessment and providing a log for each student in each session (Silva, 2009). Performance assessments may be structured or spontaneous (Stiggins & Bridgeford, 1985). Structured performance assessment involves systematic planning and design that makes use of pre-specified purposes, tasks, observations, and scoring procedures. Spontaneous performance assessment involves the teacher assessing student’s learning and abilities through naturally occurring activities in the classroom environment.

Disposition is a critical aspect of thinking abilities and performance assessment provides the means to evaluate both skills and the disposition to use those skills, including the motivational and volitional aspects of students’ learning (Halpern, 1994; Snow, 1989). Perkins et al. (1994) contend that assessment of thinking needs to consider the dispositional aspect because a person may have the ability to think but not be disposed to do so in real-life settings. According to Perkins et al. (1994), any assessment approach must take into account that people’s thinking abilities are influenced by their dispositions, their knowledge, their social interaction with others, and the setting. They propose a framework for designing written performance assessment which comprises a series of tasks that assess both dispositions and skills across different “authentic” contexts, including academic disciplines and general contexts. Perkins et al. (2000) propose a triadic model using short written stories for assessing three aspects of dispositions that may affect thinking behaviour: 1) inclination – the motivation to engage in and sustain an intellectual behaviour or thinking; 2) sensitivity – recognising opportunities to engage in certain intellectual behaviour or thinking; and 3) ability – the capacity to carry out an intellectual behaviour or thinking. Ennis (1996) points out that performance assessment of dispositions is a difficult task. If a certain disposition is targeted for evaluation, it may not manifest itself at all even if the person possesses it. Even if
evidenced, it may be instance or subject-specific, raising the issue of generalisability and consistency.

Thinking occurs in social contexts when people collaborate with peers, expert thinkers, or teachers. Different settings have different characteristics and factors, including demands and expectations, which can affect thinking performance (Brookfield, 1997; Runco, 1992). The kind and level of knowledge can influence how and how well people think (Feldhusen & Goh, 1995; Mumford, 2003). In the area of creative thinking, what is considered novel or creative may depend on the context, domain, and age (Mouchiroud & Lubart, 2001; Mumford, 2003; Westmeyer, 1998). Brookfield (1997) asserts that the assessment of critical thinking that is context and person-specific must be grounded in local conditions. In these regards, performance assessments are arguably better suited for the classroom than commercial tests.

A major goal of thinking skills instruction is to help students develop the ability to think more effectively about real-life issues involved in for example problem-solving and decision-making. Assessment of cognitive operations generally requires demonstration and performance in real-life problem-solving and decision-making tasks (Costa & Kallick, 2001). Performance assessment allows the investigation of individual or group problem-solving and decision-making in naturalistic settings and offers the potential of incorporating tasks that target specific thinking skills (Halpern, 1994). In a US-based study involving 77 children aged between nine and 12 years old, Okuda, Runco, and Berger (1991) found that performance measurement involving real-world problem-finding were better predictors of their real-world creative activities than standardised divergent thinking tests and came to the conclusion that the former measures abilities that are more closely related to the skills necessary for real-world creative activity. Performance assessment is well suited for assessing creative thinking abilities because they are open-ended and require spontaneous and free-form
responses (Sternberg, 2006b). Performance assessment has face validity because of the high level of realism, offers the most diagnostically useful information, and assesses skills most directly (Cook et al., 1996; Ennis, 1993).

Although performance assessments provide more insights into student’s thinking than tests, they are time-consuming, effort-intensive, narrow in scope, and can be costly (Asp, 2001; Cook et al., 1996; Ennis, 1996). Linn et al. (1991) point out that they do not fare as well as tests in terms of the traditional criteria of efficiency, reliability, and comparability of results from year to year. Performance-based assessment tasks, especially those that promote complex problem-solving and thinking, can be messy, involve uncertainty and complexity, and present difficulties for observation and assessment (Schmidt & Plue, 2000). Wortham (2008) observes that performance assessments require skills in acquiring, interpreting, and using information on children’s performance. Sceptics contend that face validity of performance assessments alone is inadequate and there is the lack of empirical evidence of validity for such assessment methods (Linn et al., 1991).

Khattri et al. (1998) contend that generalisability and reliability can be problematic for performance assessment. In terms of generalisability, Khattri et al. raise the question: “to what degree is a student’s performance on one or a few assessments representative of his or her performance on other, similar assessments or, more importantly, on similar real world tasks?” (p.59). The issue of generalisability could be addressed to some degree by multiple examples of student work on a variety of performance tasks over a period of time (Linn et al., 1991). However, there are limits to this approach: a study in the US involving assessment of fifth graders (11 to 12 year-olds) using hands-on performance tasks shows a fair amount of variability in task performance amongst students, leading researchers to conclude that to obtain a reliable score for an individual student would require the student to be assessed on a totally unacceptable number of tasks (Pine et al., 2006).
Inter-rater reliability can be an issue because of the complexity, open-ended nature of performance tasks, subjective interpretation of data, and different people using different frames of references (Ennis, 1993; Khattri et al., 1998). Khattri et al. (1998) suggest that possible strategies for addressing inter-rater reliability include the standardisation of task administration, establishment of explicit evaluation criteria, and assessor training. However, Harlen (2007) argues that the degree of reliability depends necessarily on the purpose and use of the assessment method. In particular, while a high degree of reliability is necessary if the assessment results are used by others and when students are being compared or selected, reliability is not an issue if the assessment is used for formative purposes to support student learning since it involves only the students and the teachers (Harlen, 2007).

The need to establish explicit evaluation criteria to guide assessment decisions has led to the use of rubrics either for quantitative scoring or qualitative assessment, or both. Rubrics that articulate skills and competencies typically provide lists such as use of effective processes and strategies, analysis and interpretation of information, communication of reasoning processes, decision-making process, strategies used in problem-solving, mathematical reasoning, and understanding and connecting loose concepts (see for example Borich, 2006; Brookhart, 2010; Costa & Kallick, 2001; Facione & Facione, 1996b; Marzano & Kendall, 2007). A common approach in using rubrics for the assessment of competencies and skills is to note a demonstration of a particular skill or to rate the performance according to a constructed range of proficiency in certain skills or sub-skills (see for example Marzano, Pickering, & McTighe, 1993).

In summary, the literature review suggests that performance assessment is well-suited for assessing children’s thinking skills because it:

- takes into consideration that thinking skills require time and experience to develop;
- can provide insights into the processes and thinking involved in task performance;
can involve spontaneous and real-life tasks;

- allows for dispositional aspects to be taken into account; and

- takes into consideration social contexts where children collaborate with peers, expert thinkers, or teachers.

Key challenges in the use of performance assessment are the need to discern the processes that students engage in when they are performing tasks, and the analysis of the data gathered. These issues in the context of young children are discussed in section 3.4 of this Chapter.

3.3 Types of Performance Assessments

A variety of different techniques are used for collecting information in performance assessment (Janesick, 2001; Puckett & Black, 1994; Wortham, 2008). I classify some of the commonly used methods into three main categories for the purpose of my discussion of their suitability for assessing thinking skills:

- Written performance assessments: essays and writing samples, journal writing, and written self-assessment.

- Documented work: portfolios, products, work samples, and in-progress work.

- Observational assessments: observer note-taking, audio-video recordings, interviews, and reflective dialogues.

3.3.1 Written performance assessment.

Besides multiple choice and open response tests, essays are the most commonly used written form of thinking skills assessment. Essays fall somewhere in between tests and performance assessment and have been considered to be belonging to either one of these forms of assessment. The purpose of essays is to obtain insights into students thinking (ten Dam & Volman, 2004). Essays are harder to assess but can provide more insights than tests
These essays can be effective in assessing students’ creativity and some aspects of critical thinking such as synthesis, analysis, categorising, and dialectical reasoning (Cross & Angelo, 1988). Rubrics may be used for evaluation and grading purposes (Brookhart, 2010; Oliver-Hoyo, 2003).

Other similar assessment methods require students to reflect on and explain their learning by, for example, writing brief responses to simple questions or prompts (Angelo, 1995) or carry out a written critical practice audit where students are guided by a set of instructions to reflect how they applied their critical thinking in the course of some significant events in the previous week (Brookfield, 1997). These assessment techniques tend to rely on a certain requisite level of reading and writing skills on the part of the students to make evident their thinking. In a study of 146 new university entrants and 150 seniors at the Southeast Missouri State University, Blattner and Frazier (2002) came to the conclusion that what students wrote and how well they wrote contributed to the overall evaluation of their critical thinking skills.

Written essays may not be suitable for young children who have not developed the requisite level of literacy and communication skills (Wortham, 2008). Essays can present other issues such as low inter-rater reliability and inadequacy in covering a wide range of thinking skills and dispositions because of constraint of time (Norris, 1988a). The lack of comprehensiveness is also caused in part by the reliance on what is written down by the respondents. As Norris (1988a) observes, there is “no windows into the examinees’ brains that shows all they are thinking or all the basis of their decisions” (p.9). Facione (1990a) notes that it is difficult to assess some of the skills such as inference and evaluation because not all workings and reasoning that a student engaged in to come up with an explanation are reflected on paper. Arter and Salmon (1987) point out that the evaluation of essays is difficult and
potentially influenced by bias and philosophical orientation of the assessor leading to inter-rater inconsistency.

The classification of essays as performance assessments is ambiguous because their authenticity is questionable to a certain extent. For example, some of the written scenarios are sometimes hypothetical or the students are asked to put themselves in the place of a protagonist in a scenario (Brookfield, 1997; Simmons & Ren, 2009). Others make use of real-life problems but they cannot replicate the same experiences that students would otherwise engage in if they were to work on a real-life task. They do present a significant advantage over real-life tasks in being more cost-effective and suitable for large-scale assessment (Halpern, 1994). Aimed at assessing both thinking processes and products, they are effective only if the objectives are clear to the students and if the students are able to communicate their thought processes sufficiently to be of value to the assessor. These assessment methods are sometimes narrowly focused on some predetermined aspects of thinking or confuse students’ conceptual understanding, ideas or working theories with the thinking processes and skills that they employ.

### 3.3.2 Documented work.

Documenting students’ work in the form of portfolios is an assessment technique widely used to evaluate student’s creativity and conceptual understanding (Cross & Angelo, 1988; Janesick, 2001; Wortham, 2008). Besides students’ work samples and products, portfolios may include data collected using other techniques, thus providing multifaceted documentation of students’ learning and thinking abilities across multiple domains (Facione & Facione, 1996a; Wortham, 2008). Assessment of products for creativity may address other aspects than creative thinking (such as elegance, hedonics and complexity) because creativity is a construct that involves creative thinking processes, products and personal attributes.
(Cropley, 2000). Ideally, portfolios are individualised and they should document a variety of tasks performance reflecting diverse learning objectives over time, provide evidence of learning and growth, and offer evidence of work at many levels of understanding (Janesick, 2001).

Constructing and assessing portfolios are time consuming, and assessing the content for thinking skills can be difficult (Halpern, 1994). Rubrics are commonly used to guide assessment of portfolios (Facione & Facione, 1996a; Janesick, 2001). There are also issues of reliability and validity (Halpern, 1994). Reliability hinges on inter-rater consistency and validity depends on how well defined and how clearly understood the learning outcomes are, and whether the evaluation criteria such as the scoring rubric are a good match to the learning outcomes (Facione & Facione, 1996a). Completed work does not necessarily provide information on the process students employed in their thinking and problem-solving. Another approach is to employ reflective dialogue to elicit additional insights into students’ thinking and to encourage reflection and self-assessment on the part of the students (Hewett, 2001; Stegelin, 2003).

3.3.3 Observational assessment.

Observations can be structured or naturalistic (Ennis, 1993). The former involves giving a variety of materials and assigning a task to the student, and observing the student perform the task. The approach developed by the National Assessment of Educational Progress (NAEP) in the US involves a combination of open-ended paper-and-pencil and hands-on tasks that require students to exercise problem-solving and critical and creative thinking skills in the context of mathematics and science (Blumberg et al., 1986). The previously mentioned CRTA model uses a list of guiding questions for teachers to obtain insights into students’ thinking and a Think-Pair-Share strategy in which students record their
reasoning in writing in relation to a particular task before sharing with the whole class (Kassem, 2005). The naturalistic approach involves making extensive observation and recording of events and focuses on the activities of one individual or a group (Sale, 2006; Wortham, 2008). In naturalistic approaches, questions may be asked to elicit insights into the student’s thinking. Observations can be useful for assessing thinking dispositions (Ng, 2006).

In New Zealand, Carr advocates anecdotal records of young children’s dispositional learning in the form of “learning stories” (Carr, 2001; Claxton & Carr, 2004). Techniques for recording information may include note-taking and audio-video recording. Interpretation of data and assessment are usually guided by checklists or rubrics constructed using a framework or taxonomy (Brookhart, 2010; Ong & Borich, 2006). As noted earlier, the use of rubrics in assessments is being questioned by Hipkins in New Zealand (Hipkins, 2009).

Observations tend to be less comprehensive than testing: “In real life situations, people generally reveal only what the situation requires, and most observable situations do not require all aspects of critical thinking” (Ennis, 1993, p.185). Observations can potentially be intrusive and greater effort is required during and after the observation in comparison to more structured methods such as tests. What is observed depends on the observer, the activities being observed, and participant’s actions in performing the task. Observational data have to be interpreted and are therefore open to subjective judgment. Quality control can be problematic with classroom assessments that rely on teacher observation and judgment (Stiggins & Bridgeford, 1985). In addition, the lack of observed behaviour does not mean necessarily the lack of certain dispositions, abilities or skills on the part of the participant.

Interviews and reflective dialogues can provide a rich source of data within real-world settings. They can be interactive and allow the interviewer to react to the subject’s response by determining the nature of the next question. They provide insights into the subject’s reasoning (ten Dam & Volman, 2004). Interviews and reflective dialogues can be carried out
individually or in groups where it might be useful to take into consideration the social context of thinking. Norris (1992) argues that interviews are particularly useful in assessing a person’s disposition to use certain abilities. If the person uses the ability spontaneously, then one can conclude that the person demonstrates both disposition and ability. If the person fails to use the ability being assessed, there are three possible explanations: 1) the person has the ability but not the disposition to use it or think to use it; 2) the person does not possess the ability at all - whether spontaneously or when prompted; or 3) the person possesses both ability and the disposition to use it but chooses not to for some reasons (Norris, 1992). Norris notes that interviewing is the only way to find out which of the explanations is applicable.

Like naturalistic observation, interviews and reflective dialogues can be time consuming and require great effort during and after the process of information gathering. After-event interviews and reflective dialogue may involve the use of specific probes, such as requests for motivations and reasons, which are considered by some to be less dependable because they require respondents to retrieve information from long-term memory or make inference, thus leading to potential distortion of information (Ericsson & Simon, 1980). Children are found to have a bias toward reporting only strategies that either were effective or were perceived by them to be helpful (Winsler & Naglieri, 2003). Interviewer subjectivity and performance can pose threats to their reliability and validity (Halpern, 1994). The interviewer could inadvertently invite “retrospective rewriting of history” (Silverman, 2005, p.8) or influence the response of the children. Arguably, issues of validity and reliability issues associated with data gathered through classroom observations, interviews and reflective dialogues may be addressed using strategies such as prolonged engagement and persistent observations, triangulation, peer review, member checking, external audit, and rich thick description of the context (Creswell, 2007). In view of the findings, observational assessment (as described here) is most suited for this study with young children because it:
• focuses on thinking processes and dispositions;
• is contextualised, person-specific, and takes into consideration local conditions;
• can be used in contexts that involve real-life problem-solving and decision-making; and
• provides diagnostically useful information.

The methodological challenge in using observations, interviews, and reflective dialogues for assessing young children’s thinking skills centres on the acquisition and interpretation of data. This is discussed in greater detail in section 3.4 of this Chapter.

3.3.4 Formative assessment.

A discussion of formative assessment is necessary since a motivation for this research study is the search for an assessment tool with the potential to provide specific insights into how children’s thinking skills can be further improved through teaching intervention. Formative assessment is aimed at providing the information needed by teachers to carry out diagnostic evaluation of students’ abilities, instructional planning in response to students’ needs, and formative evaluation to determine students’ learning progress (Wortham, 2008). Formative assessment is characterised by an on-going process that requires qualitative, interpretative judgment (Crossouard, 2009). Popham (2008) defines formative assessment as “a planned process in which assessment-elicited evidence of students’ status is used by teachers to adjust their ongoing instructional procedures or by students to adjust their current learning tactics” (p.6). Formative assessment focuses not just on outcomes, but on the processes of learning, thinking and problem-solving. Formative assessment has a proven and beneficial role in supporting student learning (Black & William, 1998; Fuchs & Fuchs, 1986). In their review of research studies, Black and William (1998) found several studies showing firm evidence that formative assessment, when properly implemented, can result in substantial
learning gains in students and no report of negative effects of formative assessment practices. Research shows that teachers can use formative assessment to help students develop the ability to take effective actions by helping them to see how they improve their work through non-judgmental feedback, take responsibility for assessing their own work, talk about and justify their reasoning, and explain things rather than just describe them (Black & William, 1998).

Formative assessment must necessarily occur in the classroom since adjustment decisions have to be made by teachers while instruction and learning is occurring and the use of tests is unsuitable because instructional decisions can be made only after tests have been completed and the test results compiled (Popham, 2008). Observation, interviews, and reflective dialogues are some of the commonly used techniques for gathering information on students’ learning on an on-going basis. Research shows that teachers generally recognise the important role of observation and questioning in formative assessment (Crossouard, 2009). In particular, the richness of the questions used by the teacher can determine the level of insights into students’ understanding (Black & Wiliam, 1998). Observations provide information that teachers need to 1) discover the interests of children and understand individual learning styles; 2) make effective decisions in the classroom about when and how to intervene with children; 3) select materials, plan appropriate activities, and ask questions that guide children in learning; 4) plan curriculum and individualise instruction; 5) monitor children’s progress and carry out assessment; and 6) report and communicate with parents, policy makers, researchers, and other interested parties (Gullo, 2006; Jablon, Dombro, & Dichtelmiller, 2007; McAfee et al., 2004; Wortham, 2008).
3.4 Observation, Analysis, and Interpretation of Children’s Thinking Skills

One of the challenges in pedagogical approaches that seek to develop competencies beyond subject-based content knowledge is the difficulty of evaluating skills-related learning progress and outcomes. When learning and teaching occur in a complex and authentic contexts that are necessary for developing such competencies, conventional assessment methods such as testing cannot adequately measure the development of skills and deep learning that occurs (Greening, 1998). According to Beyer (2001a), the observation of students’ behaviour as they engage in problem-solving is one of the best measures of their ability to think. If thinking is valued as a key curriculum objective, teachers must take time to observe, understand, evaluate and assess children’s development in this area (Wilson & Murdoch, 2006). Making systematic observations and asking children questions are widely used methods for obtaining clues to children’s development and learning. Questions that require children to think and construct responses from scratch could potentially produce rich information for interpretation (McAfee et al., 2004).

In pedagogical approaches based on social constructivist and socio-cultural principles, the ability to identify individual needs and be able to respond appropriately and just in time are crucial to effective scaffolding (Bonk & Cunningham, 1998). From the perspective of instructional design, one key challenge is determining what scaffolding to provide for each individual in a given situation, and how quickly that scaffolding should be faded and removed. To aid instructional planning and decision-making, teachers can use observations to determine a child’s zone of proximal development and the child’s progress toward achieving learning objectives (Wortham, 2008). In the context of teaching thinking skills, educators must have the means and ability to observe and interpret children’s thinking skills in order to determine where the children’s needs are and what scaffolding may be necessary. That same ability to observe and interpret children’s thinking is also necessary to determine how quickly
that scaffolding should be progressively removed. In addition to identifying individual needs and abilities, assessment of young children’s thinking skills is necessary to monitor the progress in the development of their thinking skills as it forms an integral part of the teaching process. The assessment of outcome of learning must also determine whether there is durable learning in terms of the children’s ability to apply what they learned independently in new situations (Young, 1993).

While there is a recognition of the important role of classroom assessment in the teaching of thinking skills in existing literature, the focus of assessment has always been on what the teacher wants to teach rather than the thinking processes that students themselves employ when they engage in self-directed problem-solving and construction of their own understanding. There is little description or demonstration of how in specific terms students’ own thinking processes can be analysed and interpreted in order to inform teaching. The interpretation or analysis of the information gathered is a key component of making observational assessment. Teachers need to have the knowledge about what is being observed and how the children’s actions demonstrate their thinking in order to accurately understand and assess children’s reasoning (Zan & Geiken, 2010). However, observational data gathered on thinking and problem-solving skills are a lot harder to interpret and assess than content knowledge and conceptual understanding.

Siegler and Alibali (2004) are of the view that task analysis can lead to insights about children’s thinking and problem-solving, in particular: what they are doing in situations where they solve problems efficiently, where they might have difficulty, and what the source of difficulty might be in situations in which they cannot solve problems efficiently. In the analysis of the data collected through assessment techniques, quantitative analysis answers the question of how much or how many, while qualitative analysis addresses the questions of what kind, how well, and in what ways (Cross & Angelo, 1988). It is clear that the assessment
of thinking necessarily involves qualitative analysis as we are interested in finding out what kind of thinking skills young children possess, how well they apply those skills, and in what ways. This study discusses how such an assessment approach can be achieved through a case study involving seven to eight year-olds in an urban primary classroom in New Zealand.

3.5 Summary

While there is general consensus on the importance of thinking skills, there is little agreement on how best to teach and assess thinking skills. Despite the diversity of approaches in the teaching of thinking skills, key pedagogical features that are incorporated to various degrees include instruction in cognitive processes, development of metacognitive skills, cultivation of appropriate dispositions, development of a language of thinking, teaching for transfer, opportunity for collaborative learning, and engaging learners in thought-provoking tasks. Assessment methods vary in terms of their assessment of process or outcomes, diagnostic or evaluative purposes, qualitative or quantitative nature, specificity and coverage of types of skills, type of structure and complexities, alignment with instruction, whether a dispositional perspective is adopted, and how issues of validity, reliability and generalisability are addressed, if at all.

Every assessment strategy has its strengths and weaknesses and each method can only provide certain types of information and cover only certain aspects of a child’s learning and abilities (Wortham, 2008). Using a variety of carefully chosen assessment methods can provide different perspectives and therefore a more comprehensive picture of a child’s learning and abilities (Feld & Bergan, 2002). The complexity of thinking skills cannot be captured by a single measure or simple model but any attempt to capture that complexity is likely to result in an assessment model that is too impractical (Halpern, 1994; Perkins et al., 1994). Researchers suggest that different aspects of thinking may be better assessed in
different ways and recommend the use of multiple methods of assessment (Facione, 1990a; Kim, 2006; Mouchiroud & Lubart, 2001; Plucker & Runco, 1998).

Performance assessment is recognised as most suited to assessing young children’s learning (Gullo, 2006; McAfee et al., 2004; Wortham, 2008). Gardner (1991) suggests that, the younger the children, the more assessment should be embedded in the context of teaching and learning. Assessment of young children must take into account their uneven development and highly variable behaviour from day to day and in any one domain of development, developmental constraints such as limited language skills in expressing what they know, and their sensitivity to context which limits their ability to generalise knowledge and skills (Gullo, 2006; McAfee et al., 2004). In criticising the inadequacy of the use of standardised and teacher-made tests for assessing thinking skills, Beyer (2001a) highlights the need for “congruence between the skills being tested, the techniques to measure competence in these skills, and the nature of the skills being taught” (p.40). In line with constructivist principles, performance assessment methods differ from tests in that they emphasise the children’s active participation and construction of knowledge rather than the children’s mastery of discrete skills (Wortham, 2008).

Given the difficulty in capturing entirely what a child knows or can do, it is necessary to gather information over time from multiple sources to ensure that the assessment is valid and the conclusions drawn are meaningful (McAfee et al., 2004; Wortham, 2008). Systematic observation, studying work products, and eliciting responses are widely used and most suitable for assessing young children (McAfee et al., 2004). Eliciting responses involve asking children questions, making requests, conducting interviews and dialogues, and involving children in tasks that provide opportunities for them to demonstrate their knowledge and skills with the overall aim of advancing their learning, and finding out what they have and have not learned (McAfee et al., 2004). This is the approach that was adopted in this study,
with a focus on classroom observations that incorporate interviews and reflective dialogues with the children in order to listen carefully to what they have to tell us and to gain insights into their thinking processes as they engage in performance tasks that require them to exercise their thinking skills.

In this chapter, I have provided an overview of the different approaches to teaching and assessing thinking skills. I have highlighted some issues in thinking skills instruction and assessment, particularly in relation to young children. In adopting a social constructivist framework, this thesis argues that assessment of children’s thinking skills needs to:

- Take into consideration the diversity and unpredictability of students’ thinking processes in a learner-centred classroom.
- Identify students’ current thinking abilities and needs.
- Inform decisions on appropriate teaching strategies.
- Monitor and document students’ progress in thinking skills.

Current assessment methods address to various degrees the last three of these objectives but none takes into account the first. In this study, I have sought to explore an approach that takes into account the first three objectives – what I call the “front end” of the assessment process.

The fourth objective – “tail end” of the assessment process – was beyond the scope of this thesis given research findings that there may be a delay as long as two years before results of
improvement become evident (Higgins et al., 2004). In the next chapter, I will discuss the methodology that was adopted for this study.
Chapter Four
Methodology

Having provided the theoretical and conceptual frameworks for my study, I now elaborate on the research approach and process adopted for this study. I begin by describing the research design and approach, including the site selection, participant recruitment process, the research setting, and the role of the researcher. I also discuss some of the issues and ethical considerations involved in research with children. This is followed by a description of the sampling strategy and the process undertaken to collect and analyse the data. In the process, I explain how I adapted cognitive task analysis (CTA) for my study, particularly the development and use of the concepts of thinking conversations and cognitive process mapping.

4.1 Research Approach

In the design of this research study, a key consideration was to ensure that the research problem, purpose, conceptual framework, question and research approach were logically and consistently aligned (Hatch, 2002; Schram, 2006). The study employed a participant observation study (Hatch, 2002) which is defined as research carried out in the social setting of the classroom focusing on specific aspects of a research topic, using ethnographic techniques. Participant observation has been widely used in research with young children (Einarsdottir, Dockett, & Perry, 2009). The qualitative research approach was selected for this research project because it is well suited for gaining an understanding and explanation of the meaning of a social phenomenon with as little disruption of the natural setting as possible (Merriam, 1998). Holliday (2002) attributes the usefulness of qualitative research to the fact that “. . . to understand human affairs it is insufficient to rely on quantitative survey and
statistics, and necessary instead to delve deep into the subjective qualities that govern
behaviour.” (p.7). My decision to adopt such a research design allowed me to take advantage
of two key strengths of the qualitative research approach, firstly to make meaning of the
participants’ experiences and actions, and secondly to seek an understanding of the context in
which the participants are situated (Ary, Jacobs, Razavieh, & Sorensen, 2006; Maxwell,
2005). Additionally, results and theories generated in a qualitative study in the context of a
classroom are understandable and experientially credible to the participants and educators
(Maxwell, 2005).

4.2 Site Selection

Purposeful sampling was used to select the site and the participants. Purposeful
sampling is defined as intentional selection of site and participants “who have experience with
the central phenomenon or the key concept being explored (Creswell & Clark, 2007, p.112).
The choice of the research site was made after visits to six primary schools in the vicinity of
my university over a period of two months. These visits were, in part, made possible with the
help of my supervisors.

Both personal interest and conceptual considerations influenced the choice of my
research setting. I thought that the interest of the teacher in the topic of thinking skills and her
interest in exploring this area through research collaboration was vital to a workable
relationship. According to Maxwell (2005), the partnership between the researcher and
practitioner was critical to the success of any research collaboration. The potential for a
mutually beneficial relationship between the school and the researcher was also appealing,
especially in terms of my providing inputs and literature for the school’s exploration of ways
to introduce key competencies in its curriculum and to develop its students’ thinking skills.
The teacher’s flexible, multi-faceted approach to teaching thinking skills offered favourable
conditions for richness and variety of relevant data, which I felt was an important consideration in my study. Allen (1998) postulates that richer observational data can be obtained from learning activities that involve complex tasks such as problem-solving and that requires sustained effort in contexts meaningful to students.

In addition, the selection of site also took into consideration the criteria proposed by Holliday (2002):

- Clear contextual boundaries defined by time, place, and culture.
- Availability of a variety of useful, interconnected data.
- Sufficient richness of data to constitute a “microcosm of the research topic in wider society” (p.34).
- Accessibility
- Manageability from practical and conceptual perspectives.

The classroom provided a ready-made bounded setting that was defined by place and classroom culture. The selected site fulfilled the two criteria of availability and richness of data. Accessibility was facilitated by a relatively flexible classroom schedule and the teacher’s willingness to accommodate my visits anytime, barring any externally imposed events such as school-wide events and teacher-parent meetings. The decision to carry out an in-depth study by focusing on one case study led to the selection of one research site out of the potential six.

### 4.3 Participants and Research Setting

The participants were 28 children aged seven to eight years old and their teacher Sarah (all names in this thesis are pseudonyms) in a classroom of a state-run primary school that draws its students from an upper-middle class urban community in New Zealand. The participants comprised 18 girls and 10 boys, all of European origin except for one Chinese, one Malay, two Indians, and one Maori. The school was exploring key competencies set out
in the New Zealand school curriculum and was not oriented toward any one particular approach to teaching thinking skills as was common practice in other schools. The teacher had a keen interest in children’s thinking and had previously carried out research in this area as part of her Master’s degree. The setting could be best described as a constructivist classroom where the teacher adopted flexible and multi-faceted approaches to promote thinking skills in the classroom, including problem-solving, inquiry, and philosophical discussions. It is important that I elaborate on my role and involvement as a researcher given that my interaction with the participants and setting had a bearing on the conduct of the study and the validity (credibility) of findings.

4.4 Role of the Researcher

The focus and nature of the study allowed me to be as open as possible with the participants so that they were fully cognisant of the purpose of my presence. To minimise observer effect and ensure that participants’ usual behaviour was not altered as far as possible, I sought to ensure that the participants were comfortable with and accepting of my presence. I adopted the role of an observer as participant where I interacted with the participants enough to establish rapport and elicit the children’s perspectives, but minimised my involvement in the classroom behaviours and activities (Ary et al., 2006). Nonetheless, the constructivist assumptions of my research predicated some level of participation in order to facilitate the co-construction of the findings of the study with the participants. My level of participation was driven by the following considerations: 1) priority of collecting rich data over participation; 2) level of intrusiveness versus need to build rapport with the teacher and children; 3) comfort levels of the teacher and children; and 4) provision of feedback and inputs to the teacher.

In qualitative studies, researchers need to critically reflect on their roles and assumptions (Davis, 1998; Punch, 2002). Patton (2002) suggests that being reflective involves
self-questioning and self-understanding, and undertaking “an on-going examination of what I know and how I know it” (p.64) The qualitative researcher needs “to be attentive to and conscious of the cultural, political, social, linguistic, and ideological origins of one’s own perspective and voice as well as the perspective of those one interviews” (Patton, 2002, p.65). Schram (2006) highlights the danger of the researcher seeing too much as a result of preconceived understandings, taking too much for granted and not seeing enough, or making assumptions about participants. I adopted a number of strategies to address these potential issues: examining underlying assumptions or preconceptions in the planned questions, ensuring that questions were open-ended and not framed in terms of the way I already saw things, making distinction between what was observed and what was inferred or assumed about an experience, and being open to have preconceptions disrupted by new information (Schram, 2006). Schram also suggests a number of strategies to manage researcher subjectivity which can potentially affect the validity of the study: being sensitive to emotional cues in responding to what is observed which may keep the researcher from learning, and constantly asking questions such as “Who am I seeing?”, “Where am I not going?”, “What questions am I not asking?”, and “What am I hearing but not appreciating?”. Throughout the study, I had to re-examine some of my assumptions in relation to who to observe, what I should observe, how I interpreted my data, and how the research should proceed. I was careful not to impose my own views and to allow the participants, especially the children, to express their perspectives freely.

I discovered that unexpected sources and types of data could reveal themselves when I abandoned my preconceived ideas of how the research should be conducted and was prepared to go with the flow of the children’s activities or interests. In a New Zealand-based study of children’s photographic activities in an early childhood education centre, Stephenson (2009) speaks of learning to “step back” from the data and not allowing assumptions based on the
research agenda to constrain what the researcher sees as being essential to a deeper understanding of children’s perspectives. For example, an innocent question on what a child had pinned on her dress (a plastic red poppy) led to a lively discussion on ANZAC Day\(^1\). A group of boys playing a card game they had created led to a rich discussion on how the game was created and the thinking involved. The eagerness of a boy in sharing with me how he made colourful paper stars to sell to his family members and friends revealed insights into his thinking. Having elaborated my role and involvement as a researcher, I now discuss a number of issues and ethical considerations in relation to the conduct of research with children.

4.5 Research with Children and Ethical Considerations

The Convention on the Rights of the Child drawn up by the United Nations in 1989 recognises children’s right to participate in decisions affecting their lives and communicate their own views (Birbeck & Drummond, 2007; Einarsdottir, 2007). In the context of research with children, this means adopting research practices that are respectful and fair to children in terms of confidentiality, protection, as well as assent and informed consent (Davis, 1998). In this section, I describe how these practical aspects of children’s rights were addressed in this study.

In the course of the study, every effort was made to ensure confidentiality in terms of data collected and information related to the children. Care was taken to ensure that no harm, negative social consequences or disruption resulted from the conduct of the study. This study observed the guidelines and procedures spelled out in the application to the University of Otago Human Ethics Committee (University of Otago, 2009).

Dockett, Einarsdottir, and Perry (2009) highlight the importance of researchers spending time to establish relationships with children based on trust and respect, as well as to

\(^{1}\) National day of remembrance on 25 April in Australia and New Zealand to commemorate members of the Australian and New Zealand Army Corps who fought at Gallipoli in Turkey during World War I.
give them time to make decisions about assent. Before the commencement of the study and prior to seeking the children’s assent, I made a point to visit the classroom five times and spent on average three hours during each visit to interact with the children. I also made use of these visits and three other meetings with Sarah to develop my relationship with her.

In order to provide information which enables children to understand what the research involves (Davis, 1998; Einarsdottir, 2007), I arranged for the opportunity to formally introduce my research study to the children and to provide them with background information before the commencement of the inquiry. This task was made easier by the fact that I already made acquaintance with the children during my earlier visits to the school. I described how I would be collecting data, including video-recording, observing them while they are working in the classroom, asking questions about their work, and interviewing them individually or in small focus groups. I spoke about the need to seek their assent and consent from their parents. I explained that participation was voluntary, that they had the right to withdraw at any time. Sarah also helped to provide information and answer queries raised by the children.

Throughout the study, I was wary of the fact that the children’s consent should be treated as an ongoing process and that their nonverbal actions and gestures could indicate their willingness or otherwise to participate even after consent has been given (Davis, 1998; Einarsdottir, 2007). On one occasion, for example, I respected a boy’s decision when he indicated that he did not wish to accede to my request to show how he did a particular piece of work because he wanted to move on to another task.

I was mindful of the potential unequal power relationships between children and the adult researcher (Einarsdottir, 2007). Einarsdottir postulates that some children may not be accustomed to adults’ interest in their views and opinions, and may try to please adults because they perceive adults as authority figures. I adopted a number of strategies to manage the potential inequality in power relationships even though I am of the view that it cannot be
totally eliminated. I adopted a stance of overt humility and worked hard to create a climate of mutual respect (Sumsion, 2003). I was careful to position myself as a learner who “didn’t know and who was looking for information from children because they were experts and had the knowledge” (Einarsdottir, 2007, p.204). In checking my assumptions on a constant basis and adopting a very open mind, my desire to know was genuine and I frequently observe that the children were visibly pleased to see my interest in what they did and were eager to talk to me or show me their work. Davis (1998) suggests a number of researcher roles, such as non-authoritarian adult, “friend”, and “least adult”, which I found very helpful in my interactions with the children.

The importance of on-going relationship building during the study cannot be underestimated. Communication and mutual understanding are facilitated when children are familiar and comfortable with the researcher (Smith et al., 2005). Showing respect and a genuine desire to know also helps facilitate the flow of conversation (Smith et al., 2005) and maximise accuracy of information provided by the children, thereby enhancing validity of findings (Punch, 2002). Humour played a significant role in building rapport - the children and I enjoyed many good laughs. One of the boys made the comment: “I like this guy. He’s so funny.” I also adopted the strategy of letting the children take the lead as much as possible in order to develop rapport and build a relationship of trust (Punch, 2002). Even after I had completed my field work with the children, I continued to receive very warm reception from the children when I went back to the school to continue my reflective dialogues with Sarah. Many of the children were visibly excited to see me: “Scott is here!” On one occasion, one girl asked whether I would continue video-taping them in the classroom. Another child asked when I would be working with them again.
4.6 Data Collection

Upon the approval of the Human Ethics Committee of the University of Otago, I met with the school principal and the classroom teacher, Sarah, to provide them with written information on the research study, to brief them and answer their queries, as well as to discuss the logistics (see Appendix C for letter seeking access to school). Formal consent was obtained from Sarah, who also agreed to help coordinate the logistics of seeking assent from the children and consent from their parents on my behalf. The copies of assent and consent forms were accompanied by information sheets on the research study (see Appendices D to H). We agreed to keep the schedule and duration of my field visits flexible, with the understanding that the visits were to be once or twice a week. Sarah and I adopted the approach of informally agreeing at the end of each meeting when the following visit would be. In addition, we agreed to use e-mail as the primary means of communication outside of school and to make any necessary logistical changes. Details of the data collection process are described in the next sections of this chapter.

4.6.1 Sampling strategies.

I adopted an on-going sample selection process as the inquiry evolved. The aims of the sampling strategy was to 1) discover, understand and gain insight (Merriam, 1998); 2) select information-rich cases (Merriam, 1998; Silverman, 2005); and 3) select those settings, people, events and processes that provide the information needed to answer the research questions (Maxwell, 2005). Intensity sampling was adopted in order to focus on information-rich cases that “manifest the phenomenon intensely but not extremely” (Miles & Huberman, 1994, p.28). Opportunistic sampling was helpful during the early stages of the study when it was difficult to know what to expect at the beginning of the inquiry as I gained familiarity with the teacher, students, and classroom setting. Throughout the study, opportunistic
sampling was used to take advantage of unexpected incidences of interest in relation to the topic of study and to follow new leads (Marshall & Rossman, 2006; Miles & Huberman, 1994). I video-recorded and collected field notes during each field visit, sometimes following a particular child, sometimes going where the social action and learning activities were happening in the room, and other times interviewing individuals or small groups in a quiet corner. According to Miles and Huberman (1994), sampling must also be theoretically driven – “choices of informants, episodes, and interactions are being driven by a conceptual question, not by a concern for ‘representativeness’” and the researcher needs to see different instances of the construct being studied “at different moments, in different places, with different people” (p.29). The sampling strategy employed in the study eventually led to data being collected on 19 out of the 28 students enrolled in the class.

4.6.2 Observations and interviews with the children.

The research was carried out in the social setting of a classroom with a focus on observing and analyzing young children’s thinking skills and processes. I adopted ethnographic techniques or “fieldwork” methods such as direct observations, conversations, reflective dialogues, interviewing, and artefact collection. Observations and interviews are the most common methods used in research with children (Einarsdottir, 2007). Extended periods of time in observing and interviewing in natural settings made it possible to produce rich description or narratives, including case studies, contextual details, and representation of participants’ voice. In cognitive science, observations and interviews are some of the most commonly used methods for knowledge elicitation in CTA (Chipman, Schraagen, & Shalin, 2000; Cooke, 1994; Crandall et al., 2006; Wei & Salvendy, 2004). They are considered to be more informal and less structured than other CTA techniques and recommended for tasks and domains that are not well-defined (Wei & Salvendy, 2004). They are therefore well suited for
CTA involving task performances that can vary tremendously in nature and domains within a classroom. Observation involving video-recording and subsequent coding of data is a technique well-suited for process-tracing in CTA (Chipman et al., 2000). Observations may also be supplemented with probe questions or retrospective review of video-tapes in order to increase information yield (Chipman et al., 2000).

Although think-aloud protocol has been suggested as a method for assessing thinking skills (Beyer, 2008; Halpern, 1994; Norris, 1985) and is commonly used for process-tracing in CTA (Cooke, 1994; Dehoney, 1995; Hoffman & Militello, 2008; Wei & Salvendy, 2004), it was not used in this study for four reasons:

- Young children may have difficulty following think-aloud instructions (Als, Jensen, & Skov, 2005).
- Children’s inclination and ability to verbalize during think-aloud protocols vary greatly (Barendregt, Bekker, Bouwhuis, & Baauw, 2007; Donker & Markopoulos, 2002).
- Think-aloud protocols involve the need to remind participants to keep talking (Desoete, 2008; Donker & Markopoulos, 2002; Keys, 2000), which would be impractical in the context of a naturalistic inquiry in a classroom of 28 children where interactions are unpredictable.
- Think-aloud protocols require the performance tasks to be controlled and designed according to an appropriate level of challenge (Taylor & Dionne, 2000), which again is impractical in the context of a real classroom where learning activities vary from day to day and the children are of diverse abilities.
- Think-aloud protocols have been found to be inferior to the use of interview probes in eliciting tacit knowledge because participants often need help in articulating the
critical components of their knowledge and thinking (Crandall, 1989; Hoffman et al., 1998).

Gollop (2000) suggests that it is more helpful to adopt the approach of having a conversation when interviewing children. According to Smith et al. (2005), informal conversations, interviews and discussions with children are useful methods for eliciting children’s voice and seeking their own perspectives about their learning. Some researchers recommend interviewing children informally when they are actively engaged in activities and routines already familiar to them (Cooney, 1993; Einarsdottir et al., 2009; Parkinson, 2001; Tammivaara & Enright, 1986). Talking while they are doing something tends to be less intimidating for children than face-to-face interview sessions (Parkinson, 2001).

In this research study, data were gathered primarily through observations of the children that incorporate informal conversations while the children were engaged in their activities or reflective dialogues about the work that they had just completed in the natural classroom setting. This approach provided a rich and direct source of data. I called these informal conversations thinking conversations (see Appendix I: What are Thinking Conversations?). A “thinking conversation” is defined as an informal conversation that focuses on eliciting children’s thinking in much the same way as interviews are used to elicit expert knowledge in CTA. In a thinking conversation:

- The adult questioner is not “expert” holding the right answer(s) – the children are the experts.
- The adult questioner listens to understand rather than to test or correct.
- Questions are asked to gain information not to assess against a predetermined set of criteria.
- Objective is to explore children’s thinking and identify aspects for subsequent analysis, evaluation (using more targeted assessment tools for example), or intervention.
- Attention is on learning through the conversation rather than one specific outcome.

In thinking conversations, children’s attention are drawn to and encouraged to talk about aspects of their thinking. In thinking conversations, learners are encouraged to engage in reflective thinking, to justify ideas, to make judgments, and to offer supportive reasons for actions taken or conclusions reached. The goal of thinking conversations is to promote the understanding of others’ thinking and draw out the solutions/ideas/goals that are inherent within the task performance. Thinking conversations engage children in thinking as they talk about their work and the strategies they employed in task performance. The key difference between a “thinking conversation” and other forms of interaction between the adult and the children is that questions are posed to elicit information on children’s thinking rather than to ascertain what they know, to determine what they have learned, or to communicate information to them.

The duration of each observation depended on the length of the day’s activity, as well as the schedules and routines of the children and their teacher. The duration of each observation varied greatly, ranging from 5 minutes to approximately under an hour. Interviews were also conducted after the event or “off-line” in a separate room to encourage the children to reflect on their experiences in order to extract evidence of creative thinking and critical thinking by seeking out the children’s views and perspectives of the process they had gone through. To aid in memory recall, the children’s completed work were used where necessary to encourage recall and reflection on their experiences. Other reasons for employing interviews include the intent to employ multiple methods of data gathering and the fact that it
was not possible for this researcher to observe all activities when they occurred in the classroom.

Interviews incorporating open-ended questions were conducted on a one-to-one basis and within small focus groups with the children in order to obtain information that could not be gathered through observations and to verify the observational findings. Focus group interviews present certain advantages over individual interviews. Einarsdottir (2007) postulates that children are “more powerful when they are together, and they are also more relaxed when with a friend than when alone with an adult” (p.200). Group interviews make use of the group dynamics where children discuss the questions, help each other with answers, keep each other on track, help their friends fill in details, and pose questions themselves (Einarsdottir, 2007; Parkinson, 2001). Social interactions among the children during group interviews can also generate useful information for the researcher (Parkinson, 2001). Some of the disadvantages of the focus group interviews include the possibility of someone’s voice being lost within the group and difficulty in “crowd” management when the ratio of children to researcher is relatively high (Smith et al., 2005). The length of each individual or focus group interview was no more than half an hour. The interviews were either semi-structured or unstructured conversational type of interviews where questions arose from the situation. The semi-structured interviews made use of a list of open-ended questions to serve as a guide and provide focus - questions such as “Can you tell me about . . . ?”, “Can you tell me more about that?”, “Can you give me an example?”, “What was the outcome?” and “Why, how, or when do you do that?”. A flexible structure was adopted to allow for certain points of interest to be clarified or further pursued, and to allow for fresh insights and new information to emerge. Respondents were free to answer questions in their own words and were able to answer either briefly or at length.
4.6.3 Data collection strategies and considerations.

Several key rules were observed during my interactions with the children. I took care not to impose my own agenda or bias, and not to mention specific terms or over-cue the interviewees (Ary et al., 2006). In order to increase reliability, the questions were focused on content related to the children’s work and interest to ensure relevance and meaningfulness (Birbeck & Drummond, 2007). Attempts were made to direct responses to concrete, detailed accounts (Ary et al., 2006). Strategies such as the use of open-ended questions, the probe and the pause were employed (Ary et al., 2006). Every attempt was made to keep the questions simple given that complex questions are likely to result in errors especially when children have to make recalls (Birbeck & Drummond, 2007). I was also mindful of the need to uncritically accept what the children had to say “as an indicator of perception rather than as a ‘right’ or ‘wrong’ answer” (Birbeck & Drummond, 2007, p. 25).

It was necessary to make prolonged and close observations in the classroom because it was difficult to observe young children’s thinking processes as they engaged in activities that require them to exercise their creative and critical thinking skills. My task was rendered even more difficult by the children’s uneven development and highly variable behaviour from day to day and in any one domain of development (Gullo, 2006; McAfee et al., 2004). As in the case of Stephenson’s (2009) study, I found that prolonged period of data collection allowed those who were initially wary to approach me in their own time. Prolonged engagement with the children also created opportunities for all children to engage in the research process even though different children responded to those opportunities to different degrees or not at all.

A reflective and critical approach is necessary in order to recognise the advantages and limits of various data gathering methods, and the reasons for using them (Punch, 2002). During the study, I became aware of limitations of individual interviews in terms of how quickly the children got tired of simply talking about what they knew and how they
sometimes struggled for words to accurately describe their thinking process (Cappello, 2005). In contrast, the use of probes and informal conversation while observing the children in the natural setting of the classroom was challenging but yielded rich data and insights into the children’s thinking and problem-solving.

Data from the thinking conversations and interviews with the children were video-recorded and subsequently transcribed. Video-recording offers the possibility of deciphering unclear responses using the visual images (Parkinson, 2001). It also helps the researcher to focus on the participants so that he or she can respond appropriately or pose meaningful questions that would result in a richer and deeper understanding of the research topic (Parkinson, 2001). In addition, video-recording allowed me to conduct repeated reviews and close examination of the data collected. Data gathering over a period of three months generated approximately 25 hours of video recording of the thinking conversations and interviews with the children. I wrote reflective logs, comments, and memos as they occurred throughout the data gathering process.

4.6.4 Reflective dialogues with the teacher.

The reflective dialogue sessions with the teacher, Sarah, involved a joint review of the transcripts, my feedback on incidents that I observed, reflective logs and memos that I wrote, as well as the results from my preliminary analysis. The main objectives were to obtain additional insights from Sarah to support my analysis of the data gathered on the children, and to validate and cross-check findings. Reflective dialogues with Sarah generated a total of 12 hours of audio-recording over a period of seven months. These were subsequently transcribed, reviewed, and analysed to provide additional and supporting findings. During this process of data gathering and transcription, reflective logs, thoughts, comments, notes and memos were again written as soon as they occurred.
4.6.5 Peripheral data.

In addition to the core data gathered by focusing on the events in the classroom, peripheral data could help the researcher to situate the core data within the context of the school and wider educational community (Holliday, 2002). Peripheral data in this study included the observations made during my visits to the six primary schools, conversations with the principal and other teaching staff in the staffroom, classroom documentation, and information shared by the teacher, Sarah, in relation to her teaching philosophy, professional development, and personal reflections on her teaching practice. They contributed to my understanding of the contexts within which I conducted my research. Selected artefacts such as samples or documentation of children’s work were particularly helpful in anchoring conversations with children in their own experiences (Smith et al., 2005). In the interpretation of children’s work, emphasis was placed on listening to what they had to share and their interpretations rather than my interpretations of their work in order to get a more accurate picture (Einarsdottir, 2007). Having elaborated the data collection process and strategies, I now describe my approach to data management and analysis.

4.7 Data Management and Analysis

Most studies do not adopt an exclusive or “pure” version of a particular research approach (Schram, 2006) and all researchers develop their own ways of analysing data (Taylor & Bogdan, 1998). Schram (2006) observes that it is “often easier (and more accurate) to claim that studies are only relatively more oriented toward this or that approach” (p.112). Not wanting to be constrained by one particular research tradition or approach, I adopted a strategy of analysis that involved:

- Interpretative approach to data analysis (Hatch, 2002)


- CTA using the cognitive process mapping technique developed for this study

  More often than not, data analysis involves both deductive and inductive thinking (Hatch, 2002; Thomas, 2006). Harry, Sturges, and Klingner (2005) question whether educational and social science research can ever be totally inductive. They cast doubt on the notion that findings can be totally “grounded” in grounded theory analysis given that researcher interpretation begins early in the research process and the researcher often brings preconceived beliefs and perspectives to the study. According to Patton (2002),

  Inductive analysis involves discovering patterns, themes, and categories in one’s data. Findings emerge out of the data, through the analyst’s interactions with data, in contrast to deductive analysis where the data are analysed according to an existing framework. (p. 453)

The process of analysis that I adopted was both deductive and inductive in nature.

4.7.1 Cognitive process mapping technique.

It is necessary at this juncture to explain the concept of cognitive process mapping that was developed and used in this study. According to Holliday (2002), the very open-ended nature of qualitative research creates research opportunities for investigation into unforeseen aspects of the research topic and such unforeseen discoveries can lead to a change in research questions and the focus of inquiry. The initial questions and data analysis led me to investigate the various ways in which the children exhibited creative and critical thinking skills. In order to analyse the children’s thinking, I sought to graphically map out the processes that they engaged in using the transcripts from my video-recording. The choice of this approach was driven by two factors. Firstly, being a visual person, it was a convenient
way to manage and make sense of the complexities involved in order to get the big picture. Secondly, my previous work experience as a strategic planner had taught me that visual representation of processes could be an effective way of organising complex planning and thinking processes, and explaining these processes to my management. McKinsey consultants, for example, used a form of graphical representation called an issue tree to organise their thinking in a logical and systematic manner in order to generate solutions to their client’s problems (Rasiel & Friga, 2002). Interestingly, Holliday (2002) notes the similarity between the work of a consultant and a researcher, particularly in terms of the concept of opportunism within a disciplined and rationale structure which seems to be a common feature of both qualitative research and consultant work. Silverman (2005) observes that our prior experience could have an important influence on the way we approach our data. The utilisation of graphical representation in data analysis is not uncommon. For example, matrix displays, concept maps, cognitive maps, or other forms of networks are some of the data analysis techniques used by researchers (Miles & Huberman, 1994; Patton, 2002).

I developed the cognitive process mapping by using a tree-like logic structure to create an approximated framework of the complex thought processes nested in the data. In its simplest form, a cognitive process map is constructed by linking two sequential comments or observed behaviours with an aspect of thinking that has been inferred from the participant’s observed behaviours and the context within which the thought-provoking experience took place. The following simple example illustrates how cognitive process mapping was applied to a child J’s comments when he made an observation during a class activity involving a whole-class discussion on pumpkins and the making of pumpkin soup. J first observed that pumpkins were big and were of different colours, and then inferred that they would taste different:
The observed comments or actions were represented as paraphrases in labelled boxes. A differentiation between a child’s comment or observed behaviour and that of a mediating adult could be made by using a coloured or shaded box for the latter in order to highlight any adult intervention. The inferred thinking skills involved were represented as labelled lines and arrows were used to show the sequence of events or logic. More details on the construction of cognitive process maps are provided in Chapter Five.

The concept of cognitive process mapping can be compared to two other similar but essentially different concepts: mind-mapping and concept mapping. Mind-mapping is commonly used for recording ideas generated, for example through brainstorming, around a specific topic. It does not follow a sequential or logical process, and the focus is on ideas and content. Concept mapping is used commonly in the classroom to document students’ developing understanding of a specific topic or concept at a given point in time. Concept mapping is used to record what children know about a topic and what they understand about relationships among concepts (McAfee et al., 2004). The focus is on knowledge and understanding of content (Birbili, 2006). The concept of cognitive process mapping in this paper differs from mind-mapping and concept mapping in that it was used to graphically and systematically map out the thought processes that children adopted as they engaged in work that required them to exercise their thinking. It is essentially process-focused, although content did lend meaning and context to the interpretation of the information gathered in the study.
I recognise that children’s thinking is too complex to be represented fully and accurately in any form. Cognitive process mapping is not another reductionist thinking framework that tries to provide a list of components that characterise thinking skills but a tool to make evident and gain insights into children’s thinking processes. Nickerson (1990) describes the paradoxical duality of any attempt at representing complex processes: while representational models or organising frameworks provide a convenient conceptual simplification to guide us in our understanding and discussion of thinking skills, they pose the risk of over-simplification and restricting our thinking at the same time. There is the “problem of reification; what was intended to serve as a conceptual expedient soon becomes perceived as reflecting the way things really are” (Nickerson, 1990, p.505). However, as Nickerson points out, a representational model of complex processes does not need to be an accurate reflection of reality to be useful. Many theories and models of the physical world are no more than limited or approximated representation of reality but they prove to be extremely useful in the progress of science and in practical applications of technology. One example I can think of is the finite element analysis (Heinrich & Pepper, 1999) model that I worked on during my undergraduate engineering studies. While a highly complex software model and useful engineering design tool, it was in reality only an approximation of the fluid dynamics that occur in a nuclear plant heat exchanger.

4.7.2 Process of data analysis.

Analysis of data was carried out early in the study and simultaneously with data collection to generate initial descriptions of the children’s thinking processes and skills. The video data were imported into NVivo and each episode of recordings was transcribed into text using the software. Each episode comprised complete interchanges between the participant(s) and the researcher, which essentially made up a segment of a thinking conversation or
interview that serves to illustrate a focal point of interest and discussion. Breaking the data into episodes allowed me to examine the participants’ thinking processes and skills that were involved when they performed a task such as completing an assignment, carrying out an inquiry, solving a problem, or preparing a presentation. The software enabled me to preserve the time-line sequence of the recorded conversations and to number each utterance. An utterance can be defined as a speech sequence by one participant during a conversation and each utterance is terminated by a contribution made by the other participant (Belkin, Brooks, & Daniels, 1987). At the initial stage, my unit of analysis was the participants’ utterances and I coded line by line according to thinking skills that I was able to infer from what the participants said. When I became more familiar with the data and having progressed further along in my preliminary analysis, I began to selectively identify units of meaning and transcribe relevant segments of the video-recording for analysis.

I started my analysis with a deductive step by establishing a preliminary list of thinking skills for my coding scheme (Hatch, 2002). This step is also typically employed in typological analysis (Hatch, 2002; Lincoln & Guba, 1985). In typological analysis, “data analysis starts by dividing the overall data set into categories or groups based on predetermined typologies” (Hatch, 2002, p.152). Hatch postulates that researchers often move from typological analysis to an interpretive approach and that “most studies will be richer and findings more convincing when interpretive analytic processes are used along with or in addition to typological or inductive analyses” (p.181). According to Patton (2002), qualitative analysis could begin with a deductive or quasi-deductive approach where data are first examined in terms of theory-derived sensitizing concepts or a theoretical framework. This is then followed by looking at “the data afresh for undiscovered patterns and emergent understandings (inductive analysis)” (Patton, 2002, p.454). This is also the preferred approach of Miles and Huberman (1994).
In typological analysis, typologies are generated from “theory, common sense, and/or research objectives” (Hatch, 2002, p.152). In the predefined approach to coding, initial codes could come from the “conceptual framework, the research questions, hypotheses, problem areas, and/or key variables that the researcher brings to the study” (Miles & Huberman, 1994, p.58). They could also be derived from literature, professional definitions, local common sense constructs, researcher’s prior experience or theoretical orientations, or characteristics of the phenomena being studied (Ryan & Bernard, 2000).

Given the broad scope of thinking skills that could be analysed, I chose to focus on aspects that are typically considered part of critical and creative thinking. Creative and critical thinking skills are recognised as important cognitive skills that play a key role in students’ learning, including young children (Fisher, 2003; Helm & Gronlund, 2000; Robson, 2006; Thornton, 1995). Creative and critical thinking play important complementary roles in problem-solving (Bjorklund, 2005; Robson, 2006; Siegler & Alibali, 2004) which is an integral part of the learning process as it provides much of the purpose for other cognitive processes, and it supports the development of the whole child (Bronson, 2000; Hope, 2002; MacNaughton & Williams, 2004; Segatti, Brown-DuPaul, & Keyes, 2003; Siegler & Alibali, 2004). The list of 60 categories that formed my initial coding scheme was derived from my earlier study of young children’s creative and critical thinking skills (Lee, 2007), as well as a number of definitions and taxonomies found in literature (see Appendix J: Initial Coding Scheme).

At the same time, the initial deductive step did not preclude me from “being aware that other important categories are likely to be in the data” or prevent me from searching for them (Hatch, 2002, p.161). Ryan and Bernard (2000) point out that “good codebooks are developed and refined as the research goes along” (p.781). Miles and Huberman (1994) suggest that the list “be held lightly, applied to the first set of field notes, and examined
closely for fit and power” and that having “a dozen or so up to 50-60 codes” in the start list would allow the analyst to keep the list in short-term memory without constant reference to the full list (p.58). As a new element of thinking skill was identified in the data, I compared it to other thinking skills and categories. If it was not related or did not belong to an existing category, a new category was created and the item coded accordingly. To reduce overlap and redundancy, categories were combined, linked under a superordinate category when meanings were similar, or deleted (Thomas, 2006). The iterative process of adding, deleting or modifying the list of categories occurred throughout the analysis until the coding scheme was stabilized (Appendix K: Final Coding Scheme). During the coding process, I engaged in memo-writing to explore ideas about the data and to direct further data gathering.

Next, I carried out a CTA that focused on the interpretation of children’s thinking processes and skills involved in their task performance. Using the cognitive process mapping technique, I graphically mapped out the transcripts of episodes of my video-recording. The previously coded items were essentially the inferred thinking skills represented as lines and arrows in these cognitive process maps. The corresponding utterances were paraphrased and represented as labelled boxes in the cognitive process maps. In addition to examining the skills level, I analysed the children’s knowledge, procedures, strategies, thought processes, and decisions as well as the structure of the cognitive maps generated from the data. I analysed the cognitive process maps and read the data in order to identify patterns and themes. I simultaneously documented points of interest and continued to write memos to record my thoughts and impressions as they occurred. In the writing of memos, efforts were made to link to relevant literature in order to support or situate my interpretations of findings. According to Patton (2002), interpretation goes beyond the descriptive data:
Interpretation means attaching significance to what was found, making sense of findings, offering explanations, drawing conclusions, extrapolating lessons, making inferences, considering meanings, and otherwise imposing order on an unruly but surely patterned world. (p.480)

Schlechty and Noblit succinctly describe interpretation as being one of the three forms: making the obvious obvious, making the obvious dubious, or making the hidden obvious (Schlechty & Noblit, 1982; as cited in Patton, 2002). The last was largely the approach adopted in this study.

The objective of the CTA undertaken in this study was to arrive at “some generalisations that capture the patterns, relationships, and themes discovered in the data” (Hatch, 2002, p.229). Miles and Huberman (1994) describe the process of data analysis as the generation of “propositions or connected sets of statements, reflecting the findings and conclusions of the study” (p.75). A collection of data excerpts that support the generalisations or propositions was identified. These excerpts were used for subsequent reference during the writing of the findings. Although rich data were generated in the course of the study, the cognitive process mapping technique provided structure to the analysis by offering a visual and convenient way to organise and make sense of the complexities involved. The data analysis process is summarised in Appendix L: Process of Analysis of Children’s Data.

As the memos and initial findings were generated, I discussed them with the teacher, Sarah, during the reflective dialogue sessions in order to solicit her views, test emerging interpretations of the classroom observations, and carry out stakeholder checking (Thomas, 2006). The discussions with Sarah were audio-recorded and interview logs were used instead of full transcripts. Merriam (1998) points out that rather than transcribing the interview verbatim, interview logs capture the main points and “noting the tape position allows the
researcher to access the original data quickly.” (p. 91). During the reflective dialogue sessions, field notes and memos of impressions were recorded as they occurred. An interpretative analysis process was adopted (Hatch, 2002) as shown in Appendix M: Process of Analysis of Teacher’s Data. Throughout the process of data analysis and writing of findings, I constantly revisited the transcripts, codes, field notes, and memos in order to ensure that relevant data were thoroughly considered in relation to my research questions and focus of inquiry.

4.8 Credibility and Trustworthiness

Several strategies were employed in the study to address the issue of trustworthiness in terms of credibility, dependability, confirmability, and transferability (Lincoln & Guba, 1985). The credibility of the study was enhanced by the use of multiple methods of data collection and the triangulation of data gathered from classroom observations and interviews with the children, reflective dialogues with the children in relation to their work, individual interviews, small focus group interviews, and reflective dialogues with the teacher (Creswell, 2007). Strategies employed to enhance the interpretive validity of the study included prolonged engagement and persistent observation in the field, search for discrepant evidence, stakeholder checking with the teacher, memo writing to chart the steps taken in the interpretation of data, and clarification of assumptions that may be potential cause of bias (Creswell, 2007; Thomas, 2006). Dependability was addressed by triangulation of data gathered from the multiple sources and by multiple methods (Merriam, 1998). In addition, dependability and confirmability were addressed by an audit trail maintained through the recording of on-going reflection and interpretation through memo-writing, and by keeping records of field notes and transcripts (Merriam, 1998).
Although generalisability may not necessarily be a goal for qualitative study, Miles and Huberman (1994) state that it is useful and important “to know something about the relevance of or applicability of the research findings to other similar settings” (p.173). To address the issue of transferability, every attempt was made to provide a rich thick description of the context and participants so that others can make judgments about applicability to other situations and the broader context (Ary et al., 2006; Hatch, 2002; Merriam, 1998). Providing an audit trail and rich description is also important in another sense. In many ways, this study served to demonstrate how the concepts of thinking conversations and cognitive process mapping could be used to document and analyse children’s thinking skills as they engage in various tasks. Leaving an audit trail and providing a rich description offer educators and researchers the opportunity to replicate or explore these concepts further.

4.9 Significance

Patton (2002) suggests that qualitative findings should be judged by their “substantive significance”, which is addressed by the following questions (p.467):

- How solid, coherent, and consistent is the evidence in support of the findings?
- To what extent and in what ways do the findings increase and deepen understanding of the phenomenon studied?
- To what extent are the findings consistent with other knowledge?
- To what extent are the findings useful for some intended purpose?

The first question is an issue of credibility, which has been addressed in the previous section. In terms of the second question, the findings increase and deepen the understanding of children’s thinking skills by providing insights into their thinking processes and abilities. These insights were revealed through their “voices” because the findings were co-constructed with them as they brought the researcher into their “mental worlds”, although the final act of
interpretation was necessarily the researcher’s. Patton (2002) recommends that the third question could be addressed either in terms of confirmatory significance where the finding is supported by or supportive of other work, or in terms of innovative significance where the finding breaks new ground. Using Phillips and Pugh’s (2000) guidelines on what is considered original contribution, I believe this study is innovative to the degree that it demonstrated a new approach to researching and analysing children’s thinking processes and abilities in terms of the concepts of thinking conversations and cognitive process mapping. Finally, the findings of this study could contribute to both research methodology and educational assessment methods.

4.10 Limitations

I focus on the boundaries of the study and the potential issue of generalisability (Glatthorn & Joyner, 2005) in my discussion of the limitations of this study. I discuss firstly the issue of the uniqueness of the setting and secondly the limitations of the method used in analysis.

While offering the opportunity for rich data to be gathered, the teacher’s flexible and multi-faceted approach to teaching thinking skills created a rather unusual classroom culture and therefore a potentially unique research setting. This could limit the generalisability of the findings in respect of the children’s thinking behaviour. At the same time, it potentially demonstrated the flexibility of thinking conversations and cognitive process maps as methods for observing and analysing children’s thinking processes in being relatively adaptable to the different contexts exemplified in the research setting. Further research will be needed to investigate the use of cognitive process mapping in other settings and with children of other age groups. The sample size and procedures for participant selection also limit the
generalisability of the results to a larger population of either a similar age group or children of different age groups.

There are two potential concerns in the usage of cognitive process mapping as a tool in my analysis of the data. Firstly, it should be noted that there was a degree of subjectivity and interpretation involved in constructing the cognitive process maps even though the procedures were guided by the reported or observed sequences in the processes adopted by the study participants as they engaged in various classroom activities. There could, therefore, be more than one way of constructing any given cognitive process map, potentially resulting in alternative research findings and interpretations. Secondly, the identification of the various types of thinking behaviour exhibited by the children could be subject to other interpretations given that mental processes were not visible and the observer could only make inferences from children’s behaviours and actions (Howie, 2003). On the other hand, these issues could be perceived as advantages of the technique because it offers the observer the flexibility to decide how to analyse and what aspects of thinking to focus on. That these issues arise should not be surprising within the context of a social constructivist paradigm which holds that universal, absolute realities are unknowable and that multiple realities exist and they are mentally constructed, experiential, and context-bound.

4.11 Summary

In summary, this was a participant observation study using a research design that was largely consistent with a constructivist and pragmatist paradigm. The data collection and analysis strategies were both deductive and inductive in nature. An adapted form of CTA was used to analyse the data in order to obtain insights into the children’s thinking processes and skills. The concepts of thinking conversations and cognitive process mapping were developed and explored in this study for the purposes of elicitation and analysis (to borrow the
terminology of CTA) of the children’s thinking processes and skills. Several strategies and considerations were important to the successful implementation of the research design:

- Building rapport and trust prior to and throughout the study.
- Engaging with the children over a prolonged period.
- Being flexible, open-minded, and adaptive.
- Being reflective and constantly re-examining my assumptions.
- Being a learner and showing genuine interest in knowing.
- Respecting the children and treating them as experts in their own lives, including their learning and thinking.
- Being humble, having a good sense of humour, and being prepared to adopt a variety of roles, including “friend”, non-authoritarian adult, and “least adult”.

The qualitative research approach adopted in my study provided the flexibility to modify the research design and focus during the research process. Reflecting on the research journey taken to complete this study, adopting an opportunistic, flexible, open-minded, and adaptive stance constantly struck me as both necessary and effective in exploring in an open-ended manner the research opportunities that the research setting and the actions of the participants offered. This reality was reflected in the evolution of several aspects of the project, including my research focus, questions, data collection and analysis, findings, and emergent theories. The qualitative research approach permitted me to strike a “judicious balance between taking the opportunity to encounter the research setting while maintaining the principles of social science” (Holliday, 2002, p. 8). Having described the research process and the methodology adopted for this study, I present and discuss my findings in the next three chapters.
Chapter Five

Cognitive Process Mapping as a Technique for Analysing Children’s Thinking Skills.

The discussions of findings in this thesis draw on the many similarities between cognitive task analysis (CTA) and the approach to data collection and analysis employed in this study. It should be noted, nevertheless, that there are some significant differences in goals and approach between conventional CTA and this study. CTA usually involves the identification of declarative knowledge and procedural knowledge (skills) needed or effectively used by an expert to perform a specific task in a well-defined work context (Chipman, Schraagen, & Shalin, 2000; Crandall, Klein, & Hoffman, 2006; DuBois & Shalin, 2000). The result is a single set of knowledge representations for a given job or task which can be used for assessment of performance, systems development, or instructional design (Chipman et al., 2000; Crandall et al., 2006).

The approach adopted in this study differs from those typical of CTA. The objective of the study was not to develop a single representation or model of expert performance. The intent was to seek insights into children’s thinking competence across diverse task performances and contexts, resulting in multiple representations of their thinking skills. The children in the study were all treated as individuals to be observed and were regarded as “experts” in terms of their perspectives on how they reason and their own thinking approach. The researcher was positioned as a learner who did not know and who was looking for information from children. The representations generated took the forms of cognitive process maps and visual models of the children’s thinking processes and skills, which are the focus of the discussion in this chapter. Cognitive process maps, briefly described in Chapter Four, are discussed in detail in this chapter along with illustrative examples of what they can offer. I
also discuss in this chapter how visual models can be constructed of a child’s task performance to give an overall picture of the child’s thinking abilities.

For the purpose of discussion, I draw a parallel between the approach undertaken in my study to the four phases described in DuBois and Shalin’s (2000) Cognitively Oriented Task Analysis (COTA):

- **Planning:** This phase in CTA involves the selection of experts, obtaining consent, identifying a suitable context, determining tasks to be observed, and choosing data collection methods to be used in cognitive task analysis. This is equivalent to the research design phase in this study which involved development of the sampling strategy, selection of research site, establishing the context and activities to focus on, and obtaining the participants’ (“experts”) consent.

- **“Knowledge” elicitation:** CTA makes use of data collection techniques such as observations, questions, probes, and interviews. This study employed collection techniques of thinking conversations (conversations with children focused on eliciting information on their thinking), informal interviews with the children, and reflective dialogues with the teacher.

- **“Knowledge” representation:** In CTA, data can be represented in various forms, such as narratives, data or graphic organisers, flow charts, and process diagrams (Crandall et al., 2006). The data in this study were analysed and represented in the form of vignettes of thinking conversations, cognitive process maps, and visual models of children’s thinking processes and skills.

- **Application:** CTA has been used for performance assessment and identifying learning needs (Crandall et al., 2006). The results of this study are discussed in the contexts of observation and assessment of children’s thinking competence, identification of
learning needs, and comparison of children’s thinking processes to theoretical models for certain task performances such as problem-solving and decision-making.

Using this framework, the discussion in this chapter centres on the three forms of “knowledge” representation – narrative vignettes, cognitive process maps, and visual models – and how they can serve as research and assessment tools in relation to children’s thinking processes and skills. Chapter Six and Chapter Seven focus on the application aspects of narrative vignettes, cognitive process maps, and visual models of children’s thinking processes and skills. In this thesis, an episode refers to a segment of a thinking conversation or interview that serves to illustrate a focal point of interest and discussion. Each thinking conversation or interview could have several episodes that were used to discuss various aspects of the children’s thinking processes and skills.

5.1 Cognitive Process Mapping as a Research Tool

Alvarez (1990) posits that much can be learned about young children’s understanding and thinking abilities from their conversations with other children and adults, and visual representation of such conversations can be a useful means to “explicate ideas and organization of children’s thoughts” (p.89). In Chapter Four, I described the concept of thinking conversations that was used to gather information on children’s thinking abilities and the processes that were involved in their task performance. The following vignette illustrates an episode of thinking conversation I had with two children E and K. They were engaged in using the Google search engine to find an answer to the question of what the most popular celebration food was 50 years ago:
E: So we want to type in the most popular food back then - what was the most popular food back then.

K types “popular food of celebration 50 years ago”.

While K types on the keyboard, E helps her by correcting the spelling and telling her what to type. A list of search results appeared on the computer screen after K hit the return key on the keyboard.

E: And now we just go through—(pause for a couple of minutes as the children appeared to be reading the search results as they stared at the screen silently).

Researcher: So which one do we choose?

K: Yeah, you can just choose any of them.

E: You can choose anything you want really.

Researcher: But there are so many.

K: Yeah.

E: Yeah. But maybe you should pick one of the main ones you've done.

Researcher: Okay, how do you know which one is a main one?”

E: Just click on anything and then you'll find out (smiles).

K clicks on the following search result:

“Sandwich celebration | Dairy Foods | Find Articles at BNET
http://findarticles.com/p/articles/mi_m3301/is_n2_v96/ai_16678986/
Sandwich celebration from Dairy Foods provided by Find Articles at BNET . . . And without the development of the automated sandwich machine 50 years ago, this American tradition may have remained . . .”

The children read the text on the computer screen in silence.
E: So that's how we find out. So we just look up and read it all and then we can find the answers to the questions.

The children continue to read the text on the computer screen in silence.

E: Ice-cream sandwiches?

E: Go up (instructs K to scroll down).

E: The machine made ice cream sandwiches—(points to and reads aloud text on computer screen).

Researcher: So, they had ice-cream sandwich machines?

E: It's actually quite good because you can have ice-cream with sandwiches now.

Vignettes with analytical comments commonly used in qualitative research find a parallel in CTA in the form of narrative representation which presents an account of a selected incident together with information on knowledge and skills “beneath the surface of the initial account” (Crandall et al., 2006, p. 120). The episode of thinking conversation between the researcher and the children revealed that E was able to define the task to be carried out, and describe and sequence the steps involved in the search. She attempted to prioritise and rank search results according to whether they were “main ones” but it was not clear what her criteria were. She made predictions about the children’s ability to find out which were the “main” results by reading the information on the computer screen. She made an attempt to decipher the information on the computer screen and drew her conclusion that an ice-cream machine was a “good” idea because it made ice-cream sandwiches available today.
What was the most popular food back then (50 years ago)

Define & describe Sequence

And now we just go through

Which one do we choose?

You can choose any of them

But there are so many

Prioritise & rank

You should choose one of the main ones

How do you know which one is a main one?

Predict / hypothesise

Just click on anything and then you’ll find out

Describe Sequence

So that’s how we find out . . . just look up & read everything

Clicks on link that says “Sandwich celebration . . .

Ice-cream sandwiches?

Decipher information

The machine made ice-cream sandwiches

They had ice-cream making machine?

Draw conclusion

It’s actually quite good because you can have ice-cream with sandwiches now

Relevance of conclusion to original task?
Crandall et al. (2006) describe the knowledge representation in cognitive task analysis as the display of data, presenting findings, and communicating meaning. A cognitive process map can be constructed to visually display the children’s thinking process and skills (Figure 5.1). This arrangement presents the foregoing analysis in a clear and succinct visual display showing different aspects of thinking skills in relation to the children’s articulations about their ideas, knowledge, or understanding at various junctures of the thinking conversation during the internet search.

The cognitive process maps were constructed by starting with the focus of the thinking conversation or main task involved in each episode of interest. The boxes represent paraphrases of observed comments of the child. Those of a mediating adult were represented by coloured or shaded boxes. The inferred thinking skills involved were represented as labelled lines and they correspond effectively to the 36-category coding scheme developed in the course of this study. The coding scheme represented my interpretation of key aspects of critical and creative thinking skills (Appendix K: Final Coding Scheme). The choice of categories in the coding scheme represents in effect the aspects of thinking skills that the observer chooses to focus on. Arrows were used to show the sequence of events or logic. The cognitive process maps can be represented by various visual representational structures which can be expanded or combined to form increasingly complex structures corresponding to the complexity of the observed interactions and task performance. In this study, a cognitive process map is constructed for each of the several episodes of interest in a given thinking conversation instead of a single cognitive process map for the entire conversation. This is to avoid cumbersome constructions, to focus only on episodes of interest, and to facilitate discussion of the findings. The three main forms of structure used in this study were linear, divergent, and convergent (Figure 5.2).
In addition to analysing data collected concurrently during task performance, cognitive process mapping can also be used to analyse data collected through thinking conversations with the children about the work that they have done. In this case, the thinking processes and skills observed and represented are those that the child engages in when elaborating and explaining the completed work and/or what the child reports on. The data do not represent necessarily the processes that the child actually undertook during the performance of the task. This is not an issue if the aim of data collection, as in this case, is to seek insights into the thinking abilities of the child in the context of the conversation. The following episode occurred in the course of a thinking conversation between the researcher and R about his healthy lunch menu project. R was happy to talk about what he had done when I went up to him while he was working on his project and asked if he would like to explain to me what he was working on. R had drawn two columns on an A4-sized paper. In the left-hand column, he had drawn 4 lunch boxes, each with different types of food in compartments. Prices of “$9”,
“$11.50”, “$8.60”, and “$10.30” were written next to each lunch box respectively. In the right-hand column, he had written names for each lunchbox, namely “BLT box”, “carrots and cake”, “choc chip”, and “fruity tutti”. He had also written the title “Healthy lunch menu” at the top of the page. R explained his work systematically item by item:

R: This is healthy lunch menu - with drinks and stuff. And this is their names. And in this—sometimes there is a little treat in the lunch box like biscuits or something.

Researcher: So, let's go to the first one. This is a biscuit and that's a treat.

R: Yep.

Researcher: What is the other stuff?

R: That's a banana, apple and a sandwich.

Researcher: What kind of sandwich is that?

R: It's a BLT.

Researcher: And you reckon that is healthy?

R: Ah—yeah.

Researcher: How do you tell if it’s healthy?

R: Lettuce is healthy, but—and tomato is healthy, but bacon is like—fatty.

Researcher: So, bacon is fatty. And it's not healthy then?

R: But if you buy pre-packaged food, it doesn't mean that they are junk food or—like—unhealthy because it could be healthy.

Researcher: How do you know when it is healthy and when it is not?

R: Coz sometimes I look on the box it says how many sugar and stuff it has.
The corresponding cognitive process map (Figure 5.3) readily and succinctly shows that R was able to generate details in elaboration, analyse by breaking down the components for evaluation, compare and contrast, and classify and categorise food according to whether they were healthy. In response to the researcher’s question, he was able to evaluate his own assumptions and recognise inconsistency in his own previous reasoning. He evaluated the accuracy of the researcher’s observation that a BLT sandwich might not be healthy, even though the relevance and strength of his counter that pre-packaged food could be healthy is suspect. When questioned further, he was able to explain how he used the criterion of the presence of unhealthy food products in the listing of ingredients to draw his conclusion about whether a pre-packaged food was healthy.

It is clear, from these examples, that the cognitive process map can be used to display the sequential logic of the child’s thinking. Systematic, sequential thinking – the ability to proceed through a sequence of analytical steps – is an important foundation of critical thinking and involves “definable mental activities” that thinkers engage in as they seek to comprehend ideas and solve problems (Whimbey, 1977, p.256). Cognitive process maps can also draw our attention to children’s divergent and convergent thinking. Both divergent and convergent thinking play important roles in creative and complex problem-solving (Basadur & Hausdorf, 1996; Goldschmidt, 2011; Kim, Shin, & Shin, 2011; Spivack & Rubin, 2011; Turvey, 2006; Wolf & Mieg, 2010). According to Basadur and Hausdorf (1996), divergent thinking involves ideation and the generation of ideas, options, possible solutions, and different points of view; while convergent thinking involves evaluation of these results of divergent thinking. Similarly, Sternberg and Williams (1996) posit that critical thinking is needed to analyse and evaluate ideas generated through creative thinking in order to differentiate good idea from bad ones.
Figure 5.3: Cognitive process map of R’s elaboration on healthy lunch menu project
The following example shows how cognitive process maps can be used to analyse the convergent structure of the children’s thinking. Convergent thinking may be described as narrowing of focus of attention to one single answer or limited number of ideas (Cropley, 2006; Goncalo, 2004; Larey & Paulus, 1999). It has alternatively been characterised as involving reduction of options through systematic analysis (Spivack & Rubin, 2011) and evaluation of ideas, solutions, statements, or arguments (Cropley, 2006; Spivack & Rubin, 2011; Sullivan, 1973). In the thinking conversation between the researcher and R on his healthy lunchbox project, R was asked about some of the components that made up his healthy lunchboxes:

**Researcher:** Is popcorn healthy?

**R:** Well, it says on here (*rises from his chair and stretches over to point to a poster on types of healthy food*) — on this — and it says popcorn there.

**Researcher:** Oh. Okay, so you checked.

**R:** Yeah (*laughs*).

**Researcher:** And wedges? Are they healthy?

**R:** Potato is but it’s probably processed — like put other flavours onto it, there will be salt — (*pause*) — probably not.

A cognitive process map of the thinking conversation was constructed as in Figure 5.4. It shows that R was able to break down the issue of whether wedges were healthy in order to carry out a systematic analysis, evaluate whether his inclusion of wedges in one of his healthy lunch boxes was warranted, and arrive at the conclusion that wedges were probably not healthy.
The next example demonstrates how children’s divergent thinking can be captured in a cognitive process map. Sarah (the teacher) was engaged in a discussion about how one could read in different ways. She wrote on the blackboard the ideas that the children contributed.

**Sarah:** Can you read in different ways?

**E:** Well, can you read—read as in silent and you can read aloud?

**Sarah:** M?

**M:** You can read in Braille?

**D:** Video games.
B: You can read people's minds.

A: You can read newspapers.

SI: You can read books that don't have words.

CP: You can read in different languages.

V: You can read the Powerpoint. Actually, you can read the computer.

JA: Well, you can read with like different feelings—like happy, sad, scared.

M: You can read nature.

Sarah: How can you read nature?

M: You can read by the sounds and the looks?

Sarah: So you're saying that you can read it with the sounds and the looks—so you are talking about with your ears and with your eyes.

MI: You could like—maybe like the tree was swishing so you could read like you could maybe say the tree was saying hello to me (waving with her right hand).

Sarah asked the children to look at the tree outside the classroom.

Commenting that the tree had lost its leaves, she asked them what feelings came to them as they looked at it.

SI: Sad and weak?

(Part of conversation went off track and omitted).

R: Lonely?

CP: Sad and sleepy?

Sarah: You could interpret that tree as sad and sleepy—

E: Hibernation?
Figure 5.5: Cognitive process map of classroom discussion on reading in different ways
Sarah: I was going to say hibernation.

S: It's losing its colour.

Sarah: Losing its colour—

A cognitive process map can be drawn based on the thinking conversation (Figure 5.5). It becomes clear that there were a lot of divergent thinking going on among the children in this episode. The cognitive process map makes the divergent thinking in a lengthy narrative evident in a succinct manner. It can be seen that the children exhibited fluency and flexibility in generating varied ideas readily. Fluency and flexibility are often considered aspects of creative or divergent thinking (Hu & Adey, 2002; Rodd, 1999; Runco, Dow, & Smith, 2006). M was able to elaborate on her idea of reading nature by generating further details. MI demonstrated her imaginative ability when she described the movement of the tree branches and leaves in the wind as “saying hello”.

The observed tasks and classroom interactions in this study varied in terms of their complexities. The thinking conversation with R on his healthy lunch menu, for example, generated seven cognitive process maps that were used to construct an overall visual model of the thinking processes and skills involved (Appendix N: Visual Model of R’s Lunchbox Menu Project). On the other hand, observation of a simple interaction between J and the teacher, Sarah, generated two cognitive process maps (Figures 5.6 and 5.7). The cognitive process map in Figure 5.6 makes evident J’s ability to make inference from his observations of certain aspects of pumpkins and is another example of a convergent structure. The teacher made her own inference from J’s observations and immediately engaged in divergent thinking as she wondered aloud about other possibilities (Figure 5.7).
It is often expedient in cognitive task analysis to manage the complexity of task performance by constructing a simplified picture of separate cognitive functions and processes to focus the analysis and facilitate interpretation (Crandall et al., 2006). Rupp and Mislevy (2007) argue that the fine grain size of cognitive task analysis results is generally unsuitable for educational assessment which requires information at a coarser level. In the case of the thinking conversation with R on his healthy lunch menu for example, one way to proceed is to construct a visual model by combining the cognitive process maps derived from the thinking conversation (Appendix N: Visual Model of R’s Lunchbox Menu Project). The visual representation was constructed by summarizing the information gathered on key aspects of R’s work and main tasks that he carried out. The thinking processes and skills were
inferred from conversation with the help of the seven cognitive process maps constructed. Such a visual model provides an overall picture of the thinking processes and skills involved in R’s creation of his healthy lunch menus. The visual model shows that R:

- Drew on relevant information from his current knowledge and a reference material such as a poster on healthy food and ingredients to select components that made up his various healthy lunch boxes.
- Carried out his analysis by breaking the problem into parts – he evaluated the components according to pricing and whether they were healthy.
- Compared and contrasted, and classified food items according to a set of criteria.
- Evaluated the counter argument and the accuracy of the conflicting information presented by the researcher. In doing so, he evaluated whether his own conclusion was warranted and recognised an inconsistency in his selection of components for his lunch boxes.
- Made use of the key components of his lunch boxes to develop names that differentiated one lunch box from the other.
- Developed and applied the two criteria of size and affordability to set the prices of his lunch boxes.
- Drew on his knowledge of prices of food and past experiences to make pricing decisions.
- Demonstrated the ability to synthesise the information and results of his analysis to create his healthy lunch menu.

The usefulness and applications related to such visual models of children’s thinking processes and skills are discussed in greater detail in Chapters Six and Seven.

According to Lambiotte, Dansereau, Cross, and Reynolds (1989), the usefulness of a visual knowledge representation over a written or spoken description is determined by its
ability to facilitate faster search and recognition of relevant information. The discussion thus far demonstrates that cognitive process maps and visual models can complement narratives or vignettes by offering a succinct visual representation that facilitates analysis of children’s thinking processes and skills.

5.2 Cognitive Process Mapping as an Assessment Tool

One of several key components necessary for effective formative assessment is the use of open-ended questions to engage students in expressing and communicating their understanding and skills (Harlen, 2007). Thinking conversations can provide insights into children’s thinking abilities by engaging them in thinking as they talk about their work and the strategies they employed in task performance. Furthermore, Annett (2000) argues that a detailed “cognitive model” that describes the skills, processes, and knowledge is necessary because observing overt behaviour can offer only a superficial understanding of a person’s task performance and even questioning “does not always reveal the underlying cognitive structure” (p.32). Cognitive process maps and the visual models constructed from them can be viewed as visual representations that facilitates the assessment of the structure and process of a learner’s thinking approach and the elements of thinking skills employed in a given task performance. They can be thought of as one of several sources of information needed to provide an integrated approach to assessing children’s thinking abilities during task performance.

The power of thinking conversations and cognitive process mapping lies in their ability to take into consideration 1) the emergent, unpredictable and situated nature of children’s performance; 2) the variety of contexts in which children manifest their thinking skills; and 3) the multiplicity of the children’s approaches. The next three episodes serve as illustrative examples. The first involved a joke that I happened to share with a group of
children which turned out to be a philosophical exchange. The children’s responses took me by surprise and their reasoning abilities became even more evident to me when I subsequently analysed the video transcripts using cognitive process mapping (Figure 5.8). CD’s response showed that she was able to question, evaluate, and recognise inconsistency in my comment. CP’s response revealed that she identified the central element in my comment (the person always lies) and arrived at a logical deduction: “He may be lying when he has his hand up”.

Figure 5.8: Cognitive process map of discussion about person who always lies

The second example was D’s self-created card game. On one occasion, I observed that D was working on a game during free-choice time. Free-choice time was a frequent part of the classroom schedule whereby the children were given the freedom to choose a topic and / or activity to work with. I asked him to explain his game to me, video-recorded our thinking conversation, and constructed a cognitive process map to organise and make sense of the resulting lengthy transcript (Appendix O: Cognitive Process Map of D’s Card Game). The cognitive process map makes evident D’s ability to invent, adapt, generate varied ideas (flexibility), and elaborate on concepts by generating details. He was also able to clarify ideas,
define and describe concepts, and prioritise by setting rules to determine who would win the
game and who would be runner-up. The third example involved an incident that occurred
when B came up to me to tell about his scheme to sell hand-made paper stars. Through the
ensuing thinking conversation, I was able to elicit information on the thinking processes and
skills involved in his conception of a scheme to sell hand-made paper stars to his friends and
family members:

**B:** Well, they're like lollies and all these stars are in this - the middle bit.
And we have . . . different packs. I tell you a secret - we put a dot on this
special pack because this special pack is the one that says you can—it's got
a piece of paper saying in it . . . if somebody buys this one, then they can
get another pack free and we put a dot in it so we knew which one it was.
And that's a blue pack. Oh no, that's a mixed pack with all the different
kind of stars. And this is a blue pack.

**Researcher:** How much are they?

**B:** Fifty cents each. But the mixed pack's sixty cents because you've got an
extra one.

**Researcher:** Do you think it's a good price?

**B:** Uh-huh.

**Researcher:** Why do you think it’s a good price?

**B:** I don't know. They are ten cents each for these stars.

**Researcher:** Ah, that's how you came up with fifty cents?

**B:** Yeah. But the mixed pack’s about twelve each but these ones are ten
cents each because there are five in them and they're fifty cents

**Researcher:** Did you say there's twelve in here?
B: Ah no, there's six in these ones because that's why they are sixty cents.

Researcher: How many have you sold?

B: Six.

Researcher: There are six and they are fifty cents each. How much did you get?

B: Guess how much is it.

Researcher: Is there a way to figure out how much you should get (for the six packs sold)?

B: Yeah—I don't really know . . . (conversation turned to who he sold his stars to).

The corresponding cognitive process map shows that B invented his scheme to sell hand-made paper stars by adapting the concept of packs of sweets and elaborated his concept with detailed ideas (Figure 5.9). He was able to apply his understanding of part-whole relationships to derive and justify the pricing of his packs of paper stars. He exercised his creative thinking skill in generating an alternative when he was posed the challenge of determining the total amount of money he should have received from selling six packs of paper stars. However, he did not appear to have any pricing strategy or criteria. It also appears that he did not know how to solve the problem of working out how much money he should get from selling six packs of paper stars. These observations and insights would not have been possible had I not given B my attention when he wanted to talk to me about his scheme to sell hand-made paper stars, engaged him in a thinking conversation, and recorded and transcribed the information for subsequent analysis using a cognitive process map. More likely than not, such an emergent connection would have gone unnoticed because it was not part of the normal learning activities in a classroom.
Figure 5.9: Cognitive process map of B’s hand-made paper stars
The teacher, Sarah, expressed her surprise at the level and type of information that were collected on the children’s thinking during my reflective dialogues with her. The insights provided by the findings helped overcome her initial scepticism:

When I first look at this, I thought . . . alright, “so what?” kind of thing. Then when I start doing the comparing of them - what is it that they haven't got, what is it that we need to be working on, what is it that we need to be refining . . . these are the kind of things that I have in my head as part of the you know picture of kids but I don't have evidence which is where you gave some of the evidence and when I looked at—relating these to some of the other kids who don't have these things—so that's useful.

The things that you have observed because they're still there - they're still valid. It doesn't mean they are not there - it's just that you've not observed it.

She was surprised at the level of thinking involved in D’s construction of his game, E’s internet search, R’s work on the healthy lunch menu, and B’s scheme for selling hand-made paper stars. The following were her comments on the findings on E and R:

And it's interesting that the kids you (researcher) picked out - I would like to look more at. One of the people I've been really impressed with - and I've got a much better insight to because of the things you've got there - is E . . .
He has (*R has his own thinking framework / approach to his healthy lunch menu project*). And as you said it is based on so much knowledge - knowledge of prices and things like that and they’re pretty sound. Because when you first talked about it, I thought well, R is probably talking through a hole in his head. And I started reading (*researcher’s observational findings*) more carefully in relating my knowledge of prices and things - he's probably not far away.

Sarah added that the cognitive process maps and visual models were useful in helping her to examine children’s thinking behaviours:

They are really useful for me to study. They confirm and explain hunches that I have about the way kids operate. They also help me work out what is happening and what is not happening – and where I need to go next. For example, it has been useful for me to look closely at thinking behaviours - R and the healthy lunch menu and identify specifically the higher order thinking that was happening. While I suspect that this kind of thinking may be occurring, the maps provide evidence and confirm my hunches. That’s really reassuring to me!

The unpredictable and emergent nature of the children’s thinking performance was apparent to Sarah. She recognised that the kind of insights into children’s thinking abilities provided by the findings would require paying close attention and spending time to listen to what the children have to say.
And it's messy and it's unpredictable and that's what you have captured in here.

. . . that's what you get from being able to sit and talk with them. It's suspending your own thoughts so that you can give total attention to what the kids were saying . . . if you are going to learn about kids and learn from kids, you've got to give them that sort of total mind space of your own which is such a hard concept—such a hard thing to do—invariably there is all these stuff going on and you treat them without the respect that you need to have.

The findings suggest that children’s thinking and problem-solving approaches may not always be noticed, recognised, and responded to in the classroom. The need for educators to notice, recognize and respond to children’s learning in the socio-cultural contexts is an important issue highlighted, for example, in the New Zealand early childhood curriculum Te Whariki (Ministry of Education, 2004) and the early childhood exemplars of children’s learning Kei Tua o Te Pae Assessment for Learning: Early Childhood Exemplars (Ministry of Education, 2004). Even and Wallach (2004) observe that teachers need to be tuned in to their students and believe that there is something to be learned from listening to their students in order to form an accurate assessment of their student’s abilities and ways of thinking. Engaging children in thinking conversations can provide useful insights for the purpose of assessing their thinking abilities. Furthermore, cognitive process maps and the visual models derived from them can reveal how children apply content knowledge in addition to the processes and skills that they employed during task performance.
In CTA, verbal data are typically analysed to identify either process skills or knowledge structure (such as conceptual understanding, mental models, and beliefs) using protocol analysis and verbal analysis respectively (Leighton & Gierl, 2007). Protocol analysis is suitable for rule-based performance tasks that involve a clear solution path from start to finish. Protocol analysis makes use of a pre-established “cognitive model” of information processing that represents the solution path to guide the coding of data (p.149). It is used to identify processing skills and to confirm if students are performing tasks according to the rules prescribed in the cognitive model of task performance established in advance by the assessor. On the other hand, verbal analysis is more exploratory in nature and is used for tasks that are “largely knowledge-based and ill-defined in terms of an objectively correct answer” (p.165). It is used to explore and identify students’ knowledge structures. Data are coded inductively according to categories, patterns, and themes.

In contrast to either protocol analysis or verbal analysis, cognitive process maps and the visual models can reveal information on both thinking skills and domain knowledge through the ideas and thoughts expressed by the children during thinking conversations. Figure 5.6, for example, succinctly shows how J applied domain knowledge in relation to pumpkins and made inference to arrive at a conclusion. The cognitive process maps and visual model of R’s processes discussed earlier in this chapter reveals his thinking skills and how he used domain knowledge from his experience and available resources to select components of his lunch boxes, set pricing, and create a variety of lunch boxes for his healthy lunch menu project.

Cognitive process maps and visual models can consequently be used to identify gaps in children’s thinking skills (“procedural knowledge”) and domain knowledge (“declarative knowledge”). The spatial display offered by the cognitive process map of the thinking conversation with E and K (Figure 5.1) makes it relatively easy to locate and evaluate a
specific area of thinking skill or domain knowledge involved in the search process. The cognitive process map draws one’s attention to 1) what criteria, if any, E and K used in prioritising and ranking search results; 2) the manner in which they decipher and interpret information they read on screen; and 3) how they came to a conclusion, and the relevance and quality of the conclusion they drew. The cognitive process map in Figure 5.3 draws one’s attention to the relevance and quality of R’s argument that pre-packaged food is not necessarily unhealthy. The cognitive process map of the thinking conversation with B highlights the issue of his ability to apply mathematical concepts to solve a real-life problem (Figure 5.9).

In the thinking conversation on their healthy lunch menu, R and his team mate CP shared with the researcher that they also created a “junk food menu” (Figure 5.10). Highlighted in the cognitive process map are two problematic areas that invite further probing: 1) How do they hope to achieve the goal of showing people what not to eat given that junk food might appear tempting to some? 2) Is it not healthy to have “just chicken, lettuce and tomato”? The competence of children’s thinking abilities and flaws in reasoning is discussed in greater detail in Chapters Six and Seven.

Cognitive process mapping can yield information on the curriculum and learning at the broader level. CTA has been used to observe performance of learners in order to reach conclusions on specific learning needs common among learners and identify important aspects that training should focus on (Schraagen, 2009). In a similar vein, multiple observations of classroom interactions and student task performance over a prolonged period can identify learning needs common among learners as the following examples show.
Figure 5.10: Cognitive process map of R and C’s junk food menu
Multiple observations of classroom interactions and student task performance during
the study revealed the prevalence of divergent thinking in the classroom interactions. Figure
5.5 is one example which shows that the children readily exercised divergent thinking.
However, the children were not engaged in convergent thinking to evaluate the ideas
generated in terms of their relevance and quality. The children’s ability to generate multiple
ideas was again manifested in an episode during which the teacher Sarah encouraged the
children to flip through a book that contained a variety of stories, games, and handicraft
activities and talk about what they saw (Appendix P: Discussion on Skim Reading). They
promptly responded with many observations. Another example is a discussion on text where
the children effortlessly generated multiple ideas on what could be considered as text
(Appendix Q: Discussion on What is Text).

Brainstorming, which involves divergent thinking, appeared to be a favoured
tool for solving problems as the following vignette illustrates:

Sarah was working with the children to write down what they had been
learning and working on in the previous weeks on a long sheet of white
paper. The paper was approximately four metres long and one metre in
width. It was laid on the floor with the children seated, standing, or
kneeling all around it. The children helped contribute ideas and Sarah
wrote their inputs on the paper randomly in a loose chronological order
from left to right. At one point, Sarah stopped to talk about what they
needed to do next.

Sarah: Here’s what we’ve got to look at. I need you to think where we are
going to next. We’ve got next Thursday a parents’ evening and we have to
show— your parents come and listen to us do some talking in the hall and
then they come back to the classroom and see what we've been doing with our 50 years project. One of the things that I've volunteered you to do—I said Room 3 could do something about food over time. So between now and next Thursday, which isn't very long, we've got to come up with some displays that shows what we've been thinking about food and we've gonna have to answer these questions: what's worth knowing, what's worth learning about food, and where we are going with our learning and why we are doing it.

S: We could get into pairs and like pick maybe 2 or 3 foods that we think might have changed or just one food and we should learn about it in the pairs or something like that and then we can put our ideas together in a brainstorm and we could do this big sort of like a poster.

Sarah: Ah, so you think the easier way to do it will be to divide into groups - small groups rather than big groups—

S: Sort of do a brainstorm together and get all your ideas and then we get together and do a big brainstorm and do a big poster.

Sarah: Nice idea—because by Thursday, we want to have something - might have to be a whiteboard covered with a whole lot of thinking - because we want to show thinking.

AN: Well, I think of S's idea. We could divide into star buddies.

B: Or we could do pairs and then we could do pairs and then . . . we could get another group to join you so then you get group of four.
Another incident occurred the day after the school had a parents’ evening during which the parents of Sarah’s children had an opportunity to look at some of the work that the children had done for their project on food 50 years ago. Sarah asked the children to think of ways of making their presentation more interesting following a comment by one of the children that some parents did not appear to be interested in the children’s work. I observed N working on her food project as she sat at her desk with an A4-sized paper and a set of colour markers. N believed that brainstorming was the way to solve the problem of finding ways to make her presentation more interesting to parents:

N: Food can't be interesting if you don't have good ideas for it.

**Researcher:** Is that the next thing you going to work on?

N: Yes . . . I am doing a brainstorm about food.

**Researcher:** I thought you already did it. What's new?

N: I don't think that was a brainstorm. That was just about what . . . we have to do to get better at like interesting stuff to surprise parents.

**Researcher:** How do we know what is going to surprise them?

N: Well, we need something that they don't know about cos if they already know about it, then . . . it isn't going to be interesting enough for them and it won't surprise them. But they will always know that kids - that children might not have known about that and they might feel real proud of them cos now they know.

*Conversation went off track.*

N: Well, we're looking for good ideas about food cos if . . . food isn't interesting then people aren't going to be interested and they gonna go

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2 Parents’ evenings are meetings with parents held once every school term, four times per school year. The purpose is to encourage dialogue between the teacher and the parents, as well as to show some of the children’s work to the parents.
snoring and fall asleep *(laughs)* and but they wouldn't but they'll do it on the inside . . . they'll start getting really sleepy *(laughs).*

**N:** Ideas— *(mutters softly to herself as she looks at the paper on the desk in front of her and caps the marker she was using)*.

**N:** *(Speaks out aloud)* And right now I am doing a brainstorming about food. Well, what I mean by brainstorming about food is that . . . what we need to do with food and . . . what we have to get better at with food and we need to do stuff about. I think we need to do more stuff about interesting food and how we get to make the crowd not fall asleep . . .

Sarah also practised and modelled divergent thinking in the classroom. Figure 5.7 serves as one example. In one classroom activity, Sarah instructed the children to work in pairs to evaluate a number of games in a book by trying them out. She generated in rapid succession a number of areas that the children could look at in order to evaluate the games:

> Can you get better at it?  Is there strategy in it?  Is there some kind of thinking involved?  Could we have experts in it? And is it a game that's got enough challenge in it to for people to want to keep playing it.

On another occasion, Sarah engaged the children in a discussion on reading that focused on whether it made sense to "read like a reader" and "read like a writer".

**Sarah:** I wonder if this makes any sense to you?

**JA:** Yes.

**RO:** Reading like a writer doesn't make sense.
B: I think it does.

Sarah: Reading like a writer doesn't make sense. Reading like a reader - different people will think different things, which is the nice thing about this.

Sarah invited the children to work in groups to think about a number of questions.

Sarah: You are going to ask does this make any sense? Could you
understand there's a difference between this and this? Or does it make no
sense whatsoever? And what might it mean if you were reading like a
writer, what would you be looking for? And if you were reading like a
reader, what would you be looking for?

The corresponding cognitive process map makes evident the divergent thinking modelled by
the teacher (Figure 5.11). The coding of data also lent some support to this observation: the
incidences of codes related to aspects of divergent thinking constituted almost 60 percent of
total code references.

Such broad level feedback can play an important role in supporting reflective teaching.
In reviewing my findings, Sarah came to recognise that she was doing a lot more creative
thinking activities with the children than activities that involved critical thinking. This
realisation prompted her to reflect on her own practice and come to the conclusion that she
needed to plan for learning activities that would involve more critical thinking:

. . . it's useful to compare kids (looking at the visual models that the
researcher had constructed of R’s and S's thinking in relation to their
work on their healthy lunch menu projects and points to one and then the
other, and back again) because then you get a picture of where teaching
things come from or the things you're doing well. That's where I keep
looking at the creative thinking and not so much on the logical or critical
thinking . . . what I wondered was . . . if I had a different group of kids,
would the emphasis be different— with less creative thinking and more,
say, logical thinking if we have a group of J’s (students like the child J).
If you have got (children such as) BE and AM and other people - I know
it’s the so-called creative stuff that's hooked them in - then I wondered if the creative thinking is an easier option for them whether or not I am doing it, the kids are doing it because it's pleasurable activity. You know, it does appeal to them because it's fun, it's not such hard work. And then I thought we've got to have a theme for Term 4 which I think has to be prove it kind of thing where we've got to test assumptions and where we've got to look at more of the deductive reasoning.

And so this is another thing that's been interesting this year - looking at kids and their critical thinking and the gaps or the imbalance of the critical thinking and the need to teach more critical thinking.

You can see when I think back at the kind of theory that I engaged with - the way it suits the way I see the world . . . you can see the creative things coming through - you can see the risk-taking or the opportunity for risk-taking coming through—the lack of specific teaching that has come through as well—maybe the teaching can fit at the right kind of time and where you fit it in. And then when I look at the kids and— these kids have got these strengths and talents and interests - then let's sort of do that and help the others catch up. But what we haven't done - and particularly it's come through your research is looking at critical thinking . . .

Sarah made a similar comment about her emphasis on divergent thinking when she reflected on Figures 5.6 and 5.7:
I looked at that and I wonder if I've introduced too much or encouraged too much uncertainty . . . and then I said do such wonderings - because there is a lot of wonderings - and I said do such wonderings confuse or overwhelm certain kids or is it a prompt for further thinking . . . and that's the bit I agonise over a wee bit. I looked at this and I can see where J was going and I see where I was—all the things that I was throwing at them—thinking now is it cruel to throw a whole lot of things or should I pick on something—one thing and develop that idea so that they effectively all get it.

The positive impact of formative assessment on learning is maximised when teachers make an effort to review information gathered carefully and use it systematically to inform their teaching (Black & William, 1998; Fuchs & Fuchs, 1986). The findings in this study suggest that the information gathered on children’s thinking processes could be used to inform teachers in relation to what aspects of thinking might need to be incorporated into learning activities, how the children’s thinking abilities could be enhanced, and what teaching intervention might be needed.

5.3 Potential and Limitations

Educators contend that assessment should be integrated with instruction and learning in order to ensure the effectiveness of teaching intervention and maximise the educational benefits from assessment (Carless, 2007; Cross & Angelo, 1988; Harlen, 2007; Popham, 2008; Tomlinson, 1999, 2005; Wortham, 2008). However, I have argued in Chapter One and Chapter Three that traditional assessment approaches lack sufficient specificity with regard to the thinking processes and skills that children employ in task performance. The task analysis
techniques used in this study, such as thinking conversations, cognitive process mapping, and visual models of children’s thinking processes and skills, can facilitate the integration of assessment with the teaching of thinking skills by identifying the knowledge, thinking processes, and thinking skills used by children to perform tasks and solve problems. They also provide formative information by identifying both competence and gaps in thinking skills so that the teaching of thinking skills in the classroom can be differentiated according to what children are already capable of as well as individual learning needs (Appendix R: Cognitive Process Mapping and Visual Modelling as Assessment Tools).

In summary, the findings show that the task analysis techniques in this study offer many of the advantages of performance assessment for young children cited by Wortham (2008):

- They can be conducted in the context of what the children are experiencing and form an integral part of instruction.
- They can provide meaningful information and take into consideration the emergent and situated nature of children’s learning.
- They are based on the premise that children construct and co-construct their understanding.
- They focus on the child, what the child is capable of, and what areas the child may need scaffolding, and not the child’s expected response to the teacher.
- They can take advantage of a variety of means or contexts whereby the child could demonstrate what he or she is capable of.

However, critics contend that CTA tends to be complex, require a lot of time and effort, and use research methods that may prove to be too complex and cumbersome for practical settings (Schraagen, 2009; Seamster, Redding, & Kaempf, 1997). Furthermore, CTA has been described as more of an art than science, and criticised for producing results in a
format that might not necessarily be useful to the end users (Schraagen, 2009). How applicable and to what degree such criticisms are to the techniques employed in this study remains to be investigated in future studies. It is clear, in the course of this study, that the processing and interpretation of data was time-consuming. The issue of resources constitutes probably the greatest challenge to the use of these techniques in the classroom for assessment purposes. Further studies will be needed to investigate the feasibility of these techniques in educational assessment.

There is clearly a degree of arbitrariness in the way the cognitive process maps are constructed – a characteristic typical of visual organizers. All forms of representation have their limitations – they are subjective, they cannot be comprehensive, and they can be useful for some tasks and in certain contexts but not for other purposes and in other situations (Peterson, 1996). However, in spite of their limitations, representations do serve a purpose as Potts (1996) points out:

Representations direct our attention to aspects of their objects which we should otherwise be inclined to overlook. What is represented is usually complex, so we see it as organised in some way, as having a structure. Precisely because it is complex, though, we can look at it in more than one way, even if one particular way seems more natural to us than others.

(p.86)

5.4 Validity, Reliability, and Bias

Validity, reliability, and bias have been identified as the issues that affect informal assessment methods such as classroom observations, interviews, narrative reports, and portfolios (Wortham, 2008). Validity refers to the extent to which what is being assessed
corresponds to the behaviour or learning outcomes that is intended to be assessed (Harlen, 2007; Puckett & Black, 1994). As noted in Chapter Three, performance assessment is generally considered to have face validity because of the high level of realism, offers the most diagnostically useful information, and assesses skills most directly (Cook et al., 1996; Ennis, 1993). The examples of findings discussed in this chapter demonstrate that the techniques employed in this study were able to provide information on children’s abilities in terms of the type of thinking processes and skills employed by the children, the effectiveness of the thinking processes that they employ, the areas that the children had not mastered, and where teaching intervention might be needed.

Three cautions, however, need to be taken in interpreting and using these results. Firstly, it is often impossible to verify the comprehensiveness of the information obtained through techniques that rely on verbal reporting and the data are not complete in most likelihood (Taylor & Dionne, 2000; Wilson, 1994). Secondly, the information gathered in this study reflects the processes and strategies that the children know and are able to articulate, but not necessarily those they actually applied in performing the tasks or those they fail to mention (Taylor & Dionne, 2000; Wilson, 1994). Nevertheless, the information can provide useful insights into the children’s theories about the workings of their own minds and how they engage in task performance such as problem-solving. Thirdly, there was a certain degree of latitude in interpreting children’s thinking abilities and activities. It could be difficult at times to differentiate whether a child was merely making an incidental comment, or whether the child was exercising reasoning or presenting an argument. In their study of children’s informal argument, Anderson, Chinn, Chang, Waggoner, and Hwajin (1997) observe that:

- The children participants were frequently elliptical in their discussions, although the unstated or vaguely identified information could often be readily inferred by other participants or were previously explicitly stated.
• Naturally occurring arguments were often enthymematic and failed to be deductively valid.

• The researchers had to be “extremely charitable” in interpreting children’s argument in assuming that the children were rational and intend to make sense when the children spoke (p.146).

Validity may be threatened by distortions that could be introduced when we ask people to verbalise their experience and when we attempt to represent the complexity of cognitive processes in some simplified forms (Crandall et al., 2006). The issue of whether verbal reports, where students are asked to report their problem-solving processes, significantly affect their problem-solving (issue of reactivity) is contested and studies so far have resulted in conflicting claims (Leighton & Gierl, 2007; Wilson, 1994). The techniques used in this study face similar limitations as verbal reports in CTA. Verbal reports are limited by the fact that they rely on students’ facility and ability to report thoughts underlying their task performances, and the researcher’s efforts to ensure that accurate data are captured (Leighton & Gierl, 2007). I have noted in Chapter Four the measures that were necessary to ensure that conditions were favourable for collecting accurate data, including: 1) managing the power relationship between adult researcher and child; 2) building trust and relationship on an on-going basis; 3) showing respect and a genuine desire to know; 4) engaging with the children over a prolonged period; 5) being reflective, checking one’s own assumptions on a constant basis; and 6) being flexible, open-minded, and adaptive.

The interpretation of performance on cognitive tasks is a keenly contested aspect of research because of potential subjectivity and multiplicity: “. . . researchers are concerned about the difficulty of being certain about what really goes on in the internal cognition of trainees or system operators. Often the evidence seems indeterminate with respect to several possible internal mechanisms” (Chipman et al., 2000, p.17). The potential subjectivity and
multiplicity of interpretation pose a threat to reliability. One approach to address this threat is to try to achieve some level of agreement between two or more observers and coders (Wilson, 1994; Wortham, 2008). However, Harlen (2007) argues that the degree of reliability depends necessarily on the purpose and use of the assessment method. In particular, while a high degree of reliability is necessary if the assessment results are used by others and when students are being compared or selected, reliability is not an issue if the assessment is used for formative purposes to support student learning since it involves only the students and the teachers (Dochy & McDowell, 1997; Harlen, 2007). Furthermore, the adequacy of evidence gathered for formative purposes can be managed by careful gathering of information and seeking better evidence should the need arise to verify or rectify a judgment (Harlen, 2007).

Bias on the basis of language and cultural differences can be a significant issue in assessment (McAfee, Leong, & Bodrova, 2004). The fact that insights into children’s thinking could only be obtained through some form of interaction or communication potentially limits the scope of using thinking conversations as a research or assessment tool. For cultural or experiential reasons, some children might not be accustomed to being posed questions in relation to what or how they think (McAfee et al., 2004). In this study, little information was gathered on children who did not engage in the learning tasks or thinking conversations, and from those who were not as articulate or expressive. This does not mean that they were necessarily weak or poor thinkers. In certain occasions, some children may not be interested in being assessed or may not feel motivated to cooperate with the observer (McAfee et al., 2004). It is possible that this was a contributing reason as to why data were collected on 19 out of the 28 students enrolled in the class. In Chapter Four, I cited the example of a boy’s decision not to accede to my request to show how he did a particular piece of work because he wanted to move on to another task. The impact of factors such as language and culture on children’s willingness and level of interaction with researchers and therefore the effectiveness
of task analysis merits further study. Further investigation will also be needed on how the observer’s experience, mental model, and preconceived knowledge about thinking processes may impact on interpretation of data.

All techniques of data collection and analysis have their strengths and weaknesses. It would be spurious to claim that a particular technique is immune to threats in relation to validity, reliability, and bias. It is important to understand the limitations and conditions under which such threats can be reasonably managed, and that any conclusions drawn from the research results are at best, in the words of Dewey, warranted assertions (see Chapter Two).

5.5 Summary

Seven to eight year-old children are able to express their reasoning and thinking through language, and these expressions vary according to their thinking competence and experience. Cognitive process mapping of data gathered through thinking conversations with children can reveal their thinking approaches and emergent thinking competence across different contexts. These representations are not fixed and vary according to the approaches adopted by the children, their task performances, and the contexts. Cognitive process mapping and the visual models derived from them make evident children’s thinking abilities so that adults can better understand and support children’s thinking skills. Cognitive process maps adopt a constructivist perspective of task performance, and illustrate the interaction between thinking skills and domain knowledge in the process of task performance. In this chapter, I have discussed the usefulness of cognitive process maps and visual models as tools for research and assessment. I also noted a number of potential issues and limitations in the use of cognitive process mapping as a research or assessment tool in the classroom. In the next chapter, I explore another approach to the analysis of children’s thinking competence and identification of learning needs using cognitive process maps and visual models.
Chapter Six

Comparison of Children’s Performance to Theoretical Models

In this chapter, I examine how cognitive process maps and visual models can be used to compare learner’s performance to theoretical models\(^3\) for certain task performances such as problem-solving and decision-making. Annett (2000) argues that cognitive task analysis (CTA) should be more than just data collection and should be viewed as a problem-solving process “in which the questions asked and the data collected are all aimed at providing answers to the questions posed” (p.33). In comparing learner’s performance to theoretical models, I address the question of how cognitive process maps and visual models can be used as tools to determine children’s competence, identify learning needs, and inform teaching strategies.

According to Schraagen (2009), the goal of instruction “is to transform a novice into an expert” (p.163). The assessment of development of expertise in CTA can be carried out by comparing learner’s performance to that of experts (Carley & Palmquist, 1992; Chipman, Schraagen, & Shalin, 2000; Lajoie, 2003; Naveh-Benjamin, McKeachie, Lin, & Tucker, 1986). For example, Britton and Tidwell (1995) developed a computer-based form of cognitive diagnostic assessment where they constructed and superimposed graphical representations of students’ and experts’ knowledge structure in order to diagnose the state of students’ knowledge as it developed and identify the types of teaching intervention needed to address misconceptions and inconsistencies in students’ knowledge. In order to adopt a similar approach to that of comparing learner’s performance to experts’, there is a need in this study to:

\(^3\) Moseley, Baumfield, et al. (2005) define models as “a construct that behaves in some way like the phenomenon it represents” (p.40).
a) Identify specific tasks for which comparisons of learners’ performance to that of experts are to be made.

b) Establish what constitutes expert performance for each of these tasks.

c) Determine how comparisons of learners’ performance to that of experts can be made in order to identify learning needs and inform teaching.

6.1 Identifying Specific Tasks

An overall picture of the kind of thinking activities that went on in the classroom would need to be established in order to identify the specific tasks to focus on. My findings have shown that a significant amount of thinking took place in the classroom amongst the children. Trying to describe the observed thinking activities that occurred in the classroom was a challenge, not least because thinking and learning are complex, interactive and recursive processes. The complexity of the task is heightened by the variety of classroom activities which were characterised by:

- Flexible groupings ranging from individual work to working in pairs, small groups of two to four individuals, and whole class discussions.
- Combination of teacher-directed instruction and child-initiated learning activities, including free choice time.
- Combination of subject content teaching and learning with integrated learning experiences, such as project work and exploratory play.

I mentioned how hard it was for me to try to describe what went on in the classroom when I paid a visit to the school on 2 June 2010 to follow up on the principal’s interest in developing “models” of good thinking that could be used for teaching purposes. Sarah, the teacher, responded: “It is hard, isn’t it?” This echoed her earlier comments about finding it challenging
to observe and describe the learning and thinking that were going on in the classroom (see Chapter Five).

One way of proceeding is to focus on selected key processes the mastery of which is necessary for competent performance (Crandall, Klein, & Hoffman, 2006; Mumford, Friedrich, Caughron, & Antes, 2009). Efforts have been made in the past to identify a number of key processes commonly involved in real-life task performances. Perkins, Jay, and Tishman (1994) argue that, despite great diversities of contexts, most “thinking occasions” fall into a limited number of basic problem types and suggest that assessing of thinking could be carried out around these basic problem types – defined as “familiar kinds of thinking challenges that occur in many different settings across several domains and involve similar standards across those settings” (p.74). They identify three basic problem-types, namely decision-making, justification, and explanation, while acknowledging there can be many other problem types that could be added. Swartz (2003) contends that problem solving and decision-making are two complex thinking tasks that people commonly face in their lives or professional work, and both types of tasks require creative and critical thinking skills. Problem solving and decision-making have generally been recognised as complex tasks that require a range of thinking skills (Beyer, 1984b; Marzano et al., 1988; Yinger, 1980). Rankin (1987) posits that a common pattern can be identified in key processes such as problem-solving, decision-making, disciplined inquiry, concept formation, principle formation, comprehending, and composing in that they “generally begin with an unresolved problem, disequilibrium, or indeterminate situation and move to a resolution, new equilibrium, or new meaning” (p.7). Rankin and his colleague Hughes developed a framework of thinking skills by identifying steps or stages common to these processes. Inquiry, information gathering and processing, decision-making, problem-solving are some of the commonly identified cognitive
processes in thinking skills literature - see for example the review of 35 thinking skills framework by Moseley, Elliott, Gregson, and Higgins (2005).

Marzano et al. (1988) make a differentiation between thinking processes and thinking skills, in that processes are “rich, multifaceted, and complex, involving the use of several thinking skills” that are simpler cognitive procedures such as classifying, inferring, and comparing (p.32). Although the demarcation between processes and thinking skills is not necessarily so clear in reality, the processes suggested by Marzano et al. can be adapted in this study to explain some of the thinking processes that occurred in the classroom. At least six types of thinking processes can be described using the observational findings: wondering, brainstorming, decision-making, problem-solving, investigation, and composition. The two processes of wondering and brainstorming involve divergent thinking and were most evident in the classroom – an observation that the teacher concurred with (see Chapter Five). The discussion of this chapter focuses on the four thinking processes of decision-making, problem-solving, investigation, and composition. There is more inherent structure in these four thinking processes than the processes of wondering and brainstorming, in part because they are likely to involve specific and definable goals to be attained. Appendix S (Overall Picture of Thinking and Learning Activities in the Classroom) provides an overall diagram of the learning and thinking activities that were observed in the classroom. The diagram was validated with the teacher, Sarah, during one of our reflective dialogues. She commented: “And this sums up the environment pretty well, doesn't it?” The classroom activities observed include free play and exploration, small and large group discussions, philosophical discourses, project or inquiry-based learning experiences, direct classroom instruction, reading and comprehension, and exploration of key concepts in various disciplines such as science and

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4 Marzano, et al. (1988) use the term *composition* to describe the process of conceiving and developing a product.
history. The thinking skills observed in the classroom are reflected in the coding scheme used in this study (Appendix K: Final Coding Scheme).

### 6.2 Defining Expert Performance

Expert performance could be determined by carrying out CTA of an “expert” thinker engaged in the same tasks as the children in the study. Unfortunately, no work of this nature has been carried out and the feasibility of such an approach has never been explored. Furthermore, models of expert performance are subjective – experts do not always agree on their approaches, processes, or knowledge structures – and evaluation of learners’ performances depends on the expert model or criteria chosen (Britton & Tidwell, 1995). A way forward is to take the cue from Mumford et al.’s (2009) suggested approach of assessing leadership competence through the comparison of mental models of leaders to either expert mental models or theoretical models. An alternative approach is, therefore, to compare the performance of the children to theoretical models.

Marzano and Kendall (2007) make a distinction between models or theories, and frameworks: models and theories are systems that allow one to predict phenomena, while frameworks are organised sets of principles that describe the characteristics of a given phenomena without necessarily the power of prediction. Moseley, Baumfield, et al. (2005) define a framework as “a general term for a structure that provides support . . . for thinking about thinking” (p.34). According to Moseley, Baumfield, et al., a framework can be 1) a list – essentially a miscellany of unrelated items; 2) a group – a collection of items that are similar or related in some way; 3) a model – “a construct that behaves in some way like the phenomenon it represents” (p.40); and 4) a taxonomy – a group of items sorted, ranked or ordered according to one or more dimensions. In view of Moseley, Baumfield, et al., frameworks cannot describe completely the processes of learning and thinking in individuals.
or groups. They are, instead, economical descriptive devices that can “support thought and action”, the potential of which depends on how exhaustive they are, how relevant they are to the task at hand, and how readily they can be related to the observed world (p.42). They all involve classification and are in some ways simplified accounts of thinking and learning processes, since “the human mind can only operate consciously with a limited amount of information” (p.10). Organising a subject of study according to a framework “reduces its complexity, enables a more parsimonious description of it, and reduces the burden of thought to what can be managed” (p.33). The suitability of a framework, the kinds of thinking and how they are organised, depend on the intended purposes and applications which include assessment of students’ learning and thinking (Moseley, Baumfield, et al., 2005). The definitions of framework and model proposed by Moseley, Baumfield, et al. are adopted for the purpose of this discussion.

### 6.3 Comparison of Children’s Performance to Theoretical Models

I wrestled throughout my study with the idea of whether it was necessary to have thinking frameworks or models that researchers and teachers could use to interpret children’s thinking and /or to support the children in the development of their thinking skills. There are many existing and often overlapping frameworks serving different purposes, none being totally adequate in capturing the complexity and diversity of children’s thinking processes (Moseley, Baumfield, et al., 2005). Approaches to teaching thinking skills are often guided by such frameworks and driven by predetermined methods of how students should be taught to think more effectively, a point made at the beginning of this thesis. While children may learn best at times from adult-guided experience, they seem to learn best at other times from child-initiated experiences where they acquire knowledge and skills through their own exploration and experience (Epstein, 2007; Siraj-Blatchford, Sylvia, Muttock, Gilden, & Bell, 2002).
Child-initiated experiences should include the opportunities for children to adopt and apply their own thinking approaches to complex tasks within a supportive learning environment. In such instances, effective scaffolding should take the form of timely and appropriate teaching interventions that respond to what the children are already capable of and doing in order to extend their thinking and metacognitive capacities beyond their current abilities.

There are both theoretical and empirical arguments for such teaching interventions. Firstly, cognitive load theory states that the interaction between the learning experience and the architecture of the learner’s cognitive system must be compatible and aligned in order for effective learning to take place (Schmidt, Loyens, van Gog, & Paas, 2007). Cognitive load theory posits that learning can be adversely affected by heavy working memory load which occurs when a learner lacks the necessary prior knowledge and schemata to process novel information. Cognitive load theory makes a distinction between intrinsic load and extrinsic load: intrinsic load is dependent on the number of elements a learner has to attend to simultaneously, while extrinsic load is determined by the way in which the learning task is presented to the learner and the learning activities that the learner has to engage in. Extrinsic load can be mediated by instructional methods such as direct instruction, teacher guidance, and scaffolding. According to Kirschner, Sweller, and Clark, 2006, it is important that novice learners be provided with close guidance in order to help them “acquire the necessary schemata that allow them to meaningfully and efficiently interpret information and identify the problem structure” (p.83). It is generally agreed that one of the ways in which scaffolding can support learning is to provide structure to help the learner to concentrate on aspects of the task that are the focus of learning (Hmelo-Silver, Duncan, & Chinn, 2007; Kuhn, 2007; Schmidt et al., 2007). More specifically, scaffolding can support learning by making thinking and strategies explicit by providing structures for students to follow or through the modelling of expert performance for learners to emulate (Hmelo-Silver et al., 2007).
Secondly, while my findings show that children used a variety of thinking approaches of their own choosing in handling different tasks, their approaches were not necessarily effective or efficient. The findings demonstrate that the children’s approaches were sometimes flawed and unproductive. Furthermore, the children had to contend simultaneously with new information and thinking processes required either to search for information, or to use them together with current knowledge to achieve a goal such as solving a problem (see for examples E and K’s internet search and R’s healthy lunch menu project described in Chapter Five, or N’s work on her food project and S’s internet search described in the later part of this chapter). Kirschner et al. (2006) contend that such situations produce working memory overload which is detrimental to effective learning. It follows therefore, that theoretical models of more effective thinking processes could serve to scaffold and extend children’s own approaches and frameworks in these situations. Some of the thinking processes observed in the study, such as decision-making, problem-solving, investigation and composition, could be rendered more effective and efficient with more structure. In formative assessment, interpretation of evidence has to be made against some form of lesson goals in order to obtain information about the student’s progress and determine what next instructional steps are necessary and appropriate (Harlen, 2007). Theoretical models could serve to guide observation and assessment of children’s thinking processes, and highlight specific thinking skills that individuals may need help with when they engage in these processes.

The teacher, Sarah, felt that the comparison of cognitive process maps and visual models that I constructed of the children’s thinking to theoretical models could potentially be useful when I reviewed the results with her during a couple of reflective dialogue sessions:
It would just build a bigger picture . . . yes . . . this makes me think about the bits that I am not doing and then why we are doing the bits we are doing—and what are we doing for kids.

They are useful as a reference point to help identify next teaching steps to address learning needs. Not only what is happening now, but also where to next. For example, I became much more aware of the divergent thinking that was happening, and the absence of sufficient convergent thinking to reach satisfactory conclusions. They were also helpful to impose a framework on what is happening, and thus clarify the features of certain behaviours.

Sarah again remarked about the potential usefulness of the approach on another occasion:

**Researcher**: What I have done is to build from ground up models of different kinds of task performances.

**Sarah**: Yes.

**Researcher**: But it may not apply to all situations

**Sarah**: No—The whole idea of model is quite intriguing, isn't it?

**Researcher**: The danger is that people might just use it as another tool for teaching thinking skills and dogmatically try to force fit into all kinds of contexts.

**Sarah**: Yes. But the interesting thing from a teacher's point of view to be able to say, for a particular kid, I see this and I haven't seen this before - what do I have to do to look closer or put something in place so
that there's evidence of that or what teaching intervention do I need to put in place.

**Researcher:** If you look at this - you generate ideas about how to solve the problem and then you do an evaluation to decide which strategy to use.

**Sarah:** Yes, which is fairly simple input-output kind of thing isn't it - instead of getting sidetracked on the way or things that happen that stops you from getting here. It's been really interesting to look at different kids and wonder . . . like JA, why he is so inconsistent. There are so many inconsistencies. What can I do to ensure there is less inconsistencies, what do I need to put in place, because the inconsistencies are the most intriguing, aren't they when you look at learning needs?

**Researcher:** I was working towards the whole idea of using cognitive process mapping to make visible children's thinking and processes, observe different children on the same task, do it for different kinds of teaching approaches . . . to identify gaps in children's learning . . . what I have done is to try and see if I can extend children's thinking into learning of concepts. So if we take S’s boat for example, she said she's got a point in front to ride through water. I asked what do you mean and she explained that it would break up water. One potential way to extend her learning would be to ask: How does it work? Can you explore how it works? Can you experiment with that? Can you do an information search for evidence? And eventually come to an understanding of hydrodynamics and that is actually a concept by itself . . . or it could
also be gaps in thinking skills such as the ability to diverge and converge.

. . . or flaws in reasoning such as the assumption that because I typed “lunchboxes 50 years ago”, therefore it must be 50 years ago. So you can actually use that to identify various types of gaps in children's thinking and learning.

**Sarah:** Yes. Which is useful. Parents would be interested in this too.

The reliability of an assessment approach that involves comparison of children’s performance to theoretical models may need to be examined, especially if the aim is to develop them into psychometric measures that involve some form of scoring. However, as argued in Chapter Three, questions of validity and reliability are less contentious if the assessment is made for formative purposes in order to inform teaching in the classroom. The following sections provide examples to illustrate how comparison of children’s performance to theoretical models can be undertaken for the processes of decision-making, problem-solving, investigation, and composition.

### 6.3.1 Decision-making.

Wales, Nardi, and Stager (1986) suggest a four-stage model of decision-making: 1) state goal; 2) generate ideas; 3) prepare a plan; and 4) take action. Ehrenberg, Ehrenberg, and Durfee (1979), on the other hand, propose a three-step decision-making model comprising: 1) clarify requirements and anticipate the ideal characteristics that would meet all of the requirements; 2) identify, clarify, and verify characteristics of each alternative against the ideal, and select the closest alternative; and 3) verify choice against the requirements. Beyer’s (1984) model of decision-making involves 1) stating the desired goal; 2) identifying the obstacles to realising the goal; 3) identifying alternatives available for overcoming the
obstacles; 4) examining the alternatives in terms of resources needed, and the costs and the constraints involved; 5) ranking the alternatives; and 6) choosing the best alternatives. The models of Ehernberg et al. and Beyer suggest the necessity of some sort of selection criteria to guide the making of choice among multiple options and these criteria should be dependent on the goal and requirements of the situation at hand. Wales et al. (1986) went further by including taking action as the final stage. The rationale, presumably, is that we would not know if the selected option is a sound one until we implement the decision. But we also need to evaluate the results of implementation against the original goal and requirements. Adaptation and modification of these models resulted in the following theoretical model for decision-making which I used to compare and contrast the children’s thinking approaches to decision-making:

![Theoretical model of decision-making](image)

Figure 6.1: Theoretical model of decision-making

The case of N’s constant divergent thinking when she worked on her food project could be viewed as a lack of an effective decision-making process. As previously mentioned in Chapter Five, Sarah asked the children to think of ways of making their project presentations on food 50 years ago more interesting to their parents and N believed brainstorming was the way to solve the problem. The following vignette describes the second
part of the thinking conversation I had with her while I observed her working on her food project. She was sitting at her desk with an A4-sized paper and a set of colour markers:

N: And right now I am doing a brainstorming about food and if—well, what I mean by brainstorming about food is that . . . what we need to do with food and what we have to get better at with food—and we need to do stuff about—I think we need to do more stuff about interesting food and how we get to make the crowd not fall asleep—I don't know if I can think of anything else.

Researcher: What about starting with what you know?

N: What I know is that parents do feel very, very proud of their kids if they wouldn't know something. And sometimes if they don't know something they feel very proud because they've learned something off their kids. And they feel really proud of their kids because their kid's teaching them.

Researcher: So, based on what you said, maybe we should think of something that your parents don't know and do we have any idea what they might not know?

N: Well, my parents - well my mum and dad do know some different things. Like my mum might know—when food packages came around and dad might not, or dad might know—when plastic food packaging came around and mum might not— and then they might both know. So you don't really know because it's your mum and your dad - you don’t really know what they think and what they do—We have this big project thing going on last night you don't know if people liked it or
what they were thinking or what they were reading - they might have been reading, they might have been looking at the pictures. You don't really know what they are thinking about—

**Researcher**: That's true. Can we guess what your parents might not know? Like for example, maybe there are some countries they haven't been to?

**N**: Yeh, well, I don't think they know that—that they might not know that—I don't know if they don't know, they might actually not know. But I don't actually think they know that in other countries that they haven't been to— (that) they cook different food—she might say she was going to the country and she might want to cook— for other people in that country but they might not like it cos they might think it's different and she might not know that they cook it differently. And might be the same with my dad but my dad doesn't really do cooking a lot—I sort of learned off my brother how to cook and I'm actually quite good at cooking.

**Researcher**: You are? Maybe you can find some recipes that your parents don't know?

**N**: I am on an elective that bakes pancakes from all over the world— I've been trying—well, I've been getting better at cooking those types of pancakes. And in the elective that I am in with cooking all over the world we have a big kid that's in it that knows all about it - so he will tell us about what to do and then we get all the ideas. So then we have a big recipe book that we put out - so that when we are done, we can put all the recipes in and then we can maybe drawing around it.
During my observation and reading of the subsequent transcripts, I had a hard time trying to understand why I had the impression that she was not going anywhere with the task that she had set for herself. It then became clear to me from the cognitive process map (Figure 6.2) that she constantly engaged in divergent thinking. Her divergent thinking generated many ideas but hindered her in moving forward in the search for a way to make her food project more interesting to parents. One cannot be constantly engaging in divergent thinking because there is a need at some point in time to evaluate the options against the task at hand to come to a decision. Furthermore, the relevance of some of her ideas and comments to the task at hand is either unclear or questionable, for example “. . . my dad but my dad doesn't really do cooking a lot”, “I sort of learned off my brother how to cook and I'm actually quite good at cooking”, and “we have a big kid that's in it that knows all about it - so he will tell us about what to do”.

Using the theoretical model of decision-making in Figure 6.1 as a benchmark for comparison, it can be seen that N had potentially two key components of the decision-making process. She generated several alternatives that she could explore and evaluate for suitability, such as:

- Cook something since she thought that she was quite good at cooking.
- Make a big recipe book.
- Do something on pancakes from other parts of the world.
- Do something on cooking from countries that her parents might not have been to.

There were also two considerations that she could potentially use as criteria to evaluate her options and help her make a decision:

- “. . . they (parents) feel very proud because they've learned something off their kids and they feel really proud of their kids because their kid's teaching them”
Figure 6.2: Cognitive process map of N’s work on her food project
“I don’t actually think they know that in other countries that they haven't been to . . . they cook different food . . .”

N evidently had some very good ideas but a more structured approach such as the one in Figure 6.1 may be helpful in organising her thoughts and ideas in order accomplish the goal of making her project more interesting for parents.

The impact of a lack of sound evaluation criteria in decision-making is evident in an episode involving a thinking conversation I had with CP and E in relation to their project on food 50 years later (Figure 6.3). CP wondered what sort of food would not exist 50 years later. Together, CP and E were able to generate two possibilities, namely bananas and tomatoes. I suggested apples and oranges as possibilities. The process they engaged in had several components described in the theoretical model of decision-making in Figure 6.1, namely the generation of alternatives, some attempt at evaluation of the alternatives, and the selection of choice (bananas). However, CP and E did not appear to have a clear set of criteria against which to evaluate the possibilities to help them determine which of these possibilities could best answer their question. While E’s logical deduction was sound, her reasoning that bananas could only grow in some places and not in others did not appear to have any relevance and therefore failed to provide sound justification for her view that bananas would not be around 50 years later. At the process level, the children could have incorporated the additional steps of developing a set of evaluation criteria and evaluating the outcome of their decision against it. In terms of thinking skills, they could benefit from teaching support in terms of their ability to critically appraise the various alternatives in order to make a choice based on sound reasoning. The lack of a structured process such as the one in Figure 6.1 led to a discussion that quickly went off track and off-task:

In this thesis, an episode refers to a segment of a thinking conversation or interview that serves to illustrate a focal point of interest and discussion.
**Researcher:** But wait a minute, they say that the world is getting warmer, and banana trees grow well in warm weather. So they should be around.

**E:** Oh yeah. But not in cold.

**CP:** Well, we need proof.

**Researcher:** That's right.

**CP:** Just say that banana trees won't be around, because . . . I don’t think so.

**Researcher:** We can try to reason logically. What I am saying is we know for sure that the world is getting warmer and what kind of trees grow well in warm weather?

**CP:** Feijoas, figs, oranges, apples, lot's of other trees.

**E:** Yeah, mostly, most of the trees grow in the warm.

**Researcher:** Apple trees may not be around because they grow well in the cold. Don't they?

**CP:** I don't know. I haven't done much study on trees or vegetables.

**E:** Cabbage, carrots . . .

*TH, who came and sat down at the table to observe, joins in the conversation.*

**TH:** In Fiji, normally trees and things grow in warm weather, like coconuts—pineapples.

**E:** Coconuts are really dear at the moment because—the coconuts are going to come over from Fiji to Dunedin. And they're four dollars for one.
Figure 6.3: Cognitive process map of CP and E’s work on food 50 years later
**CP:** I think it's going to be one dollar fifty—I hope it will be in the future.

**TH:** I think—you know things were like less expensive in the past. I think things are going to be more expensive in the future because people are going to be more rich, there' going to be more money.

The topic of food in 50 years’ time is a difficult one. It is hard for adults, let alone young children, to work out what food might be like in 50 years’ time on a logical basis. It is not surprising that children might resort to speculation or imagination. The children could have used a criterion such as the effect of global warming on plant habitats to come up with reasoned predictions. Even so, the children would need to have the necessary knowledge to be able to carry out an evaluation of the various possibilities using such a criterion. The conversation suggests that knowledge can play an equally important role as thinking skills in the effectiveness of children’s reasoning (see Chapter Seven). For example, CP made the point that she was unable to comment on whether apple trees grow well in the cold because she had not “done much study on trees or vegetables” and TH appeared to be familiar with “trees and things grow in warm weather” in a place such as Fiji. The episode also demonstrates that the demarcation of the types of processes is not always clear and any task performance could easily involve two or more of the processes of decision-making, problem-solving, investigation, and composition. For example, the decision-making process where the children need to decide which possibility is most likely can equally become either 1) a problem-solving process where the children need to solve the problem of how to find a way to determine what food might not be around in 50 years’ time; or 2) an investigative process where the children need to seek out the information necessary to answer the question: “What food might not be around as a result of global warming in 50 years’ time?”
Theoretical models of processes such as decision-making, problem-solving, investigation, and composition cannot be applied strictly. As mentioned in Chapter Three, people’s natural approaches to problem-solving took a wide variety of forms (Douglas, 2002; Isaksen & Treffinger, 2004). The next episode shows that not all decision-making can be characterised by the theoretical model of decision-making in Figure 6.1. As part of the thinking conversation with R on his healthy lunchbox menu (see Chapter Five), I asked him how he came up with the price of nine dollars for one of his lunchboxes:

**Researcher:** And how do you decide it's nine dollars?

**R:** We didn't really. We just picked it.

**Researcher:** So, you just plucked a number out there?

**R:** But if it is too expensive, they won't buy it.

**Researcher:** Is nine dollars expensive?

**R:** Er, no. Don't think so.

**Researcher:** And how do you know it's not expensive?

**R:** Cos, usually in cafes or something, they are five dollars or something or something like that.

The thinking conversation shows that R had the criterion that his lunchbox should not be “too expensive” and he used his knowledge of prices in cafes to guide him in his decision-making, even though it is debatable whether nine dollars compared to five is not overly expensive. R had one option of nine dollars in mind instead of generating multiple alternatives. It is arguable that the quality of his decision on what price to set could be improved by a more sophisticated set of pricing criteria, consideration of multiple options of prices, and evaluation of the outcome of his pricing decision. Because the project did not involve real food and
transactions, alternatives to real-life implementation and evaluation of outcome would have to take other forms such as feedback from peers and adults on his pricing decisions.

Notwithstanding the abovementioned limitations, the approach of comparing the children’s decision-making process to theoretical models can identify and suggest additional steps that could help the children make more thoughtful and considered decisions. Such an approach is contingent on the ability to make the children’s processes visible and a suitable choice of theoretical model for making the comparison. Thinking conversations with the children enable information to be gathered on the children’s decision-making processes. The visual representation afforded by cognitive process maps and visual models facilitates the procedure of comparison considerably.

6.3.2 Problem-solving.

Pretz, Naples, and Sternberg (2003) describe the problem-solving process as a cycle involving the following stages:

- Recognise or identify problem
- Define and represent the problem mentally
- Develop a solution strategy
- Organise one’s knowledge about the problem
- Allocate mental and physical resources for solving the problem
- Monitor one’s progress toward the goal
- Evaluate the solution for accuracy

In the US, the Assessment Policy Committee responsible for the National Assessment of Educational Progress (NAEP) carried out a study back in 1985-86 to develop a framework and a number of performance assessment exercises to assess third, seventh, and eleventh grade (13 to 16 year-old) students’ thinking and problem-solving skills in mathematics and
science (Blumberg, Epstein, MacDonald, & Mullis, 1986). The eleven consultants who were “leaders . . . in the development of higher-order thinking skills” (such as creative and critical thinking) in science and mathematics came to the consensus that, at the most general level, higher order thinking skills are used to “formulate a problem, design and perform an analytical procedure, and reach a conclusion to a problem or situation” (pp.9 – 11). On this basis, they posit that mathematical and scientific investigation and problem-solving may be characterised by the following cycle of dynamic and iterative steps: understanding the problem or situation, developing a plan or investigation, implementing a plan or investigation, reaching a goal, assessing, and formulating new hypotheses, problems and goals. Basadur suggests a model of creative problem solving that involves the three phases of problem finding, problem solving, and solution implementation (Basadur, 1990 as cited in Spivack & Rubin, 2011). Kim and Hannafin’s (2011) model of problem solving consist of five activities: 1) problem identification and engagement – making observations, and generating or finding questions; 2) exploration – examining resources, planning investigations, and exploring evidence; 3) reconstruction – proposing answers, explanations, and predictions; 4) presentation and communication – communicating the results and justifying explanations; 5) reflection and revision – reflecting and revising ideas or theories. Bransford and Stein (1984) propose the IDEAL model of problem solving: 1) identify problem; 2) define the problem; 3) explore strategies; 4) act on ideas; and 5) look for the effects. It is not always clear, however, when a problem is considered as resolved and it is possible that some problems cannot be completely resolved. In such instances, it might be expedient to establish a set of criteria for what could reasonably be considered a successful resolution of the problem. Furthermore, the strategies or solutions that can be explored are likely to be dependent on the skills, information, and resources available. I adapted the IDEAL model and expanded it to include
these considerations to develop the following theoretical model for problem-solving which I used to compare and contrast the children’s problem-solving approaches:

![Theoretical model for problem-solving](image)

Figure 6.4: Theoretical model for problem-solving

The following vignette illustrates an episode of problem-solving involving S and her work on a food poster. She had compiled a set of Powerpoint slides on her food project into a booklet which formed part of her presentation to parents during a parents’ evening at the school. Given that not all the children were present to explain their work to their parents, Sarah felt that some of the parents did not get the opportunity to have a good understanding of their children’s work and asked the children to find ways to make their work stand out more.

**Researcher:** What was the question again? Can you tell me?

**S:** The question was what do you want people to find out and I think
that we should want people to find out what was in the lunch boxes and what they were made of—

Researcher: I thought you already did that, didn't you?

S: Yeah—Mrs Grant [the teacher, Sarah] said that it doesn't really tell them, it just sort of shows them

Researcher: What do you mean by that?

S: It shows them and tells them because you're telling them but—if the information sort of stands out because this one's in the middle of a book and—if it were sitting on a desk it would stand out.

Researcher: And how do we make it stand out?

S: Well, you would probably get a bit of paper and write the question and the answers on and you would go over it in a really bold colour - so it would stand out and then you would stick it somewhere where people would look.

Researcher: Instead of having it in a book - like in a poster?

S: Yeah—We're just sort of fiddling around with the background and see if there is any (existing pictures of) food we can use—Mrs Grant said that we could choose if we wanted to do a poster or not with the Powerpoint because we've done the Powerpoint and I think we should just get a big bit of paper and write the ideas on and then bold them.

The thinking conversation shows that S was able to identify the problem by explaining the challenge posed by her teacher. Her ability to define and evaluate the problem could be seen in her explanation as to why her booklet of Powerpoint slides was not providing information to the audience beyond showing pictures. She had an idea of what the presentation of her
work should be able to do (criterion of success): the information must “stand out”. She came up with a single solution involved using very bold colours to make a poster, which was eventually what she did. She made use of existing pictures of food and available resources such as paper and colour markers. Using the theoretical model for problem-solving in Figure 6.4 as comparison, a couple of areas could be identified for teaching intervention. S could have explored and evaluated a variety of possible solutions in order to maximise her chances of success. She could have reviewed the outcome against the criterion of success that she defined at the outset in order to improve the effectiveness and quality of her solution. She could also have been more specific about her criterion and included feedback from adults in her review process.

The issue of the lack of a structured approach is evident in an episode involving D and his project on packaging and wrapping. D was trying to solve the problem posed by Sarah of how to make his work more interesting to parents. Figure 6.5 shows the cognitive process map of the thinking conversation I had with D as he worked on his project. D was able to describe what his project was about and define the problem as one of finding a way to make his project presentation more interesting to parents. He reviewed the three pieces of work that he had already done:

- A display of wrappings and packaging made up of some plastic food storage boxes, a plastic grocery bag, and a roll of cling-on wrapping on his table.
- Pieces of paper in front of him which he later explained were records of his brainstorming.
- A self-made booklet on Coca Cola drink cans with drawings in it.

However, D did not complete the process of defining and evaluating the problem. For example, he did not elaborate what were the possible causes of the problem and what needed to be addressed. When I asked him what he was going to do next, he talked about doing three
more “wonderings” to fill up a space he had on one of the sheets of paper that showed his brainstorming and felt that an important question to ask was “how has wrapping changed?”

While D generated ideas quite readily, it is unclear whether he had a well-defined mental picture of what aspects of the problem he was attempting to address and how his ideas were intended to solve the problem. He did not seem to have any criteria for success that would help him determine whether his ideas would actually address the problem and evaluate the outcome after implementation. He cited the internet and books as resources that he would probably need but it is unclear whether he knew what specific websites or books would be needed or how he intended to find them. Sarah did not appear surprised when I shared my observations about D with her during a reflective dialogue session:

**Researcher**: And if you look at this one (cognitive process map of his project on wrapping and packaging) it's the same - there is a lot of divergent thinking. He actually created a story on coke cans. When I asked him what has that to do with the project, he couldn't quite answer me. He forgot his project was on packaging and wrapping. Maybe he got carried away? It seems that he is good at creative or divergent thinking, but weak at convergent thinking and adopting an organised approach.

**Sarah**: Which you would expect him to.

**Researcher**: I suspect that - and I don't know if it is a fair comment - it's because this is kind of task is a problem solving kind of task and D is not very good at that. He's good at imaginative, story writing kind of stuff where there is no boundaries, no constraints to overcome and he just flows with it.
Figure 6.5: Cognitive process map of D’s project on packaging and wrapping
Sarah: Yes, yes. And you see we're talking today about the creative thinking and critical thinking. The creative thinking was fine but the next stage and that was the logical thinking and reasoning in that you have to know things and to make it work.

Problem-solving is a central part of all of our lives and an integral part of the learning process as it provides much of the purpose for other cognitive processes (Hope, 2002; Siegler & Alibali, 2004). Effective and efficient problem solving requires good thinking skills. The awareness of and the ability to adopt a more organised approach could also enhance the efficiency and effectiveness of problem solving. According to (Norris, 1985), better thinkers tend to spend some time initially to identify the correct problem to solve and to make decision on the overall strategy to use before embarking on the actual process of solving the problem. Poorer thinkers, on the other hand, usually get to work immediately, fail to identify the correct problem, and often get embroiled in irrelevant details or go off-task. While there are other theoretical models of problem solving other than those presented here (Beyer, 1987; Polya, 1957; Sternberg, 2001; Stonewater, 1980), the discussion serves as an illustrative example of how the comparison of children’s performance to a theoretical model can facilitate the identification of areas that can improve children’s thinking and problem solving skills.

6.3.3 Investigation.

Investigation is a key component of many learning approaches such as inquiry-based learning, problem-based learning, project approach, and research in the form of scientific inquiry. The practice of inquiry-based learning, for example, typically involves identifying a question, investigating information sources for answers, analysing and interpreting evidence, and drawing conclusions (Kuhn, 2007). This model is perhaps the closest to the investigative
processes that I witnessed in the classroom when the children searched for answers to questions they had in the course of their project work. Adapting elements of this practice of inquiry to what I observed in the classroom, I developed a theoretical model for investigation which enabled me to analyse the processes adopted by the children in their investigative efforts (Figure 6.6).

![Theoretical model of investigation](image)

**Figure 6.6: Theoretical model of investigation**

The first case involves S and her Google search for lunchboxes 50 years ago. S showed me a booklet that she and her friend created using Powerpoint slides that displayed what they had discovered and learned during their project on lunchboxes 50 years ago. S explained that they found some of the information on the Internet and I asked her to show me how she conducted her Internet search. She went over to the computer and typed "lunch boxes fifty years ago" on Google search. The search generated results that appeared to be irrelevant. I was not sure whether she realised this or whether she was unable to make sense of the list of search results. After a brief moment of silence looking at the search results, she clicked on
Google images and pictures of a few lunchboxes among other things appeared on the screen. These included pictures of lunchboxes which were clearly not from fifty years ago, such as lunch boxes decorated with images of Pokemon and lunchboxes from paleofuture.com (a collection of past predictions made by people of the present time and the recent past which is relevant for those who are interested in what predictions came true and what did not).

**Researcher:** How do we know if these are lunchboxes from fifty years ago?

S: Um because we googled 50 years ago, so it will come up 50 years ago. This one—this one—this one *(points to three of the pictures of lunchboxes one at a time, including the one with images of Pokemon on it).*

**Researcher:** And they don't look like the current lunchboxes? What's the difference?

S: Well, the current lunchboxes are more like—they've got a whole lot of compartments and things like that.

**Researcher:** And these ones don't have that?

S: Ah no. Just one big one like this one because this one is 50 years ago *(points to the old lunch box that was brought to class by the teacher as an example of lunch box from 50 years ago).*

**Researcher:** But we don't know. It's the outside. Can we look at the inside *(points to a picture of a lunch box on the computer screen)*?

S: Usually comes up with information there, sometimes *(clicks on the picture).*

**Researcher:** Looks like this one doesn't have it. How do we tell if it's
it's got one compartment or lots of compartments?

S: Well, you can tell because the ones with compartments have slots on them.

Researcher: But we can't see inside, can we?

S: No—(silence for few seconds then points to one of the pictures on the screen)—but that one is fifty years old because that's one of the ones that we picked up on the internet—

I compared and contrasted S’s internet search for lunch boxes 50 years ago with the theoretical model in Figure 6.6. The analysis shows that S was able to state the question, use at least two sources of information (the internet and the old lunch box sample provided by the teacher), and analyse the evidence she generated by examining one key characteristic of old lunchboxes that differed from current ones to arrive at her conclusion. Her investigative strategy involved first typing the search words “lunchboxes 50 years ago”, followed by the use of Google images and selection of those images that showed pictures of lunchboxes. Her strategy was simplistic and she assumed that the search results showing images of lunchboxes were all relevant.

Although she was challenged by the researcher on the Pokemon lunchboxes that featured in her Google search results, she steadfastly insisted that they were lunchboxes from fifty years ago because she typed “lunchboxes 50 years ago” into the search box on the computer screen. While she exhibited deductive thinking skills, her conclusion was faulty because of several reasons: 1) her lack of knowledge of how the Google search engine works and allowed technology to do the thinking for her; 2) her flawed assumption that typing “lunchboxes 50 years ago” in the search box was sufficient in ruling out negative cases; and 3) her assumption might have led to the failure to realise that the pictures of the Pokemon
lunchboxes did not show the compartments inside and therefore her comparison of her evidence to a second source of information (characteristics of old versus new lunchboxes) was invalid. This case study shows that, while the process adopted by S was similar to the theoretical model, her application of deductive thinking skills was flawed. These findings suggest that the effective teaching of thinking skills must take into account both the overall process which provides structure, and the application of specific thinking skills in each step of the process.

Figure 6.7 shows a comparison of the process adopted by E and K in their internet search (see cognitive process map in Figure 5.1) on the most popular celebration food 50 years ago can also be made to the theoretical model of investigation. The comparison shows that E and K’s process had components of the theoretical model. They defined the question: “What was the most popular celebration food 50 years ago?” They used the Internet as their source of information with Google as the search engine. Their investigative strategies were relatively unsophisticated: “you can choose anything” (random choice), “pick one of the main ones” (search results), “just look up and read everything”, and choosing one to explore (browsing). It is unclear what were considered the “main ones” in terms of search results. They generated some information on ice-cream sandwich making machines and came to the conclusion that there were such machines 50 years ago and that “It’s actually quite good because you can have ice-cream with sandwiches now.”

However, E and K did not evaluate their findings and conclusion against the original search question to determine their relevance. Their conclusion was logically weak and irrelevant to their original question. At the process level, they could have benefited from additional sources of information in order to triangulate their findings and conducted an additional step involving a more thorough analysis and interpretation of evidence generated by their search. In terms of thinking skills, they seemed to need some support in developing
their ability to employ more sophisticated investigative strategies, generate wider range of evidence, carry out analysis of their evidence, and make logical deduction to arrive at a sound conclusion.

In the subsequent part of our thinking conversation, I asked E and K if there was another way of conducting their search for celebration food 50 years ago:

**Researcher:** Is there a smarter way of doing it?

*There was silence for a moment as the children appeared to be deep in thought.*

**E:** You could look up all of them but it would take quite long.

**K:** We can try Wikipedia.

**E:** Yeah, Wikipedia would be good. So instead of searching Google, maybe you should search Wikipedia.
The girls went into the Wikipedia website and typed "ice-cream sandwich". The search generated a definition of ice-cream sandwich, a picture, and a brief write-up on ice-cream sandwiches for each of the following countries: Australia, Scotland, Singapore, Ireland, England and Wales, and the United States.

K: It looks just like a biscuit.

The girls read the section on Singapore.

E: Wafer ice cream is a type of ice cream popular in Singapore. It consists of two original wafers holding together a block of ice cream (reading). Oh, I know the block of ice-cream (both girls appeared very excited as their eyes lit up). The block of ice cream usually comes in a pack which is a little box and then you open it up and you cut it off and you probably put like two wafers together and—

K: Yeah, we still have them—because in the supermarket they have these but they are a bit different—they are like these wafers and there are those penguins.

E: Yeah, the penguins, the penguins - they are like stuck together and you just eat them. So they are kind of like ice cream in them.

The girls then read the section on Australia.

E: My dad used to go there. My dad is from Australia. Maybe I can ask him about the giant sandwich—Because wafers would probably be like those top bits are probably bits of wafer (points to picture of brown chocolate wafers on the computer screen). So they are big blocks of wafer that you just stick on and is probably covered with chocolate.

K: I am going to do a New Zealand (types on keyboard “ice cream
sandwiches New Zealand”

The search did not turn up any results.

Researcher: Maybe there are no ice-cream sandwiches in New Zealand?

The girls decided to search for ice-cream sandwiches on Google again and ended up with search results on desserts. They clicked on Google images and found pictures of desserts.

E: That one (points to one of the pictures).

K: That's an ice cream sandwich.

E: Click on that.

K: That's not an ice cream sandwich.

Researcher: Why is it not an ice cream sandwich?

K: Because it is not in the shape of a sandwich.

Researcher: How does a sandwich look like?

K: Well, it's (a sandwich) not in a container—not in any one of those containers (points to the picture).

E: It's not in a cup because if you put my sandwich in a cup, I would have to drink it up. It will take me all day—it will take me all day to drink it down (imitates drinking action and laughs).

Apart from losing track of the original question, the process undertaken by the children appeared to be relatively complete when compared to the theoretical model in Figure 6.6. The children were able to think of another alternative source of information. E briefly considered her father as another potential source of information. They built on their previous search result of ice-cream sandwiches but in doing so, they risked compounding their first mistake and
went further off track from their original question. They were able to use their current knowledge and theory in relation to sandwiches, biscuits, wafers, and ice-cream to evaluate their search results. They came to a conclusion regarding the last search result that showed a picture of an ice-cream in a cup. They could have a better chance of staying on task by revisiting their original question before embarking on the second search effort and relating the question to their findings and conclusion. Figure 6.8 shows the comparison of the children’s search process to the theoretical model of investigation (Figure 6.6).

Reiser (2002) contends that carrying out an investigation is a complex cognitive task that challenges the learner in terms of both content knowledge and processes:
This requires coordinating domain-specific processes and content knowledge, and metacognitive processes to plan, monitor, evaluate and revise these investigation plans. Thus, learners face challenges at several levels. The knowledge students are mastering includes conceptual knowledge, basic domain process skills, domain-specific strategies, and more general metacognitive processes. (p.256)

Reiser (2002) notes that learners tend to give little attention to reflection and evaluation of their investigative work. In particular, children conducting information search on the Internet are often inefficient and possess inadequate navigational skills, prefer to browse for information rather than employ systematic or analytical search strategies, have difficulty with search query, tend to seek specific answers to the task rather than develop understanding from the information found, and have difficulty finding relevant information in fact-finding tasks (Bilal & Kirby, 2002; Cooper, 2002).

Scaffolding is therefore essential in supporting young children when they work at the computer because they rarely plan and can potentially go off task when they are left to work on their own (Clements, 2002). Many real-life problems require people to make a distinction between information that is relevant or important to answering the question or solving the problem, and what is not (Brookhart, 2010). Children need to develop skills that are necessary to decide which information is important to the problem or inquiry, to monitor their own processes to ensure that progress is being made toward appropriate goal, to ensure accuracy, and to make decisions about the use of time and mental effort. The comparison of the children’s investigative processes to the theoretical model can be useful in revealing the challenges that the children face and areas where they could improve their performance.
6.3.4 Composition.

I was fascinated by the range of thinking skills that the children employed when they drew upon diverse information sources to construct an end product in the course of their project work. Although Marzano et al. (1988) claim that the process of conceiving and developing a product goes beyond writing to creating “a dance, a song, a painting, or a sculpture” (p.56), they fail to demonstrate how the process of composition can be applied beyond written composition. I examined the following cases in order to explore the process of conceiving and developing a product:

- D’s card game
- R’s work on healthy lunchbox project
- S and E’s work on their healthy lunchbox project

Examination of the three cases led to the identification of a number of common elements that served important functions in the process of composition: 1) stating or defining the task; 2) drawing on multiple sources of information needed for the task; 3) developing criteria for evaluating usefulness of information; 4) generation of ideas and strategies; 5) organisation and synthesis of ideas / information; and 6) implementation and representation of end product. The process could be enhanced by the inclusion of a phase to review and evaluate the outcome. Establishment of clear and specific goals at the beginning could also be useful. Research shows that specific and challenging goals can lead to higher performance than easy or no goals, and goals can direct attention and efforts, increase persistence, and encourage development of strategies (Locke, Shaw, Saari, & Latham, 1980). The theoretical model of composition in Figure 6.9 is developed by incorporating these elements.
I compared this theoretical model to the cognitive process map of my thinking conversation with D when he showed me his card game (Appendix O: Cognitive Process Map of D’s Card Game). The cognitive process map was constructed from the thinking conversations I had with him after the fact (i.e. after D had constructed his card game) and we therefore could not know the actual sequence or the full accuracy of events. We could infer that D set about the task of creating a card game, he had some idea of the characteristics of the game he wanted to create (the game requires two or more players, involves money, and ends when all the properties are sold), he was able to draw on multiple resources (such as his personal experiences, working theories about financial transactions, and game of Monopoly), and he was able to generate multiple ideas to develop a complex card game.
He was able to organise and synthesise his information and ideas to create a stack of “cards” in the form of words, numbers, and illustrations on pieces of paper, as well as a set of rules for playing the game. The process could have been enhanced by the inclusion of a phase to review and evaluate the game. This could provide him some understanding as to whether his pricing of properties were realistic, such as the pricing of an entire airport for ten dollars and a railway station for 700 dollars. There is also the apparent haphazard and illogical manner in which the rules were applied when he played his game with me: he gave me 50 dollars for no apparent reason when I paid a hundred dollars for the town square according to its listed price, he said "...you could just give me four hundred dollars and I'll give you two hundred dollars" when previously he set the rule that there could be no trading of money, and one gets 400 dollars when one mortgages any property regardless of the price of the property. A review that involves a trial and feedback could help address this issue. In addition, D could have established clear goals to guide him in his task and subsequent review and evaluation.

A number of insights could similarly be obtained by comparing the visual model of R’s work on his healthy lunchbox menus (Appendix N: Visual Model of R’s Healthy Lunchbox Project) to the theoretical model of composition in Figure 6.9. R appeared to have a clear idea of what he was out to accomplish and was able to draw on multiple sources of information. He used a set of selection criteria (such as healthy food and pricing) to decide what to include in his lunchbox menus. R was able to break down information, analyse, organise and synthesize them into different types of lunchbox menus which he translated into writing and drawing in a highly organised format. He was able to apply his personal experience and his knowledge of food pricing, numbers, money and mathematical concept of part-part whole in order to price his lunchboxes according the estimated prices of the components. It is unclear whether he set specific goals or clarified the requirements of the task at the beginning. The quality of R’s work might have benefited from a review and
evaluation. For example, a review might help him realise that the prices of the components did not add up to the total price of each lunch menu.

The visual model of S and E’s work on their healthy lunchbox project (Appendix T: Visual Model of S and E’s Healthy Lunchbox Project) was constructed using four cognitive process maps of the thinking conversations I had with them while they worked on their project. Comparison with the theoretical model shows that they were able to establish the goal of creating two menus, draw on multiple sources of information, used a set of criteria to guide them in their decisions, generate multiple ideas to create their menus, organise and synthesise their information and ideas, and translate their ideas into writing and drawings to produce two sets of menus for their healthy lunchboxes. I also observed that S was highly organised and systematic in her approach: she was responsible for deciding at the beginning how many menus to create, developing a title for their work, planning the layout on paper, and developing a set of criteria to help her decide what to include in the menus. At the process level, S and E’s work could have benefited from an additional step of review and evaluation at the end. In terms of thinking skills, they could work on their analytical skills and be more precise in their evaluation of the type of food to include in the menus. For example, their decision on what constituted a “balanced” menu was arbitrary even though they used a reference list of healthy foods to determine what were considered healthy and relied on their own experience and current knowledge to decide what would be unhealthy. They did not apply characteristics such as taste, appearance, and smell of ingredients to determine whether something is healthy even though these characteristics were mentioned as part of their considerations in their choice of healthy food.

The findings show that a theoretical model of composition could be derived from common elements identified in the children’s creative processes and used to evaluate the children’s task performances. The issue of reflecting on, reviewing, and evaluating their work
seems to be a recurring one. Most learners, especially young children, do not naturally attend to such activities (Ertmer & Simons, 2006). Reflection is an important part of metacognitive activity and requires critical thinking because it involves revisiting of the learning process to evaluate the actions taken, the outcome, mistakes made, and learning that has occurred (Georghiades, 2002). The development of the ability and disposition to review and evaluate one’s work might have benefited from a better balance in promoting both critical thinking and divergent thinking in the classroom – an issue which the teacher, Sarah, acknowledged (see Chapter Five).

6.4 Summary

The discussion of findings in this chapter shows that comparisons of children’s performance to theoretical models can offer another dimension to the analysis of children’s thinking competence and identification of learning needs. The findings show that seven to eight year-old children may lack structure in their processes, which can have a significant impact on their task performance. In addition, their ability to reason effectively depends as much on their knowledge as their thinking skills. These two key issues are further discussed in the next chapter. Various approaches such as problem-solving, project work, inquiry, and philosophical discussions have been used to sharpen children’s thinking skills (see Chapter Three). These approaches may involve, implicitly or otherwise, one or more of the processes of wonderings, brainstorming, decision-making, problem-solving, investigation, and composition. The constructivist classroom where the teacher, Sarah, adopted flexible and multi-faceted approaches to promote thinking skills in the classroom, including problem-solving, inquiry, and philosophical discussions, offered the ideal setting to explore the flexibility and adaptability of the data collection and analysis techniques employed in this study. The findings show that vignettes of thinking conversations, cognitive process maps,
and visual models can be used to analyse and represent children’s thinking processes and skills across different contexts. The findings demonstrate that the usefulness of these techniques in making evident children’s thinking competence is relatively independent of the approach adopted to teach thinking skills.

A note of caution is necessary in adopting the approach of comparing children’s task performance to theoretical models. Inherent in such an approach is the notion that a theoretical model can be applicable to the various situations in which the children’s complex thinking skills are manifested. The findings in this thesis show that the children’s approaches to task performances and the processes involved vary widely. It is a faulty assumption to expect that children’s processes follow a given theoretical model exactly regardless of the situation in which the task performance is carried out. Any visual representation of children’s thinking processes should portray their many approaches to task performance and allow for multiple perspectives by observers.

Frameworks or models can be limiting just as they can be useful. They can never be a fully accurate description of reality and each model can capture only a part of reality. Hoffman and Militello (2009) note that:

> There is no single problem-solving process or critical thinking process, and reasoning cannot be usefully or exhaustively taxonomised into types of stages based on some form of structural analysis of problems. Rather, there are supporting processes . . . that are always highly parallel and interacting. (p.135)

While admitting that a framework does not need to be an accurate reflection of reality in order to be useful, Nickerson (1990) cautions that we must be wary of the over-simplification and distortion of reality that are inherent in any framework. This inherent over-simplification and
distortion of reality inevitably limits the accuracy and usefulness of the framework. Any framework, according to him, serves as a conceptual convenience that should be used only when it proves to be useful in a given context and should be discarded for another more suitable alternative if it is necessary and expedient to do so. Nickerson points out that:

Organising frameworks – theories, models, taxonomies, paradigms, etc

. . . They channel thinking. The difference between a channel and a rut is somewhat a matter of perspective. (p. 504)

Frameworks or models pose the risk of tempting educators into mandating how children should think and that they should all think the same way and approach similar tasks in similar fashion – leading to what I call teaching of “mass-production” thinking. Isaken and Treffinger (2004) offer the following explanation for the move away from a prescriptive model to a more descriptive one in the evolution of their model of creative problem-solving (CPS) from 1985 through to 1992:

The constructivists argued that each individual must construct his or her own process approach in a personally meaningful way. From this, we took away a valuable concept: the importance of enabling people to “customise” or personalise their understanding and application of CPS. We recognised the importance of intentional, purposeful cognition and the importance of creating personal meaning in one’s approach, and we were confident that those principles could be incorporated into CPS to enhance its power and practicality. (p.15)
One of my research goals has been to demonstrate that children are likely, given their own choice, to approach each thinking task differently and use their own thinking frameworks to make sense of their experiences (see Chapter One). My argument has been that the teaching of thinking skills needs to take this into account and incorporate Vygotsky’s concept of zone of proximal development. Individual thinking needs, preferences, and abilities should be taken into consideration and the teaching of thinking skills needs to be differentiated accordingly. On the other hand, purposeful planning, thoughtful intervention, and structure are a necessary part of good instruction (Epstein, 2007; Kuhn, 2007). The findings show that some structure in the children’s thinking processes may be useful in helping them to think more effectively and productively. The key for educators is to strike an appropriate balance between teacher-directed instruction and child-centred learning experiences, and to be flexible and responsive according to situations, learning tasks, and individuals (Epstein, 2007; Schwartz & Bransford, 1998; Siraj-Blatchford et al., 2002). A balance between teacher-directed instruction and child-centred learning experiences is also consistent with Dewey’s pragmatist stance (see Chapter Two). A corollary of that is the need to use theoretical models as guides in a flexible manner to support children’s thinking processes while respecting diversity in the ways in which children approach thinking tasks. It is important, for that reason, not to stick to one but adopt what is most appropriate theoretical model for a given situation (Moseley, Baumfield, et al., 2005; Presseisen, 2001). In the next chapter of the thesis, I focus on the scaffolding of children’s thinking competence in open-ended and ill-structured tasks. I discuss how the techniques developed in this study – thinking conversations, cognitive process maps, and visual models – can be used to identify children’s thinking competence and learning needs when they engage in such tasks.
Chapter Seven

Scaffolding Children’s Thinking Competence in Open-ended and Ill-structured Tasks

This chapter focuses on the scaffolding of children’s thinking competence and identification of their learning needs in open-ended and ill-structured tasks. I describe the challenges of scaffolding children’s thinking competence in such tasks – including the difficulty faced by the teacher, Sarah, in identifying the strengths and gaps in children’s thinking ability at a level of specificity required for effective scaffolding and teaching intervention. The discussion also underscores the inter-connected roles of domain knowledge and thinking abilities in children’s task performance. Six case examples are discussed to demonstrate that the techniques developed and employed in this study - thinking conversations, cognitive process maps, and visual models - can provide insights into the strengths and weaknesses in children’s domain knowledge, working theories, and thinking skills at a specific level needed for formative purposes. I then discuss how the ability to adopt a structured or organised approach to open-ended and ill-structured tasks can be a challenge for children and affect their task performance. In this chapter, I use the term content knowledge to refer to “facts” that are typically taught in the classroom in relation to different subjects such as history, geography, science, and mathematics. The term domain knowledge refers to content knowledge, as well as knowledge required to function or perform tasks within a given domain. This may include experience one has gained and knowledge acquired in areas such as cyberspace, Internet search strategies, interactive computer games, sports, farming, conducting scientific experiments, domain-specific problem solving, and location and usage of useful resources.
7.1 Challenges in Scaffolding Children’s Thinking Competence

McGuinness (1999) contends the teaching of thinking skills is more effective if they include tasks that are non-routine, open-ended, and characterised by a degree of uncertainty in order to offer learners the opportunity to construct meaning, make judgments, or produce multiple solutions. However, student’s engagement with challenges and learning are not necessary outcomes of open-ended learning experiences such as ill-structured problem solving, inquiry and project work (see Chapter Three). Scaffolding has been identified as being crucial to ensuring students’ learning and engagement with challenges in open-ended and ill-structured tasks (Ertmer & Simons, 2006; Hmelo-Silver, Duncan, & Chinn, 2007; Mergendoller, Markham, Ravitz, & Larmer, 2006). Within the constructivist framework, scaffolding is essential to guiding and supporting learners as they construct their understanding and make sense of their experiences, and is faded as the learners become more proficient (Clark, 2009). Fading in terms of progressive reduction and eventual removal of support is a key distinction between scaffolding and other forms of support (Sharma & Hannafin, 2007). An important goal of scaffolding is to transfer the responsibility for identifying strategies and making decisions from the expert or teacher to the learner (Sharma & Hannafin, 2007; Tanner & Jones, 2000). As mentioned in Chapter Three, this is to ensure that students “do not rely on the teacher to regulate and instigate thinking but are able instead to generalise particular learning experiences to more general thinking strategies” (Tanner & Jones, 2000, p.21). This goal depends largely on the learners’ ability at some point in time in their learning process to self-manage and structure their own learning. We have seen in Chapter Six that the ability to self-manage and structure complex, open-ended, and ill-structured tasks was challenging for some of the children in the study. This is an important issue which is discussed in Section 7.3.
Scaffolding should also take into consideration individual learner’s evolving understanding and abilities, and be responsive rather than directive in nature (Puntambekar & Hübscher, 2005). Van Es and Sherin (2002) posit that teachers must be able to observe and interpret classroom interactions in order to make decisions in the midst of instruction on how to proceed because lessons cannot be planned fully in advance. This is especially true in open-ended learning experiences such as those afforded by teaching practices based on social constructivist and socio-cultural principles. Van Es and Sherin recognise, however, that teachers cannot respond to all that is happening in the classroom but must be selective in what they attend to and how they respond. Interpretation of classroom interactions entails making “connections between observed classroom interactions and the broader principles and concepts that they represent” (p.573). According to Van Es and Sherin, there are three steps involved: observing what is significant in a classroom interaction, interpreting the event, and making pedagogical decisions based on those interpretations. Feedback from Sarah, the teacher in this study, shows that scaffolding was sometimes precluded in the classroom because of the difficulty in discerning specific learning needs and a lack of knowledge of gaps that exist in the students’ thinking, what could be done to help, and how students’ thinking could be extended. Sarah described the difficulty that she faced:

... the anecdotal notes that teachers write down as part of the profile of a child and some of time are just observations so you can talk to parents about the things that kids can do. But it's actually harder to find the things that kids can't do and to then work out what teaching intervention is needed ... What the teacher needs to do is to take that through and to say, ‘Hold on, there's more that's got to come from that’. You then have to do a bit of comparative stuff and say let's look at the
model of these kids - we've started with these and look at their thinking models and things like that . . . you can use another model, talk through what they did, what the challenges were, how they did it, or make it explicit what they've done.

The demands of being a classroom teacher just don’t allow me the time to record and analyse specific responses and behaviours. I’d love to be able to do it, or have someone do that as you did and shared with me. The information is really useful.

The question of how children’s learning and thinking competence could be extended was discussed during my reflective dialogues with Sarah. The discussion centred on how children could be supported in terms of both their thinking ability and content knowledge. In reviewing the findings in this study, Sarah expressed her concern over how she could support the children’s learning, their reasoning ability, and the accuracy of facts that the children knew:

Sarah: And so there are so many things that I think "Oh, I haven't got any control over that." . . . I have no idea whether the kids have a better understanding just because I am telling them . . . It's a hard thing to do - providing them with the amount of space in which they feel comfortable and confident to do things. It is that thing about how can we create an environment in which kids feel comfortable to and do we want more of the same stuff or do we want to give them room to do all sorts of different things. I was looking at what kind of inquiry model
we've got. And this is me saying there is not enough direction and manoeuvring the learning. Because here am I asking these kind of questions and not taking the role of "hold on, let's sort this out, I can give you the facts".

**Researcher:** Maybe they can have the space to go look for the information themselves and come back and talk about it.

**Sarah:** That's right. And then whether you can do that in terms of an inquiry over history - I don't know.

**Researcher:** Does it matter?

**Sarah:** Yes. It depends on how easy it is to get information we can trust.

**Researcher:** Just to use that information—even if the information is not accurate?

**Sarah:** But then it's a bit like a philosophical discussion - a lot of time going nowhere . . . And this is where not often do you get the chance to access kid's thinking that's based on so many misconceptions. If you were to be evaluating the accuracy of what the kids are saying, you would be quite worried. There is so many myths and misconceptions and some of them are promoted by the media . . . that's why there is such a need for critical literacy. Some of these (*children's ideas*) are developing understandings and how long it takes for them to be developed I don't know. And what it takes to ensure that they develop more accurately is something to ponder over. Now, what I don't know is whether what our kids are coming up with is typical of other kids coming up with . . . and what they base their assumptions on. See where
we would call them assumptions, they might call it facts, we would call them half-baked ideas or developing ideas or something like that. It's a lovely thing looking at the continuum of reasoning - at what stage when reasoning sort of forms and becomes accurate and who can do the reasoning. They can do the hypothesising, they can do the questioning. They don't actually say "I don't know". Usually they cling onto something. So, "that's what I think it is".

The inter-connectedness of content knowledge and thinking ability became very clear to us when we discussed my thinking conversations with some of the children in relation to the boats that they constructed using recycled materials:

**Researcher:** In discussing with B, JA and D – they were focused on the fact that the boat that was made of cardboard sunk. And it's very interesting how they relate to that fact which they observed. For example, when I asked B why he used a cardboard to be the mast and plastic for the sail, he said first of all that popsicle (ice-cream) sticks weren't long enough so he used cardboard and he quickly added—that he could not use too much cardboard because it (the boat) would sink. I thought to myself the mast is not going to come into contact with water. JA and D said the same thing. The whole thing was focused on cardboard becoming soggy and sinking. But those parts are not necessarily going to be in contact with water and there are a whole lot of other things that will sink.

**Sarah:** And if you use this model of teaching of developing learning
and developing understanding - giving them facts are not going to do it because they're still going to hold on to what they believe - like EM - fish wasn't an animal.

Researcher: And the whole idea that it's light therefore it can float – which was S’s comment - but that's flawed thinking. A ship is heavy - so why does the ship float?

We agreed that the children needed the ability to reason in order to apply the acquired knowledge that cardboard is a material that soaks up water and make connection with what they were constructing – for example, in terms of how the cardboard materials were used in their construction and whether the cardboard materials would be in contact with water. Critical thinking was also required to analyse what they observed and relate it to the underlying principle of buoyancy.

Sarah was also concerned over how much instruction in content knowledge would be optimal and how that could be balanced with exploratory learning that the open-ended learning experiences in her classroom afforded:

Again, this is the conundrum - whether we are going to teach the reasoning process or learning the facts and this is where, you know, the kind of results (of the study’s findings) that are coming through - how much teaching should I be doing and would it make a difference to the learning.

We haven't really got closer to doing project-based learning. It wasn't well enough defined project - how we would get information, get
experts in . . . it sort of grew a bit but it was a bit haphazard. One of things that I keep thinking - going back to those enduring understandings as well -of how much teacher-direction it should be and I don't do enough of that. Kids get away on me. They keep doing all sorts of things . . . People think it's just chaotic and there is not enough of this (teaching of content). It is happening because you couldn't get kids thinking about things if they don't have that kind of content.

Nisbet (1993) acknowledges the importance of both accurate factual knowledge and thinking skills and argues that the learning environment should have a balance between discovery learning and personal exploration, on the one hand, and systematic instruction and guidance, on the other. Hmelo-Silver et al. (2007) recognise that learning goals should include both content and process skills, and this can be achieved in environments that are similar to real-life contexts so that students can develop understandings that are “interconnected, meaningful, and useful” (p.105). Hmelo-Silver et al. (2007) note that the teacher may need to provide content knowledge on a just-in-time basis in order to facilitate the learning process in open-ended learning experiences such as those provided by problem-based and inquiry learning.

While Sarah recognised the difficulty of knowing how children’s thinking could be enhanced and what she could do as a teacher in this regard, she observed that the insights provided by the cognitive process maps and visual models could be useful in identifying specific learning needs.

**Researcher:** So you see that, having pursued the idea, they failed to evaluate their effort . . . so this is lacking here and this is lacking here

*(points to cognitive process map of E & K’s Internet search)* [See Figure]
5.1: Cognitive process map of E and K’s internet search. They went down this path and they got lost.

Sarah: They did. And that’s where I’ve got to be able to pick out this kind of stuff—and this is useful. And it’s to evaluate how well did they do. And to ask what did I do (to help).

Researcher: You can see that these guys do think - they have some form of strategies.

Sarah: They do but they haven’t quite got it right - it's almost like having ideas here and deciding this is the main idea - this is the one worth pursuing. It's been really interesting for me this year - looking more closely at the things that I do. With certain kids you can pick up what is there but you have to work out what (learning needs) is there. But when I look at other kids, I haven't got a model of them in the class at all and you end up thinking what is going on. So there is a lot of use to the models (cognitive process maps and visual models) to be able to analyse what kids are doing.

Sarah explained that the challenges that she faced in identifying individual thinking competence was partly due to the level of observation and analysis required, and partly due to the fact that there are some children who may not be as articulate or expressive as others. She noted that the information obtained through the techniques used in this study could be useful for reporting purposes.

Sarah: . . . when it comes to report writing, I've got the evidence, I've got the information right there. So these bits are really useful because in
our school report, we've got a section that said we've called it thinking and knowing and understanding through the curriculum . . . because it's more than topics, we've got to put skills in it . . . we've got to put thinking in it . . . and so to be able to write comments like these under the heading is really useful and they are the kind of things that parents want to know about. They are harder for me to find because partly because you come up with them and you analyse the conversation and that is where your mapping allows you to look back on that and then sort of categorise it, isn't it? And if you were to look at say EM or J, the people who don't say a lot, they are the ones that you say ‘I don't know much about them’.

Researcher: I did this analysis based on your previous question of how we can support kids—we could perhaps extend it by further questions or prompting . . .

Sarah: Yes, which is really useful. Because a lot of it is—you see things and you read it and you think this is not quite right in terms of where we want to go so therefore— this kind of questions are really useful. So when it comes to looking at the things that are useful for us—so this is useful in terms of knowing about kids, knowing about where to next and things like that.

The discussion of six case examples in the next section of this chapter demonstrates that, while the identification of specific strengths and learning needs of individuals in terms of their thinking abilities may not be easy, it is not impossible in the context of a classroom where children work on diverse open-ended learning activities in various grouping sizes and using
varied approaches to tasks. I explore how both thinking competence and domain knowledge can be observed, analysed, and assessed in these case examples. I identify the children’s competence, gaps in the children’s understanding and thinking abilities, as well as opportunities for learning or teaching intervention in each case example.

7.2 Children’s Thinking Ability and Domain Knowledge

There is significant amount of literature in the development of thinking skills that acknowledges that thinking and domain knowledge are closely connected (Blumberg, Epstein, MacDonald, & Mullis, 1986; Costa, 2008; Ennis, 1989; Pithers & Soden, 2000; Resnick, 2001; Silva, 2009; ten Dam & Volman, 2004), even though there may be exceptions where critical thinking task performance is independent of domain knowledge (see for example Erwin & Kimberly, 2003). The ability to think critically and creatively and to solve problems requires the use of both knowledge and skills (Gilhooly, 1987; Saye & Brush, 2002). Pithers and Soden (2000) contend that learning to think involves learning to use content in progressively more sophisticated ways. Willingham (2007) argues that, if a person knows that he or she should not accept the first reasonable-sounding solution to a problem, domain knowledge is needed to come up with alternative solutions or weigh how reasonable each alternative is. Research shows that a key factor that can influence people’s thinking ability is their domain knowledge - how people analyse a problem is dependent on information they have and people are able to think more analytically and creatively when they have deeper domain knowledge or conceptual understanding (Means & Voss, 1996; Sadler, 2004; Willingham, 2007). Research by Shin, Jonassen, and McGee (2003) shows that lack of prior domain knowledge can hinder students’ attempt to solve even well-structured problem. Taken together, existing research and literature suggest there is an inextricable link between thinking ability, on one hand, and conceptual understanding or domain knowledge, on the other. The
following case examples demonstrate how these aspects of children’s competence can be observed and assessed.

7.2.1 EM’s argument that “fish is not meat”.

Collaborative learning in group work or discussion can draw out and confront misconceptions or ineffective strategies (Brown, Collins, & Duguid, 1989) as much as demonstrate children’s competence. The example of EM’s argument that “fish is not meat” illustrates. The teacher, Sarah, was talking to a group of children about their healthy lunchbox project while they were about to go for their tea break. E made the comment that she included a fish sandwich in the healthy lunch menu that she created. Sarah asked her what kind of fish it was.

**E**: Tuna kind of fish.

**Sarah**: Tuna kind of fish. But is there anything in tuna that is good for you?

**E**: There is meat in it? *(smiles)*

**EM**: No, it's not meat. It's fish.

**Sarah**: Is fish meat?

**EM**: Fish isn't meat because it isn't an animal. It's a fish.

**E**: It is. It is a sea animal.

**CP**: If it is not an animal, what is it? If it is not an animal what is it?

One of the basic logical argument patterns in formal reasoning is *modus ponens* (Anderson et al., 1997; Bassham, Irwin, Nardone, & Wallace, 2008; Garnham & Oakhill, 1994). It consists of 1) a premise asserting that a proposition p is true; 2) a warrant, *if p then q*; and 3) a
conclusion or claim that the proposition \( q \) is true. Modus ponens is a form of formal deductive argument and, by definition a valid deductive argument can never lead from a true premise to a false conclusion (Garnham & Oakhill, 1994). If we adopt Anderson et al.’s (1997) position that the statement “\( q \) because \( p \)” is equivalent to the warrant \( \text{if } p \text{ then } q \), EM’s argument may be considered as follows (substitute \( p \) for “not an animal” and \( q \) for “not meat”):

- **Premise:** Fish is **not an animal** \((p)\)
- **Warrant:** If it is **not an animal** \((p)\), then it is **not meat** \((q)\)
- **Conclusion:** Fish is **not meat** \((q)\)

It can be seen that EM’s argument exemplified modus ponens. Her conclusion may be considered as incorrect because of a false premise but the process she adopted was perfectly logical and not at fault. One may argue, on the other hand, that what is considered as meat and animal may be as much philosophical questions as commonly accepted facts. Without further verification, we cannot conclusively say that EM’s argument was a reflection of her ability to reason logically because it could be mere accident or luck. We can observe that she had her own working theory in relation to what is considered meat and animals – a potential area for further discussion or teaching intervention.

The example also raises two interesting issues. The first is what Norris (1988b) describes as the dilemma of process versus product of thinking:

It is not clear whether rationally good processes of thinking can be identified independently of the products they yield, or whether the quality of thinking processes must be judged by the propensity of the processes to yield good products. (p.135)
The second issue is related to Snow’s (1989) point that learners come with their own preconceptions and some of these may be in conflict with the teacher’s concepts. Some of these preconceptions may be credible while others may be misconceptions and naive theories that pose potential obstacles to learning if not detected and addressed by the teacher. Learners also come with previously developed abilities and skills that may be exploited to support further learning, or deficiencies in skills that require mediation.

Interestingly, Sarah regarded EM’s theory as a misconception that warranted teaching intervention. The observation contributed to Sarah’s concern about the accuracy of facts that her students knew and her own awareness of children’s misconceptions. Sarah commented that she would be unaware of what the students did not know if not for the opportunity that she had with them. She added that, in a typical structured classroom where instructional teaching prevailed, the child “would probably sit there and listen without the teacher ever knowing whether the child is learning.” Sarah also observed that there was a conundrum in deciding whether to focus on the reasoning process or learning facts accurately. She agreed with my comments that the children could potentially engage in both if time, the curriculum, the structure of the classroom, or the learning environment permitted; but it could be a challenge in the reality of the everyday classroom.

7.2.2 Children’s discussion on ANZAC Day.

According to Saye and Brush (2002), historians consider historical accounts as human constructions and examine the social contexts in which the historical accounts were created in order to make judgments about evidence and events. On the other hand, novices tend to be confused when they encounter conflicting accounts of history because they “view history as a

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6 National day of remembrance on 25 April in Australia and New Zealand to commemorate members of the Australian and New Zealand Army Corps who fought at Gallipoli in Turkey during World War I.
straightforward recounting of events and regard historical texts as authoritative narratives” (p.79). The following example illustrates:

I was in the classroom before class started. EM came into the classroom and showed me the plastic poppy that she was wearing to commemorate ANZAC Day. I asked her what it was and a discussion ensued. Sarah, the teacher, came into the classroom asked what the discussion was about.

D: We were talking about the war.

Sarah: You were talking about the war and you were talking about the place being Gallipoli.

SI: EM picked up a poppy and Scott asked what that was.

Sarah: So you picked up a poppy and that led to the question like ‘what is it?’

EM: I explained to Scott what and I said that Turkey was trying to take over Britain.

D: It's the other way round. Instead of Britain trying to take over Turkey, they were trying to pass through to Gallipoli

JA: It wasn't them trying to get through to Gallipoli. It was them trying to get—to another part of the country to put store or stuff there.

D: There were mines.

B: There were 2 islands.

EM: The Turks were trying to take over Britain.

D: The British were trying to go to Turkey to get to Gallipoli and they were trying to take over the land. They were trying to get more people so they could get through to the other side. And then they asked Australia and
New Zealand to help."

**Sarah:** You guys have a whole lot of things going through your mind. And I can see people looking on with puzzled look on their face. You are confused.

**MI:** Because there are two people doing it. I am not sure which one is right, which one is wrong. Which one is nearly right, and which one is nearly wrong.

*Some of the other children said that they were confused too.*

**Sarah:** We have got confusion at the moment.

**JA:** They used tricks on the guns to make them go— to escape. The Turks thought that— people, the soldiers were still there shooting the guns. So the New Zealanders and Australians could get away.

**Sarah:** How do you know that?

**R and JA:** Mrs Willingham told us.

The episode illustrates the usefulness of discussion of this kind. It brought forth many misconceptions and factual inaccuracies - areas of learning that could benefit from teaching intervention. It can be observed that the children confused historical facts and their own theories. This is as much a reasoning-related issue as a matter of being accurate about historical facts. According to Kuhn (1999), both children and adults sometimes fail to make the distinction between theory-based and evidence-based sources of their beliefs - with “evidence-based and theory-based justifications functioning as interchangeable supports for a claim” (p.21). This failure to make the distinction can hinder an individual’s ability to identify evidence, critically evaluate it against their own theories, and revise their theories if necessary in the light of the evidence.
The many conflicting ideas and theories also created confusion for some of the children during the discussion. The response of a person to a challenge or cognitive conflict is dependent on his or her personal epistemology in learning and sense-making (King & Kitchener, 1994; McGuinness, 1993). Kuhn has long argued that epistemological beliefs play an influential role in the development of critical thinking (Kuhn, 1999; Kuhn, Iordanou, Pease, & Wirkala, 2008). In Kuhn’s developmental model of thinking (Kuhn, 1999), a novice thinker tends to adopt the assumption that reality is directly knowable, and that knowledge is certain and received from authoritative sources of knowledge. At this absolutist level of epistemological understanding, knowledge is regarded as facts and misconceptions can be easily corrected by making reference to a correct or adequate source of information (Kuhn et al., 2008). It is not surprising, for example, that:

- MI said, “I am not sure which one is right, which one is wrong. Which one is nearly right, and which one is nearly wrong.”
- JA and R referred to an authority figure, the history teacher, when justifying their claim.

Sarah opined that the manner in which knowledge was taught had an influence on the children’s perception of “facts” and the discussion during our reflective dialogue:

Sarah: What I had been pondering is this whole notion of facts. The things that Jen (teacher responsible for teaching history) did with Gallipoli is quite different from what I would have done. She looked at the facts and so the kids were tied up with who was going where or whatever . . . the approach influenced the kids hugely. It influenced the discussion we had.

Researcher: That is interesting - that previous experience with
knowledge influence thinking behaviour.

**Sarah:** I wouldn't have looked at it in terms of facts. I would have looked at it in terms of issues. The understandings that I would have like to come out would have been what were the kiwis doing there, at what point in time people were in the wrong place . . . it still make me think that whole notion of knowledge and the dilemma of constructivist teaching - you know the whole looking at content and knowledge, issues and facts.

**Researcher:** I suppose it depends on the way it is taught isn't it? If it is taught in a very prescriptive, top-down manner, it would influence the children's thinking. But if you help them discover them and help them to weave that into their discussion and thinking, would that help better?

**Sarah:** That might but then you still wonder what the fact is and whose perspective you're looking at things through . . .

A more sophisticated thinker develops what Kuhn calls the realist level of epistemological understanding and holds the belief that reality is not directly knowable, is uncertain, and is constructed (Kuhn, 1999; Kuhn et al., 2008). Advanced thinkers move beyond that to an evaluative view that assertions may be compared and judged by the quality of evidence and reasoning used to support them (Kuhn, 1999; Kuhn et al., 2008). There is clearly a need and an opportunity for the children to enhance their critical thinking skills. It can be observed, on the other hand, that the children were not short of ideas and theories. Here again, their creative and critical thinking abilities are contrasted (see Chapter Five).

At one point of the discussion, I tried to ask the question why New Zealanders agreed to help the British because I wanted to see how the children would respond and whether they
would be able to question the historical account that was based largely on one side’s perspective of the War. Sarah followed up on my question to extend the discussion by asking the children: “Why were New Zealanders there? Why did young New Zealand soldiers go half way round the world (to fight in Gallipoli)?” The children responded with many theories or explanations (Figure 7.1).

![Cognitive process map of children’s reasons why New Zealanders were involved in Gallipoli](image)

**Figure 7.1:** Cognitive process map of children’s reasons why New Zealanders were involved in Gallipoli

There are number of issues in relation to the children’s knowledge and understanding of history. The accuracy of some of the “facts” is questionable, for example the claim that “New Zealand asked Australia to help”. The children again confused historical facts and their own theories (this is both a knowledge and reasoning-related issue). There are also a number of issues in relation to critical thinking ability. One girl again referred to an authority figure,
the history teacher, as the justification for what she said. A number of the responses did not appear to be relevant or respond directly to the question as why New Zealanders went half way round the world to fight in Gallipoli.

At the end of their discussion, I went over to AN to ask her why she mentioned that most of New Zealanders' ancestors came from Britain:

**AN**: Because I have looked at my family tree and that because it says that.

**Researcher**: How is that relevant to our discussion on ANZAC Day? What has that to do with ANZAC Day?

**AN**: That's because Britain was involved in the ANZAC war.

**Researcher**: Britain is involved in the ANZAC war and most of your ancestors came from Britain—and what's the connection?

**AN**: That's why we were involved in the ANZAC war.

The episode contrasts with EM’s argument that “fish is not meat”. AN’s reasoning process seems to be confused. She was unable to make a coherent link between her premises and claims in order to offer a clear explanation, or at least a reasoned theory, as to why New Zealanders were motivated to travel half way round the world to assist Britain in the First World War.

Perhaps the larger issue was the failure to question the perspective taken by the historians who recorded the events of Gallipoli and to consider the possibility of alternative views adopted by another community, although one may question whether it is fair to expect children to take such a critical view of history. Historians, according to Robyns (2001), take historical events and use their interpretations as supporting evidence for their own argument.
or theory. Historical account generated may be coloured in many ways, including culture, bias, deliberate deceit, personal interests, inaccuracies, incompleteness, or ignorance. Critical thinking skills are needed to subject historical records to “the most thorough scrutiny in order to ascertain the truth, whatever that may be” (p.369). The discussion on ANZAC Day did present an opportunity to assess the critical thinking of the children in the many aspects noted above – areas which can potentially benefit from teaching intervention. Adult modelling and scaffolding can help children develop the critical thinking skills needed to examine and make judgments about evidence and events (Reagan, 2008; Reisman & Wineburg, 2008; Saye & Brush, 2002). Fisher (2007) contends that:

. . . children tend to expect to have their questions unequivocally answered by adults, not discussed by children . . . But if they have a stimulus, for example, a story, then even young children can respond to questions in ways that can be called philosophical. This may mean helping them to move from the concrete and literal aspects of the story to the conceptual and the abstract, moving the discussion from what happened in the story and why to thinking about what it means [italics in original text]. (p.623)

Fleury (2004) argues for a critical constructivist stance toward teaching that involves:

. . . introducing students, even very young children, to the issues of power that prevail in school subject matter. The teacher can develop learning activities for students that allow them to build and test viability of different knowledge claims. Through their involvement in these epistemological activities, students come to see how their view of the
world is shaped and become increasingly sensitive to the power others hold over them through textbooks, tests, media, and advertising. (p.187)

Fleury contends that, by doing so, teachers can help students develop an understanding of the contingency of knowledge (the pragmatist notion that “facts” are objectively true until new and conflicting data arise – see Chapter Two) and that all human created knowledge are value-laden culturally and politically.

7.2.3 Children’s boat construction.

The children’s engagement in exploratory learning as they constructed boats using recycled materials afforded another opportunity for observing their task performance. The teacher, Sarah, encouraged the children to test their boats by placing them in buckets of water and a sink filled with water to see if they would float. Some of the children, including B and JA, were eager to show me their boats and I took the opportunity to engage them in conversations to gain some insights into their thinking. I asked B about the rationale for his choice of materials, such as why he chose to use cardboard that he had cut into strips for his masts. The cognitive process map in Figure 7.2 shows that B was able to justify his reason for not using “too much” cardboard by hypothesising that it could otherwise cause his boat to sink. However, the connection between the rationale for his choice of material and the observation that soggy cardboard caused someone’s boat to sink was flawed. He failed to see that the cardboard masts would not be in contact with water given that he had used a plastic ice-cream container for the hull of his boat – a fact which he could also have verified by placing his boat in water. According to Gilhooly (1987), people can be confused or distracted by the superficial similarity of a situation and fail to see that the new situation is different from a previous or familiar problem. Pretz, Naples, and Sternberg (2003) observe that we
often make “unwarranted assumptions in our everyday problem solving” that can interfere with our ability to find a solution to a problem (p.5). B could benefit from opportunities to develop his critical thinking in terms of analysing situations or problems, understanding causes and effects, and critical evaluation of assumptions.

Figure 7.2: Cognitive process map of B’s rationale for using cardboard for his masts

The following vignette describes my thinking conversation with JA on his boat. JA had placed his boat in a sink filled with water to show me that it could float:

**Researcher**: And what is this for? *(Points to a piece of drinking straw taped to the side of the 'boat' and sticking up vertically).*

**JA**: The flare gun to help people notice that we're here. Cos you might get lost in the ocean so you need a flare gun so it will go poof and then other boats might see where you are like the Titanic.

**Researcher**: It goes round and round—yeah, it doesn't go in one direction.

**JA**: No, if you put the water on (turns on the tap) it will just push it . . . so it's like if it is a big wave that would happen to it.
**Researcher:** It is not clear to me which is the front and which is the back of the boat because it is still going round and round without a clear direction.

**JA:** Well, the flare gun is the back of the boat and this is the front. I wanted to make it curvier (pinches the container to make it into a sharper oval) like that but I couldn't.

**Researcher:** Can you find a way to make it curvier?

**JA:** I'll have to put something on it but I think it looks just fun like this because it's got the materials that we need to use—because the straw the flare gun there's this little bit in there—it will the shoot the flare. — like the firework part. Then we've got the little characters—so to make it just look cool and—yeah the plastic that we use is strong.

JA responded to the problem of the boat going round and round in a directionless manner by explaining that the boat needed a push from a wave. The problem persisted after he had created wave movement in the sink by turning on the tap. He appeared to then make a tenuous connection between what he observed and how he designed the front and the back of the boat. The solution of a more streamlined shape was implied in his subsequent comment. The conversation shows the process of analysis and problem-solving that JA engaged in. Clearly, there is an opportunity for JA to test his hypothesis further, develop his inquiry skills, and learn about the principles of fluid dynamics.

Reiser (2002) argues that, in order for authentic and open-ended learning experiences to be effective in supporting knowledge construction, students must not only work out solutions to a particular problem but must analyse and connect their work to concepts or principles of a discipline. Reiser (2002, 2004) notes that learning through investigation can be
compromised because learners tend to focus on constructing solutions for the given task, fail to attend to and learn underlying principles, and become distracted by the superficial aspects of the task:

. . . if students are learning about mass and density by designing toy boats to carry loads, they need to analyse and synthesise their results and work toward physical explanations, rather than focusing only on the goal of the boat-building task. (Reiser, 2002, p.256)

It may be a beneficial exercise for the children to not only design and build boats that can float, but to analyse and work out physical explanations, for example, as to why they float and how they can float, why their shapes enable them to cut through water, and so on. It would offer opportunities for them to develop their critical thinking skills and extend their conceptual understanding of important scientific principles.

7.2.4 Discussion on bulls seeing red.

JA mentioned that bulls were attracted to red and would charge at someone wearing red during a whole-class discussion on a story that involved a group of children and a bull in a paddock. I approached JA, who was seated next to D, after the class discussion to ask how he knew that bulls were attracted to red. The ensuing discussion is captured in Figure 7.3. People’s evaluation of claims or arguments can be either evidence-based or theory-based where reference is made to prior beliefs or theories (Zimmerman, 2007). The discussion with the children shows that they repeatedly offered their theories and beliefs as justification for their claim that bulls are agitated by the colour red. They even claimed that their theories were facts. This is not surprising given that research has found critical thinking in argument, such
as the abilities to provide evidence for one’s own theory, consider alternative theories, provide counter-arguments, and rebut, to be rare among even adults and university students (Anderson, Howe, Soden, Halliday, & Low, 2001; Kuhn, 1991).

Figure 7.3: Cognitive process map of discussion with JA and D on bulls seeing red
According to Belland, Glazewski, and Richardson (2008), research found that secondary school students “tended to explain their positions rather than provide evidence in support of them regardless of whether they were asked to prove or explain their positions” (p.406). Students’ difficulty or inability in creating evidence-based arguments can be due to weakness in linking claims to evidence, as well as difficulty in identifying and gathering relevant evidence. In our case, D declined to provide evidence to back his claims when I asked if he could bring something to prove his theories:

**Researcher:** Can you prove that to me next week? Can you bring something to prove that to me next week?

**D:** I've seen—when I went to a friend's house, I read a book about it and—then I haven't seen that friend in a while, so—

The episode demonstrates not only misconceptions and false beliefs that require correction, but also the need for development of critical thinking among the children. An important aspect of critical thinking to develop is the ability to make belief subservient to evidence by using evidence to guide opinions or beliefs (van Gelder, 2005) and recognise the need for evidence in what is asserted to be true (Watson & Glaser, 1980).

### 7.2.5 R’s healthy lunchbox project.

R’s impressive domain knowledge and thinking competence in his healthy lunchbox project were discussed previously in Chapters Five and Six. On the other hand, R’s lapse in critical thinking and application of mathematical knowledge was revealed in the course of our thinking conversation on how he came up with the pricing for one of his lunchboxes (Figure 7.4). It is clear that the listed prices of the
components did not add up to the total price of the lunch menu. Critical thinking is called for in evaluating the issue, and to come up with a reasoned pricing strategy and response to my question. While R demonstrated understanding of part-whole relationships, he would need to work on his ability and accuracy in applying his mathematical skills.

Figure 7.4: Cognitive process map of R’s pricing strategy

7.2.6 S and E’s healthy lunchbox project.

S and E’s healthy lunchbox project was discussed previously in Chapter Six. The cognitive process map in Figure 7.5 captures one episode of the thinking conversation I had with them. S and E were able to elaborate their criteria for what they considered to be healthy and justify their choice of food to include in their healthy lunch menu. They were able to apply their deductive thinking in concluding that healthy food does not give off odour using the premises that unhealthy food rots and food gives off odour when it rots. However, there are issues related to both critical thinking and domain knowledge. Their claim that one can tell whether food is healthy by merely looking at them or smelling them is tenuous. Their premises - unhealthy food rots and rotting food gives off odour - do not have direct links to
the conclusion they were making in relation to healthy food. From the perspective of sound logical argument, their premises can only allow them to draw a conclusion about unhealthy food. One cannot make a conclusion about something (healthy food) that the premises do not address directly (healthy food) and when the premises are statements about something else (unhealthy food). This is a basis of logically sound argument (Twardy, 2004). The reasoning adopted by S and E can also be analysed as follows. The first part comprises the pattern of modus ponens if we fill in the unstated conclusion of unhealthy food gives off odour:

- Premise: Unhealthy food rots (p).
- Warrant: Rotting food gives off odour (if p then q).
- Unstated or implicit conclusion: Unhealthy food gives off odour (q).

The second part of the reasoning adopted by S and E comprises what Bassham et al. (2008) call denying the antecedent:

- Unhealthy food gives off odour (If A then B)
- Healthy food is not unhealthy (Not A).
- Healthy food does not give off odour (therefore not B).

Denying the antecedent is considered to be a logically unreliable pattern of reasoning (Bassham et al., 2008). This can be seen in the following illustration:

- If Van Gogh painted Mona Lisa, then he was a great painter.
- Van Gogh did not paint Mona Lisa.
- Therefore, Van Gogh was not a great painter.
Figure 7.5: Cognitive process map of S and E’s explanation of what is considered as healthy
In addition, the conclusion that healthy food does not give off odour is in contradiction to the previous claim that one can tell if food is healthy by smelling it. S and E also had misconceptions about the necessary characteristics of unhealthy and healthy foods (unhealthy food rots and healthy food does not give off odour).

In summary, the findings in this study show that techniques such as thinking conversations, cognitive process maps, and visual models can provide insights into the specific strengths and deficits in children’s domain knowledge, working theories, and thinking skills when they engage in open-ended and ill-structured tasks. The issues related to the assessment of thinking skills – particularly the inadequacies of tests and the use of rubrics in performance assessment - have been discussed at length in Chapter Three. Tests that assess thinking skills do not provide sufficiently fine-grained information needed for formative purposes. While the use of rubrics in performance assessments can provide useful information, they tend to preclude aspects of thinking and learning not foreseen or included in the rubrics. On the other hand, close and prolonged observations of individual learners’ thinking processes through engagement at a personal level can provide in-depth and contextualised understanding. Kim and Hannafin (2011) observe that:

Although problem solving has been studied for decades and numerous tools have been developed to foster student problem solving, we know surprisingly little about how (or if) these tools influence student conceptions through problem-solving processes or the scaffolds demonstrated effective in the classroom. For instance, we need to identify the challenges students confront during problem-solving activities, as well as strategies they utilise to overcome them. However, these questions cannot be fully addressed by examining only student
achievement using pre- and post-test measures. Rather, it requires close investigation of individual students’ cognitive and contextualised processes of learning such as student activities with peers and teachers; interactions with technology-enhanced tools; responses to open-ended, transfer questions; and reflections on inquiry in dynamic classroom settings. (p.412)

Engaging children in thinking conversations draws the children’s attention to and encourages them to talk about aspects of their thinking. Learners naturally tend to focus on the task at the expense of reflective thinking and conceptual understanding of key principles (Ertmer & Simons, 2006). Thinking conversations can encourage learners to engage in reflective thinking which is critical to deeper understanding and developing skills. Dialogue in a thinking skills task can encourage students to justify ideas, make judgments, and offer supportive reasons for conclusions reached (Baumfield, 2004). Thinking conversations provide children with the opportunity to make links between activities and learning goals, claims and evidence, and questions and information. The findings show that thinking conversations with children can also elicit misconceptions or bias. Thinking conversations can promote what McGuinness (1999) describes as “open-minded attitudes about the nature of knowledge and thinking” and creating “an educational atmosphere where talking about thinking – questioning, predicting, contradicting, doubting – is not only tolerated but actively pursued” (p.2). The information elicited through thinking conversations can be analysed and interpreted using appropriate vignettes of narratives, cognitive process maps, and visual models in order to identify specific strengths and learning needs.
The techniques for data collection and analysis adopted in this study have surfaced detailed information about children’s thinking skills and made evident diverse forms of reasoning processes that children engage in across different contexts. The unpredictable and emergent nature of the tasks and reasoning processes was evident in the findings. It is not unreasonable to hypothesise that teaching a single approach to thinking or a predetermined set of thinking routines cannot enable children to address the diverse range of tasks and emergent contexts that they are likely to encounter in open-ended learning experiences or in the real world.

The findings also raise some interesting issues in relation to the teaching of thinking skills in the case of young children. Should we teach children logical reasoning concepts such as modus ponens and denying the antecedent when some adults, including the teacher Sarah, have not even heard of them? Yet we witness these forms of reasoning among the children in the examples above. Should we help young children develop more sophisticated level of epistemological understanding and to what extent? To what degree are young children capable of adopting a critical view of history? Should we expect children to correct their misconceptions when many adults hold on to theirs? To what degree should we teach children Internet search strategies when many university students and adults are not proficient themselves? Further investigation beyond the scope of this thesis is needed to examine these important questions.

7.3 Children’s Engagement with Open-ended and Ill-structured Tasks

The problems that the children had to solve were often ill-structured and the children had to invent their own approaches and strategies. For example, the projects on healthy lunch menu, food 50 years ago, and food 50 years later did not follow any given structure, phase-by-
phase process, or well-defined pathway even though a certain degree of support was provided by the teacher. The support provided by the teacher involved mainly provision of materials and resources, access to the Internet, responses to children’s questions, and suggestions of areas to explore. The same can be said of the exploratory and inquiry-based activities such as the construction of boats and marble tracks that I observed in the course of the study. Similarly, the group and philosophical discussions were carried out within an informal format.

The visual representations afforded by cognitive process maps and visual models make it possible to examine the ways in which the children structured their approach or the lack there of. The findings show that the children’s approaches to complex, open-ended and ill-structured tasks to be fairly organised and systematic in some cases, and poorly structured in others. The study in contrast may be made between the relatively organised approaches adopted by R (Appendix N) and S (Appendix T) to their healthy lunch menu projects, and the poorly structured approaches of N in her task to make her project on food 50 years ago more interesting to parents, the work of E and CP on their food 50 years ago project, and D’s project on packaging and wrapping (see Chapter Six). The teacher, Sarah, concurred with me on my observations of S and R:

**Researcher:** If you look at the kids for example—these two examples (visual models of S’s and R’s thinking in relation to their work on their healthy lunch menu projects)—they do have some sort of system, it may be subconscious—.

**Sarah:** And they do have a model. They do have their own ways of doing it. A lot of these (thinking) skills – they’ve got them and they know how to use them.
The findings in Chapter Six show how young children’s effectiveness in thinking and problem-solving can be impacted by a lack of structure or organised approach. Sarah mentioned her concern over the disorganised approach to tasks of other children during a reflective dialogue session:

See it was interesting J and H did a Powerpoint today. We were taking aspects and looking at in 50 years' time. They did food, drinks, cartoon, comics, and hobbies. It was one Powerpoint. Then under that the next slide was food one, food two, food three. Then it was drinks one, drinks two, drinks three. And then under each slide was a whole mish mesh of information. And then they went on to the cartoon stuff. So that when you look at, saying, okay what is the issue here - what are we talking about, what are we trying to get the audience to understand . . . the pot is all stirred up.

Sarah and I agreed that open-ended tasks where children were given the opportunity to explore and develop their own approach to tackle tasks can be challenging and required complex skills:

**Sarah:** It's nice for kids to hear that it's okay to do it in all sorts of ways.

**Researcher:** I think it's a higher level of sophistication in terms of skill level if the child is able to develop his own framework or approach of thinking—rather than an adult teaching them the method

**Sarah:** Absolutely. And it's us having the faith they can do that and not
us we have to teach then everything.

**Researcher:** The visual model allows us to look at the sophistication in terms of the complexity of the framework. I think this is a lot more complex than that one in terms of thinking (points to the visual model of S and E’s work on healthy lunch menu and then to cognitive process map of S’s Internet search on lunchboxes 50 years ago)[see Appendix T: Visual Model of S and E’s Healthy Lunchbox Menu and Chapter Six].

**Sarah:** Yes, it is.

**Researcher:** And so rightly the visual model has to reflect that complexity.

**Sarah:** And it has to be a bit random. It's not hierarchical and there are bits and pieces here and maybe here as well and then there's other bits over here and then there is some bits here—(points to different parts of the visual model of S and E’s work on healthy lunch menu).

Sarah agreed with my comment that my findings seemed to suggest that, while the children demonstrated their thinking abilities on many occasions, some form of structure could help them be more effective in their thinking. She said that the cognitive process maps and visual models of children’s thinking processes enabled her to examine the structural aspects of their task performance.

Viewing and comparing cognitive maps for different kids also gives me a better idea of cognitive structures or architecture that some children have, or don’t have. Analysing the processes - especially the lack of
them is a useful evaluative process and helps me plan teaching interventions. For example, R works in a very ordered and rational way. I can see that in the maps and also in his responses to situations. Not only do I ‘know’ that he has a framework that will support his learning in positive ways, I have evidence of that. The thinking processes that you have identified help identify and explain some of the ingredients for a successful learner. By comparison, JA seems all over the place with his thinking. When I look at his responses to situations, I’m unsure of exactly how he forms his misconceptions – not only in his acquisition of knowledge, but the processes he uses to form his conclusions. Recording his responses and mapping them may make that more explicit, and thus inform my next steps in teaching. It was N, wasn’t it who seemed quite random or divergent in her responses but was actually employing quite creative processes? The interpretation of that illustration was reassuring and helpful when it came to looking at the next steps, which included more logical, rational thinking, sifting out and identifying main ideas. From that information, you could see how a team of kids could be selected for a task, each bringing different strengths.

According to Mergendoller et al. (2006), projects and ill-structured problems often evolve on their own to the extent that intended learning might not occur. The findings suggest that the issue of structure might be a significant challenge that children face when they tackle complex, open-ended and ill-structured tasks in a constructivist classroom. I discuss this issue
and the ability to adopt an organised approach or impose structure on open-ended and ill-structured tasks in next section.

7.4 Ability to Impose Structure on Open-ended and Ill-structured Tasks.

Complex, open-ended, and ill-structured tasks can be challenging for learners because they have to orchestrate processes, thinking skills, domain knowledge, and metacognitive skills to plan, monitor, and evaluate task performance (Reiser, 2002). According to Hoffman and Militello (2009), the driving hypothesis of studies on expert performance is that experts’ knowledge - factual, procedural or metacognitive – is highly organised and highly coherent, and CTA of expert performance often shows that experts work in a systematic fashion. Saye and Brush (2002) observe that experts employ more than just metacognitive skills: “experts incorporate an abstract third dimension, broader conceptual structures that help them organise and analyse data in order to reason through a problem” (p.79). Lajoie (2009) contends that experts possess a variety of skill sets:

Experts demonstrate highly structured knowledge that helps them perceive meaningful patterns. When asked to describe such knowledge they reason using the underlying principles of the domain in question. They are aware of what they know or do not know regarding specific situations, and thus are able to monitor themselves accordingly. Experts use their mental models to drive the selection of task strategies and are more efficient at problem-solving procedures. (p.63)

Fisher (1998) notes that “problem solvers need to direct and guide their problem solving, know how to define the problem and select an appropriate strategy . . . so many problems in
learning and in life are ill-structured, complex and made ‘messy’ by containing many kinds of variables . . . have no simple solution” (p.8). In the light of these discussions and the findings of this study, I contend that effective thinking involving open-ended and ill-structured tasks requires the ability to impose structure on the process of task performance, and to orchestrate the necessary domain knowledge, thinking skills, and metacognitive skills.

The need for structure or systematic process is implicit in approaches to teaching thinking skills that typically require students to learn and internalise one or several one-size-fits-all processes prescribed by the teacher (see Chapter Three). The danger of such approaches is that of stifling students’ ability to go beyond the processes taught to creatively develop their own workable approaches to problem solving or task performance. Willingham (2007) made the following observation about programmes that teach critical thinking:

. . . the evidence shows that such programmes primarily improve students’ thinking with the sort of problems they practised in the programme – not with other types of problems. More generally, it’s doubtful that a programme to think critically in a variety of situations will ever be developed. (p.12)

The stripping away of the complexity and guiding learners in lockstep may deprive the students of the opportunity to wrestle with the complexity and the thinking that open-ended learning tasks offer (Reiser, 2004). According to McNeil and Alibali (2005), the potential interference of a familiar, well-practiced approach to problem-solving on subsequent problem-solving has been well documented. The potential negative impact of a prescriptive approach to the teaching of thinking skills on the flexibility and independent thinking performance of learners has been discussed at length in Chapter Three.
On the other hand, there is strong argument for using scaffolds to provide structure in complex, open-ended and ill-structured tasks. Reiser (2004) posits that one way of providing scaffolding for complex task performance is to provide structure that helps learners to decompose the task, organise their work, direct and focus their effort, and keep track of their plans and monitor progress. As mentioned in Chapter Six, Hmelo-Silver et al. (2007) advocate the use of scaffolds to provide structure for complex tasks and to allow learners to focus on relevant aspects of the tasks in order to reduce cognitive load for learners. Sharma and Hannafin (2007) contend that procedural structures are important to help learners focus and sustain task performance, especially in information intensive contexts. A study carried out with nine year-old students over a period of three years by Kuhn and Pease (2008) found that: 1) engagement with a structured inquiry cycle over three years helped the children develop certain inquiry skills and strategies that were found lacking in a comparison group comprising students one year older (comparison between the study and comparison groups was made at the end of the third year of the study); 2) the comparison group of students were motivated and able to draw on “numerous” logical skills, but were ineffective in fulfilling task objectives when they applied their own strategies; and 3) the skills acquired by the study group were deemed by the researchers to be fragile and likely to need reinforcement through continuing practice and engagement with the inquiry programme. One feature of the study, that is noteworthy in the context of our discussion here, is the initial use of highly structured computer interface (which was gradually relaxed) to provide guiding structure to the students. Based on the results of their study on 12 to 13 year-old students’ scientific thinking skills, Orion and Kali (2005) argue that structure can serve as a “primary scaffold provided to students in order to enhance skills required for independent open inquiry” (p.392). They contend that structured activities can provide pathways that students can learn and apply in a metacognitive manner in subsequent open-ended investigations.
It is not unreasonable to conclude that a structured or organised approach can be useful in complex task performance on one hand, and over provision of structure to simplify complex tasks by a teacher or another more competent person can be potentially detrimental to learners on the other. The effectiveness of scaffolding to provide structure and its impact on students’ learning to eventually develop and impose their own structure on open-ended and ill-structured tasks remains to be examined. As Reiser (2004) notes,

Ultimately the goal is for students to be able to direct their own investigations and to be involved in defining a problem, planning a solution, and conducting empirical investigations . . . the risk of this narrowing to provide helpful structure is that it may lead to learners just ‘going through the motions’ rather than being reflective about what is being required and why. (p.297)

7.5 Summary

The findings in this study show that techniques such as thinking conversations, cognitive process maps, and visual models can provide insights into the strengths and deficits in seven to eight year-old children’s domain knowledge, working theories, and thinking skills at a specific level needed for formative purposes. These techniques allow for open-ended observation and analysis of children’s learning needs because they take into consideration the emergent nature of children’s thinking and are not necessarily focused on preconceived aspects of children’s performance as in the case of tests or use of assessment rubrics. Pryor and Crossouard (2005) make a differentiation between convergent and divergent forms of formative assessment. Convergent assessment involves finding out whether learners know, understand or can do a predetermined thing (such as the ability to apply a given thinking
skill). The use of rubrics in assessment creates the tendency to be convergent and not take into consideration the emergent nature of learning that occurs in the classroom. Divergent assessment, on the other hand, involves a more open desire to know what learners know, understand or can do. It is more exploratory, more dialogic in nature, and guided by “helping questions” rather than “testing questions” (p.2). While advocating both forms of formative assessment as necessary in the classroom, Pryor and Crossouard point out that divergent assessment fits more clearly in the socio-constructivist framework and is guided by the intention to teach in the zone of proximal development.

Divergent assessment is accomplished from the identity of teacher and subject expert, but more particularly through the construction of the educator as a learner themselves [sic] . . . This aims to sustain learning that is indeterminate and prospective, preventing assessment from becoming a technique for reinscribing culturally recognised practice . . . Instead of creating a binary divide between legitimate or illegitimate ways of thinking and being, thereby outcasting the identity of the other, the hope is to create space for recognising difference that contributes both to the identity of the learner, and the educator (as learner). (pp.8-10)

The open-ended approach to observing and analysing children’s task performance afforded by the task analysis techniques in this study also means that unexpected information and insights thus obtained can raise additional questions even as they provide some answers to questions that researchers and educators may have about children’s thinking competence.

The findings also show that the ability to adopt an organised approach and impose a certain degree of structure on open-ended and ill-structured tasks can be an issue for seven to
eight year-old young children. I contend that this aspect of thinking competence can play a crucial role in effective and efficient task performance. The question of how children can be supported in adopting a more structured approach to task performance without necessarily espousing a rigid or teacher-directed process needs to be examined in future studies.

The study shows that seven to eight year-old children’s thinking processes can be complex and varied across individuals and contexts. One implication is that we cannot fully appreciate their competence without prolonged conversations with them and careful observation in order to establish an accurate picture or model of their thinking performance. Perkins, Jay, and Tishman (1994) argue that a reliable profile of a learner’s real-world thinking competencies should be drawn from assessments across different contexts, settings, and dimensions of thinking. The findings demonstrate that seven to eight year-old children are competent thinkers, sometimes in ways that are surprising to us. At the same time, their thinking also reveal many flaws, some of which are very similar to those found in adults’ thinking. Approaches to teaching thinking skills need to identify and recognise these issues when they arise, and develop teaching interventions to address them. Given that these issues develop as a function of real-life task performance, the assessment of children’s thinking skills and teaching intervention must be linked to the emergent and situated learning of children in order to be effective.
Chapter Eight

Conclusion

The motivation for this qualitative research study was the search for an assessment approach that can provide specific insights into young children’s thinking abilities and take into account the situated and emergent nature of children’s learning. The purpose of the study was to explore how young children’s thinking processes and skills can be analysed, interpreted, and assessed through classroom observations that incorporate interviews and reflective dialogues. My research questions were:

1. How can observational data on young children’s thinking processes and skills be gathered and analysed?

2. What can classroom observations, interviews, and reflective dialogues reveal about young children’s thinking processes and skills?

3. How can young children’s thinking abilities be formatively assessed using classroom observations, interviews, and reflective dialogues?

The three research questions are addressed in the following discussion of the major findings and conclusions drawn from this research. This discussion is followed by the researcher’s recommendations for researchers and educators, as well as areas for further research.

8.1 Observation and Analysis of Children’s Thinking Processes and Skills

The first major finding of the study is that task analysis techniques such as thinking conversations, cognitive process maps, and visual models can be effective tools for the observation and analysis of seven to eight-year old children’s thinking processes and skills. A parallel may be drawn between the approach adopted in this study and cognitive task analysis (CTA). The techniques employed to collect and analyse data may be compared to the
knowledge elicitation and representation procedures in CTA such as protocol analysis and verbal analysis. The children in the study were treated as individuals to be observed and “experts” as far as their own thinking approach and skills were concerned.

The study demonstrates that the concept of thinking conversations can be used effectively as a technique to elicit information on children’s thinking processes and skills. Thinking conversations are informal conversations that engage children in thinking as they talk about their work and the strategies they employed in task performance. Useful data can be gathered in the natural classroom setting through such thinking conversations either while the children are engaged in their activities or about the work that they had just completed. The former may be considered as a form of observation that incorporates informal interviews and the latter a kind of informal reflective dialogue. Engaging children in thinking conversations draws the children’s attention to and encourages them to talk about aspects of their thinking. Thinking conversations encourage students to justify ideas, make judgments, and offer supportive reasons for conclusions reached. They provide children with the opportunity to make links between activities and learning goals, claims and evidence, and questions and information.

Data gathered through these thinking conversations can be analysed and interpreted using the techniques of cognitive process mapping and visual modelling in addition to narrative vignettes. Their functions are similar to that of knowledge representation in CTA, namely the display of data, presenting of findings, and communicating meaning. Cognitive process maps and the visual models can reveal information on both thinking skills and domain knowledge through the ideas and thoughts expressed by the children during thinking conversations. Cognitive process maps offer a clear and succinct visual display showing different aspects of thinking skills in relation to the children’s articulations about their ideas,
knowledge, or understanding at various junctures of the thinking conversation. The technique also allows for analysis of the sequential, convergent, or divergent nature of children’s thinking. Visual models, constructed from several cognitive process maps of a given thinking conversation, offer a means to manage the complexity of task performance in the form of a simplified picture of cognitive functions and processes to focus analysis and facilitate interpretation. The power of thinking conversations and cognitive process mapping lies in their ability to take into consideration 1) the emergent, unpredictable and situated nature of children’s performance; 2) the variety of contexts in which children manifest their thinking skills; and 3) the multiplicity of the children’s approaches.

8.2 Young Children’s Thinking Processes and Skills

The second major finding of the study is that seven to eight-year old children are capable of adopting their own individual approaches to task performance, which involve thinking processes that could be complex and varied across individuals and contexts. The diverse forms of reasoning processes that children engage in across different contexts were made evident in the study through the task analysis techniques of thinking conversations, cognitive process mapping, and visual modelling. Children’s strategies are not always effective and efficient and their performance depends on the inter-connected roles of their domain knowledge and their thinking skills. The children in the study demonstrated competence in various aspects of creative and critical thinking (see Appendix K: Final Coding Scheme for a succinct summary of these skills). At the same time, there were gaps in areas such as critical analysis and evaluation, logical reasoning, factual accuracy, misconceptions, false beliefs, epistemological understanding, domain knowledge, and conceptual understanding. There were also issues related to the ability to make a distinction between theory and evidence, inquiry and investigative strategies, the ability to analyse and understand
underlying principles of observed phenomenon, efficiency in decision-making, and effective problem solving. The findings also show that young children’s effectiveness in thinking and problem-solving can be impacted by a lack of structure or organised approach. Children’s approaches to open-ended and ill-structured tasks were organised and systematic in some cases, and poorly structured in others. This may be due to the difficulty they face in orchestrating processes, thinking skills, domain knowledge, and metacognitive skills to plan, monitor, and evaluate task performance.

A further and related conclusion is the unpredictable and emergent nature of the tasks and reasoning processes that children engage in within an open-ended learning environment. Some of the insights into children’s thinking in the study were obtained in the contexts of activities that would not be considered as part of usual classroom learning experiences. These include, for example, a question about a plastic poppy that led to a discussion on ANZAC Day (Chapter Seven), a casual joke shared with two children by the researcher, D’s card game, and B’s scheme to sell colourful paper stars (Chapter Five). The types of reasoning and the competence of the children were at times totally unexpected by the researcher or the teacher. I cited the examples of CD’s ability to question, evaluate, and recognise inconsistency and CP’s logical deduction in Chapter Five, and EM’s argument that exemplified modus ponens in Chapter Seven. The level of information obtained through the thinking conversations and the insights obtained through the subsequent analysis using cognitive process maps and visual models was surprising to the teacher in the course of the study. These findings exemplify the need to pay close attention and spend time to listen to what children have to say, as much as the effectiveness of the techniques employed in the study for data collection and analysis. They also suggest that children’s thinking and problem-solving approaches may not always be noticed, recognised, and responded to in the classroom.
One implication of the findings is that we cannot fully appreciate children’s competence without prolonged conversations with them and careful observation in order to establish an accurate picture or model of their thinking performance. Measures that are necessary to ensure that conditions are favourable for collecting accurate data include: 1) managing the power relationship between adult researcher and child; 2) building trust and relationship on an on-going basis; 3) showing respect and a genuine desire to know; 4) engaging with the children over a prolonged period; 5) being reflective, checking one’s own assumptions on a constant basis; and 6) being flexible, open-minded, and adaptive.

8.3 Formative Assessment of Children’s Thinking Abilities

The third major finding is that task analysis techniques employed in the study - thinking conversations, cognitive process mapping, and visual models of children’s thinking processes and skills - can provide formative information by identifying both competence and gaps in thinking skills. These techniques allow for open-ended observation and analysis of children’s learning needs because they take into consideration the emergent nature of children’s thinking and are not necessarily focused on preconceived aspects of children’s performance as in the case of tests or use of assessment rubrics. Cognitive process maps and visual models can be used to identify gaps in children’s thinking skills (“procedural knowledge”) and domain knowledge (“declarative knowledge”). Cognitive process maps and the visual models constructed from them can be viewed as visual representations that facilitates the assessment of the structure and process of a learner’s thinking approach and the elements of thinking skills employed in a given task performance. The visual representation offered by cognitive process maps makes it relatively easy to locate and evaluate a specific area of thinking skill or domain knowledge involved in the children’s thinking process.
Cognitive process maps and the visual models can also facilitate the process of comparing children’s performance to theoretical models for certain processes such as decision-making, problem-solving, investigation, and composition (Chapter Six). The comparison of children’s thinking processes to theoretical models offers another dimension to the analysis of children’s thinking competence by revealing the challenges that the children face and the areas where they could improve their performance. Theoretical models may be adapted from existing literature or derived from a combination of existing literature and elements identified in the cognitive process maps and visual models of children’s thinking processes.

A conclusion that can be drawn from the findings is that the task analysis techniques employed in this study can provide insights into the strengths and weaknesses in children’s domain knowledge, working theories, and thinking skills at a specific level needed for formative purposes. Such a level of specificity facilitates the integration of assessment with the teaching so that informed decisions can be made in relation to effective scaffolding and teaching intervention. The techniques can be potentially be adapted to support a differentiated approach to teaching thinking skills because they provide insights into what children are already capable of, what thinking processes they engage in as they perform tasks, and gaps in thinking skills that require teaching intervention. The findings show that the task analysis techniques in this study offer many of the advantages of performance assessment for young children:

- They can be conducted in the context of what the children are experiencing and form an integral part of instruction.
- They can provide meaningful information and take into consideration the emergent and situated nature of children’s learning.
• They are based on the premise that children construct and co-construct their understanding.

• They focus on the child, what the child is capable of, and what areas the child may need scaffolding, and not the child’s expected response to the teacher.

• They can take advantage of a variety of means or contexts whereby the child could demonstrate what he or she is capable of.

Furthermore, thinking conversations and cognitive process maps can yield information on the curriculum and learning at the broader level through multiple observations of classroom interactions and student task performance over a prolonged period to identify learning needs common among learners. Such broad level feedback can potentially play a useful role in supporting reflective teaching. In the study, the prevalence of divergent thinking in the classroom interactions was identified which prompted the teacher to reflect on her own practice and led to her recognition that she was encouraging a lot more creative thinking than critical thinking among the children.

8.4 Recommendations

Researchers and educators may consider adopting task analysis techniques such as those developed and employed in this study as additions to their repertoire of existing tools for research and assessment purposes in working with young children or even older students. It is crucial that adults pay close attention and listen carefully through prolonged engagement and informal conversations with children if the goal is to achieve a better understanding and appreciation of children’s thinking competence. It can also be useful to adopt the stance of a learner who does not know and who is looking for information from children, as well as to consider children as the “experts” as far as their own thinking approach and skills are concerned.
The potential and limitations of the data collection and analysis techniques employed in this study require further exploration, including the extent to which these techniques suffer from the same criticisms that are sometimes levelled at CTA - the complexity of the analysis, the amount of time and effort required, and whether they are too complex and cumbersome for practical settings. The issue of resources constitutes probably the greatest challenge to the use of these techniques in the classroom for assessment purposes. Further studies will be needed to examine the feasibility of these techniques in research studies and educational assessment. Issues such validity, reliability, and bias will also need to be investigated given the potential distortions inherent in asking the children to verbalise their experience and visual representation of data, the subjectivity and multiplicity of interpretations, and bias on the basis of language, cultural differences, and personal experiences. Further research will be needed to investigate the use of the techniques in other settings and with children of other age groups.

Finally, a rethink about what and how we should teach thinking skills in the case of young children may be necessary in view of the diverse range of tasks that children are likely to encounter and types of reasoning that they may be involved within an open-ended learning environment and in real life. Investigation is needed into questions such as whether or to what extent we should teach logical reasoning, influence children’s beliefs and conceptions, develop children’s epistemological understanding, or help them develop the ability to impose structure on open-ended and ill-structured tasks.
References


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Wegerif, R. (2004). Towards an account of teaching general thinking skills that is compatible with the assumptions of sociocultural theory. *Theory and Research in Education, 2*(2), 143-159.


Appendix A

The New Zealand School Curriculum
## Appendix B

### Implications of Constructivist and Pragmatic Positions on Selected Methodological Issues

<table>
<thead>
<tr>
<th>Ontology (What is the nature of reality?)</th>
<th>Constructivism</th>
<th>Pragmatism</th>
<th>Approach adopted for the study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple realities (Creswell &amp; Clark, 2007; Guba &amp; Lincoln, 2004; Hatch, 2002). “Knowledge consists of those constructions about which there is relative consensus ... among those competent ... to interpret the substance of construction” (Guba &amp; Lincoln, 2004).</td>
<td>Not committed to one system of philosophy and reality (Bloomberg &amp; Volpe, 2008; Creswell, 2007). Truth is what works, not based in dualism between reality independent of the mind or within the mind (Creswell, 2007). Knowledge claims arise out of situations, actions, and consequences, rather than from antecedent conditions (Bloomberg &amp; Volpe, 2008).</td>
<td>Multiple constructions of meanings. Subjective interpretation of meanings.</td>
<td></td>
</tr>
<tr>
<td>Epistemology (How we gain knowledge of what we know?)</td>
<td>Findings are the creation of interaction (co-constructed) between the inquirer and the inquired (Guba &amp; Lincoln, 2004; Hatch, 2002).</td>
<td>Practicality and what works (Creswell &amp; Clark, 2007). Combination of deductive and inductive thinking (Creswell &amp; Clark, 2007).</td>
<td>Co-construction of meanings. Researcher as participant observer. Emergent research design.</td>
</tr>
<tr>
<td>Research goal</td>
<td>Structure of the inquiry is necessarily emergent since the form and process of inquiry are dependent on interaction with participants and the context (Rodwell, 1998). Researcher acts as participant and facilitator (Guba &amp; Lincoln, 2004). Close relationship between researcher and research participants (Creswell &amp; Clark, 2007).</td>
<td>Close relationships with children. Deductive and inductive thinking</td>
<td>Deductive and inductive thinking</td>
</tr>
<tr>
<td>--------------</td>
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<td>---------------------------------------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Research goal</td>
<td>Understanding and reconstruction of the phenomenon being studied, including participants’ views and contextual setting (Creswell, 2007; Creswell &amp; Clark, 2007; Guba &amp; Lincoln, 2004). Theory generation (Creswell &amp; Clark, 2007)</td>
<td>Focuses on practical application and solutions to problems, and the outcomes of research and consequences of inquiry (Bloomberg &amp; Volpe, 2008; Creswell, 2007; Creswell &amp; Clark, 2007).</td>
<td>Understanding of children’s thinking processes and strategies through their voices &amp; perspectives. Practical considerations and solution to problem.</td>
</tr>
<tr>
<td>Data collection</td>
<td>Meanings constructed through discussions, interactions, and open-ended questioning (Creswell, 2007; Guba &amp; Lincoln, 2004). Naturalistic qualitative research methods (Hatch, 2002). Knowledge construction is a mix of the rational, serendipitous, and intuitive (Creswell, 2007; Rodwell, 1998)</td>
<td>Multiple methods that best meet the needs and purposes of the study (Bloomberg &amp; Volpe, 2008; Creswell, 2007). Observations and interactions through “thinking” conversations, reflective dialogues and interviews. Adaptation and “going with the flow” of events and activities in the research site.</td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Data analysis</td>
<td>Interpretation influenced by researcher’s personal, cultural, and historical experiences, and theoretical background (Creswell, 2007). Interpretive approach (Creswell, 2007). Inductively generate a pattern of meaning or theory (Creswell, 2007).</td>
<td>Not constrained by one particular research tradition or approach (Creswell, 2007). Multiple methods that best meet the needs and purposes of the study (Bloomberg &amp; Volpe, 2008; Creswell, 2007). Combination of interpretative data analysis (Hatch, 2002) and cognitive task analysis (CTA). Deductive and inductive approach to analysis.</td>
<td></td>
</tr>
</tbody>
</table>
Letter Seeking Access to School

27\textsuperscript{th} February 2009

The Principal
_______________ School
_______________ Dunedin
Attention: Mr. _______________

Dear ____________

Research Study on Young Children’s Thinking

As a follow up to our earlier conversation towards the end of last year, I write to formally request for your permission for access to one of your Year 3 classrooms and to seek the participation of ______________ and her students in my study of how young children think as they engage in problem-solving. This research project is part of my PhD study in the College of Education at the University of Otago.

Participation would involve my presence in the classroom as an observer once or twice a week - the actual schedule will be worked out with the participating teacher. The children would be observed in the course of their classroom activities. They would be asked to respond to open-questioning on a spontaneous basis or during arranged but informal interview sessions, and engage in reflective dialogue with the researcher. Each observation would last no more than two hours at a time. Interviews with selected individual children would only be conducted to supplement the data collected through classroom observations. Interviews with the children would be carried out informally during classroom hours and each interview would last between 15 to 30 minutes.

In addition, I would be conducting interviews or reflective dialogues with the teacher, which would not last longer than half an hour. These interviews and reflective dialogues would be carried out during school hours, no more than once a week.

The entire data collection process would probably last at least six months but no more than a year. Every effort would be made to minimise intrusion and disruption to classroom activities and routines, given that the aim of the research is to observe the children in the course of their usual classroom activities.

The participating teacher would also be asked to assist the researcher in terms of the process of explaining the project to the children using terms that they can understand, recruitment of volunteer children participants, and obtaining informed consent from parents and children.
I would be collecting observational data in the form of written field notes, and I may make video-recordings, audio-recordings or take photographs to supplement these notes. I may also collect or make photographic records of children’s work samples.

All data gathering would be undertaken on a confidential basis and with the consent of the participants and the children’s parents. Neither the school nor the individual participant would be able to be identified in the final report, or in any material used in conferences or publications. Enclosed are the Information Sheet and Consent Form for the teacher, as well as the Information Sheet and Consent Forms to be handed out to the parents and the children prior to the start of the project.

No one from outside the classroom or school, other than my supervisors and I, would view my data. Participants would be welcome to view photocopies of my observation notes and the transcripts of their own taped conversations.

The final report of the research study would be submitted to the College of Education at the University of Otago, and deposited in the University Library. Personal identifying information such as video-recordings, audio-recordings and photographs would be destroyed at the conclusion of the project but any raw data on which the results of the project depend would be retained in secure storage at the College of Education for five years, after which they would be destroyed.

My supervisors are Professor Helen May and Dr Mary Simpson of the College of Education at Otago University. If you have any concerns regarding the study at any stage, you are most welcome to contact them at 479 4914 ext 3780 and ext 8814 respectively.

I appreciate that this will be a generous commitment on the part of the school and the participants if you consent to take part in this study. At the end of the project and at your request, I would be prepared to present a summary of my findings or to offer a copy of my report. Noting your school’s interest in developing authentic learning programmes to promote students’ key competence, I would also be prepared to share any published material related to this topic that I might come across in the course of my research study.

Please feel free to contact me at 02 111 87 689 or wfleescott@gmail.com if you require any further information regarding participation in this research project. I shall be happy to meet with you for discussion or to make a short presentation to you and your staff, if you wish to know more about the project prior to making a decision.

Yours sincerely

Scott W.F. Lee
University of Otago
Room EG 02, College of Education
Appendix D

Consent Form for Children Participants

Ethics Committee Reference Number: 09/014
1st March 2009

Exploring children’s creative and critical thinking in problem-solving in an early years classroom setting.

CONSENT FORM FOR CHILD PARTICIPANTS

I have been told about this study and understand what it is about. All my questions have been answered in a way that makes sense.

I know that:

1. Participation in this study is voluntary, which means that I do not have to take part if I don’t want to and nothing will happen to me. I can also stop taking part at any time and don’t have to give a reason;

2. Anytime I want to stop, that’s okay.

3. Scott will write down, take pictures, video-tape or audio-tape me so that he can remember what I say, but the content will be deleted after the study has ended.

4. If I don’t want to answer some of the questions, that’s fine.

5. If I have any worries or if I have any other questions, then I can talk about these with Scott.

6. The paper and computer file with my answers will only be seen by Scott and the people he is working with. They will keep whatever I say private.

7. Scott will write up the results from this study for his University work. The results may also be written up in journals and talked about at conferences. My name will not be on anything Scott writes up about this study.
I agree to take part in the study.

Signed

Date
Information Sheet for Parents

Exploring children’s creative and critical thinking in problem-solving in an early years setting.

INFORMATION SHEET FOR PARENTS / GUARDIANS

Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not to allow your child to participate. If you agree to allow your child to participate we thank you. If you decide not to take part there will be no disadvantage to you or your child of any kind and we thank you for considering our request.

What is the Aim of the Project?

This project is being undertaken as part of the requirements for the PhD in Education. The aim of this research study is to explore young children’s creative thinking and critical thinking when they engage in problem-solving.

What Types of Participants are being sought?

The project seeks the participation of school children aged from 7 to 8 years and their teacher. Children with special needs will not be considered for participation in the project because, in the opinion of the researcher and the University of Otago Human Ethics Committee, it may involve an unacceptable risk to them.

What will Participants be Asked to Do?

Should you agree to allow your child to take part in this project, they will be observed in the classroom and asked to respond to questions posed by the researcher on a spontaneous basis or during arranged but informal conversation sessions. Subject to the day’s classroom activities, schedules and routines, each observation will last no more than two hours at a time. Conversations with the children will be carried out in an informal manner and each conversation will last between 15 to 30 minutes.

The entire data collection process is expected to last at least six months and no more than one year. The number of observations over a six-month period is expected to be approximately 50. Every effort will be made to minimise intrusion and disruption to classroom activities.
and routines, given that the aim of the research is to observe the children in the course of their usual classroom activities.

Please be aware that if you decide not to allow your child take part in the project, there will be no disadvantage to yourself or your child of any kind.

**Can Participants Change their Mind and Withdraw from the Project?**

You may withdraw your child from participation in the project at any time and without any disadvantage to yourself or your child of any kind.

**What Data or Information will be Collected and What Use will be Made of it?**

The researcher will write field notes, and he may make video-recordings, audio-recordings or take photographs. Personal identifying information such as video-recordings, audio-recordings and photographs will be destroyed at the conclusion of the project but any raw data on which the results of the project depend will be retained in secure storage for five years, after which they will be destroyed.

This project involves an open-questioning technique. Your child may be asked questions such as “How did you solve the problem?” “What did you try?” “Can you tell me why you chose to do it this way?” The precise nature of the questions which will be asked have not been determined in advance, but will depend on the way in which the conversation develops. Consequently, although the University of Otago Human Ethics Committee is aware of the general areas to be explored in the conversation, the Committee has not been able to review the precise questions to be used.

Please note that your child has the right to decline to answer any particular question(s) and also that your child may withdraw from the project at any stage without any disadvantage to him or her of any kind.

The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve your anonymity (and your child’s). You are most welcome to request a copy of the results of the project should you wish. The data collected will be securely stored in such a way that only those mentioned below will be able to gain access to it.

**What if Participants have any Questions?**

If you have any questions about our project, either now or in the future, please feel free to contact either:-

Scott Lee  
College of Education  
University Telephone Number: 479 9927

Or

Dr Mary Simpson  
College of Education
University Telephone Number: 479 4914 ext 8814

Or

Professor Helen May
College of Education
University Telephone Number: 479 4914 ext 3780

This study has been approved by the University of Otago Human Ethics Committee. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph 03 479 8256). Any issues you raise will be treated in confidence and investigated, and you will be informed of the outcome.
Appendix F

Informed Consent Form for Parents

Ethics Committee Reference Number: 09/014
1st March 2009

Exploring children’s creative and critical thinking in problem-solving in an early years classroom setting.

CONSENT FORM FOR

PARENTS/GUARDIANS

I have read the Information Sheet concerning this project and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage. I know that:

1. My child’s participation in the project is entirely voluntary.

2. I am free to withdraw my child from the project at any time without any disadvantage.

3. Personal identifying information photographs, video-recordings, and audio-recordings will be destroyed at the conclusion of the project but any raw data on which the results of the project depend will be retained in secure storage for five years, after which they will be destroyed.

4. This project involves an open-questioning technique. Your child may be asked questions such as “How did you solve the problem?” “What did you try?” “Can you tell me why you chose to do it this way?” The precise nature of the questions which will be asked have not been determined in advance, but will depend on the way in which the interview develops and that in the event that the line of questioning develops in such a way that your child feels hesitant or uncomfortable, your child may decline to answer any particular question(s) and/or may withdraw from the project without any disadvantage of any kind.

5. The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve the anonymity of my child.
I agree for my child to take part in this project.

.................................................................  ........................................
(Signature of parent/guardian)  (Date)

.................................................................
(Name of child)

This study has been approved by the University of Otago Human Ethics Committee. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph 03 479 8256). Any issues you raise will be treated in confidence and investigated, and you will be informed of the outcome.
Exploring children’s creative and critical thinking in problem-solving in an early years classroom setting.

INFORMATION SHEET FOR TEACHER PARTICIPANTS

Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not to participate. If you decide to participate we thank you. If you decide not to take part there will be no disadvantage to you of any kind and we thank you for considering our request.

What is the Aim of the Project?

This project is being undertaken as part of the requirements for the PhD in Education. The aim of this research study is to develop a rich description of young children’s creative thinking, critical thinking, and dispositions in order to inform classroom practice and facilitate teachers’ understanding, observation, interpretation and assessment of these aspects of their development. The study will seek to address questions such as: How do young children exercise creative and critical thinking in solving problems? What aspects of creative and critical thinking skills can be observed in young children’s problem-solving? What thinking dispositions can be observed? How do these dispositions influence their thinking and problem-solving? What do teachers and children themselves have to say about children’s creative thinking and critical thinking?

What Types of Participants are being sought?

The project seeks the participation of school children aged between 7 and 8 years and their teacher. Children with special needs will not be considered for participation in the project because, in the opinion of the researchers and the University of Otago Human Ethics Committee, it may involve an unacceptable risk to them.

What will Participants be Asked to Do?

Should the participants agree to take part in this project, they will be observed in the classroom, asked to respond to open-questioning by the researcher on a spontaneous basis or
during arranged but informal interview sessions, and engage in reflective dialogue with the researcher.

Classroom observations of children will be the primary data-gathering technique in this study. The duration of each observation will depend on the length of the day’s classroom activities, schedules and routines. Each observation will last no more than two hours at a time. Interviews will only be conducted to supplement the data collected through classroom observations. Interviews with the children will be carried out in an informal manner and each interview will last between 15 to 30 minutes. Interviews or reflective dialogues with the teacher will not last longer than half an hour. There will be no more than one interview or reflective dialogue session per week during the duration of the project. The expected time commitment involved in participating in the interview or reflective dialogue is approximately 14 hours over a six-month period.

The entire data collection process is expected to last at least six months and no more than one year. The number of observations over a six-month period is expected to be approximately 50. Every effort will be made to minimise intrusion and disruption to classroom activities and routines, given that the aim of the research is to observe the children in the course of their usual classroom activities.

The participating teacher will also be asked to assist the researcher in terms of the process of explaining the project to the children using terms that they can understand, recruitment of volunteer children participants, and obtaining informed consent from parents and children.

Please be aware that you may decide not to take part in the project without any disadvantage to yourself of any kind.

Can Participants Change their Mind and Withdraw from the Project?

You may withdraw from participation in the project at any time and without any disadvantage to yourself of any kind.

What Data or Information will be Collected and What Use will be Made of it?

The researcher will collect observational data in the form of written field notes, and he may make video-recordings, audio-recordings or take photographs to supplement these notes. He may also collect or make photographic records of children’s work samples. Personal identifying information such as video-recordings, audio-recordings and photographs will be destroyed at the conclusion of the project but any raw data on which the results of the project depend will be retained in secure storage for five years, after which they will be destroyed.

This project involves an open-questioning technique. The general line of questioning includes: “How do young children exercise creative and critical thinking in solving problems?” “What aspects of creative and critical thinking skills can be observed in young children’s problem-solving?” “What thinking dispositions can be observed?” The precise nature of the questions which will be asked have not been determined in advance, but will depend on the way in which the interview develops. Consequently, although the University of Otago Human Ethics Committee is aware of the general areas to be explored in the interview, the Committee has not been able to review the precise questions to be used.
In the event that the line of questioning does develop in such a way that you feel hesitant or uncomfortable you are reminded of your right to decline to answer any particular question(s) and also that you may withdraw from the project at any stage without any disadvantage to yourself of any kind.

The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve your anonymity and that of the school and the children involved in the study. You are most welcome to request a copy of the results of the project should you wish.

The data collected will be securely stored in such a way that only those mentioned below will be able to gain access to it.

Reasonable precautions will be taken to protect and destroy data gathered by email. However, the security of electronically transmitted information cannot be guaranteed. Caution is advised in the electronic transmission of sensitive material.

**What if Participants have any Questions?**

If you have any questions about our project, either now or in the future, please feel free to contact either:-
Scott Lee  
College of Education  
University Telephone Number: 479 9927

Or

Dr Mary Simpson  
College of Education  
University Telephone Number: 479 4914 ext 8814

Or

Professor Helen May  
College of Education  
University Telephone Number: 479 4914 ext 3780

This study has been approved by the University of Otago Human Ethics Committee. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph 03 479 8256). Any issues you raise will be treated in confidence and investigated, and you will be informed of the outcome.
Appendix H

Informed Consent Form for Teacher

Ethics Committee Reference Number: 09/014
1st March 2009

Exploring children’s creative and critical thinking in problem-solving in an early years classroom setting.

CONSENT FORM FOR TEACHER PARTICIPANTS

I have read the Information Sheet concerning this project and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:-

1. My participation in the project is entirely voluntary.

2. I am free to withdraw from the project at any time without any disadvantage.

3. Personal identifying information video-recordings, audio-recordings and photographs will be destroyed at the conclusion of the project but any raw data on which the results of the project depend will be retained in secure storage for five years, after which they will be destroyed.

4. This project involves an open-questioning technique. The general line of questioning includes “How do young children exercise creative and critical thinking in solving problems?” “What aspects of creative and critical thinking skills can be observed in young children’s problem-solving?” “What thinking dispositions can be observed?” The precise nature of the questions which will be asked have not been determined in advance, but will depend on the way in which the interview develops and that in the event that the line of questioning develops in such a way that I feel hesitant or uncomfortable I may decline to answer any particular question(s) and/or may withdraw from the project without any disadvantage of any kind.

5. The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve my anonymity.
I agree to take part in this project.

.................................................. ..................................................
(Signature of participant) (Date)

This study has been approved by the University of Otago Human Ethics Committee. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph 03 479 8256). Any issues you raise will be treated in confidence and investigated, and you will be informed of the outcome.
What are Thinking Conversations?

A “thinking conversation” is defined as an informal conversation that focuses on eliciting children’s thinking in much the same way as interviews are used to elicit expert knowledge in CTA. In a thinking conversation:

- The adult questioner is not “expert” holding the right answer(s) – the children are the experts.
- The adult questioner listens to understand rather than to test or correct.
- Questions are asked to gain information not to assess against a predetermined set of criteria.
- Objective is to explore children’s thinking and identify aspects for subsequent analysis, evaluation (using more targeted assessment tools for example), or intervention.
- Attention is on learning through the conversation rather than one specific outcome.

In thinking conversations, children’s attention are drawn to and encouraged to talk about aspects of their thinking. In thinking conversations, learners are encouraged to engage in reflective thinking, to justify ideas, to make judgments, and to offer supportive reasons for actions taken or conclusions reached. The goal of thinking conversations is to promote the understanding of others’ thinking and draw out the solutions/ideas/goals that are inherent within the task performance. Thinking conversations engage children in thinking as they talk about their work and the strategies they employed in task performance. The key difference between a “thinking conversation” and other forms of interaction between the adult and the children is that questions are posed to elicit information on children’s thinking rather than to
ascertain what they know, to determine what they have learned, or to communicate information to them. Important considerations concerning the role of the adult questioner include:

- Building rapport and trust (Dockett, Einarsdottir, & Perry, 2009; Smith, Duncan, & Marshall, 2005).

- Engaging with the children over a prolonged period (Creswell, 2007; Stephenson, 2009).

- Being a learner and showing genuine interest in knowing (Einarsdottir, 2007; Smith, et al., 2005).

- Fostering mutual respect (Sumsion, 2003) and respecting children as experts in their own lives, including their learning and thinking (Stephenson, 2009).

- Being prepared to adopt a variety of roles, including “friend”, non-authoritarian adult, and “least adult” (Davis, 1998).

Thinking conversations make use of open-ended questions such as:

- “How do you know that . . .?”

- “Why do you think that . . .?”

- “Can you tell me about or can you explain . . .?”

- “Can you tell me more about that?”

- “Why, how, or when do you do that?”

- “Why do you think that happened?”
Appendix J

Initial Coding Scheme

The list of 60 categories (11 for creative thinking and 49 for critical thinking) that formed my initial coding scheme was derived from my earlier study of young children’s creative and critical thinking skills (Lee, 2007), as well as a number of definitions and taxonomies found in literature listed below:


- Definitions and taxonomies in relation to creative thinking (Basadur & Hausdorf, 1996; Church, 1993; Craft, 2001; Davis-Seaver, 2000; Fink, Benedek, Grabner, Staudt, & Neubauer, 2007; Hu & Adey, 2002; Moseley, Elliott, et al., 2005; Okuda, et al., 1991; Pressseisen, 2001; Puccio & Murdock, 2001; Rodd, 1999; Runco, et al., 2006; Treffinger & Isaken, 2001; Vincent, Deker, & Mumford, 2002; Wilson & Murdoch, 2006).
The review of the literature listed above produced the following 60 categories for my initial coding scheme:

<table>
<thead>
<tr>
<th>Creative thinking</th>
<th>Evaluating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generate multiple ideas or alternatives (fluency)</td>
<td>Develop and apply evaluation criteria</td>
</tr>
<tr>
<td>Generate different / varied ideas (flexibility)</td>
<td>Recognise inconsistencies in information</td>
</tr>
<tr>
<td>Generate unique or novel ideas (originality)</td>
<td>Determine factual accuracy of statements</td>
</tr>
<tr>
<td>Generate detailed ideas (elaboration)</td>
<td>Assess accuracy of observation</td>
</tr>
<tr>
<td>Imagine</td>
<td>Assess credibility of sources of information</td>
</tr>
<tr>
<td>Create metaphors</td>
<td>Recognise ambiguities</td>
</tr>
<tr>
<td>Invent / design innovative solutions</td>
<td>Evaluate arguments, assumptions, evidence,</td>
</tr>
<tr>
<td>See new relationships among ideas, options and alternatives.</td>
<td>reasoning, or authority</td>
</tr>
<tr>
<td>Make new connections</td>
<td>Evaluate whether conclusions are warranted</td>
</tr>
<tr>
<td>Adapt ideas – add, expand, change, combine, or recombine.</td>
<td>on the basis of data given</td>
</tr>
<tr>
<td>Formulate own or different points of view</td>
<td>Distinguish relevant from irrelevant information, claims, arguments, or reasons.</td>
</tr>
<tr>
<td><strong>Clarifying</strong></td>
<td>Detect bias, stereotypes, clichés</td>
</tr>
<tr>
<td>Clarify ideas, issues, problem, question, conclusions, or beliefs.</td>
<td>Evaluate hypotheses</td>
</tr>
<tr>
<td>Clarify meanings of words or phrases / definition of terms</td>
<td>Question: raising or pursuing root or significant questions.</td>
</tr>
<tr>
<td><strong>Interpreting</strong></td>
<td><strong>Synthesising</strong></td>
</tr>
<tr>
<td>Understand, comprehend, or decipher written materials, verbal or nonverbal communications, empirical data, theoretical formulations, graphics, questions, etc</td>
<td>Summarise results of analysis or ideas generated</td>
</tr>
<tr>
<td>Explain the meaning of or make understandable / paraphrase, summarize, clarify meaning of written material or</td>
<td>Integrate parts, structures and inter-relationships together as a whole</td>
</tr>
<tr>
<td></td>
<td>Develop outcome by selecting, executing, completing and refining details of the product</td>
</tr>
<tr>
<td><strong>Organising</strong></td>
<td>Classify, categorise, group</td>
</tr>
<tr>
<td></td>
<td>Sequence</td>
</tr>
<tr>
<td></td>
<td>Prioritize, grade and rank</td>
</tr>
<tr>
<td>Verbal Communications</td>
<td>Analysing</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Place in the context of a situation or one's own experience</td>
<td>Identify elements of an argument: assumptions, premises, theories, principles, steps, conclusions</td>
</tr>
<tr>
<td>Identify purpose, theme, or point of view</td>
<td>Identify focus, central element, issue, question, reasons or conclusions</td>
</tr>
<tr>
<td></td>
<td>Differentiate fact from opinion</td>
</tr>
<tr>
<td></td>
<td>Examine the reasoning that links evidence with conclusions</td>
</tr>
<tr>
<td></td>
<td>Identify logical fallacies, contradictions, or inconsistencies in a line of reasoning</td>
</tr>
<tr>
<td></td>
<td>Make connections and recognise patterns and relationships, including forming conceptual links and associations</td>
</tr>
<tr>
<td></td>
<td>Compare similarities and differences</td>
</tr>
<tr>
<td></td>
<td>Identify knowledge gaps or needs</td>
</tr>
<tr>
<td></td>
<td>Determine cause and effect</td>
</tr>
<tr>
<td></td>
<td>Consider different viewpoints</td>
</tr>
<tr>
<td></td>
<td>Estimate and make educated guesses</td>
</tr>
<tr>
<td></td>
<td>Examine implications and consequences.</td>
</tr>
<tr>
<td></td>
<td>Analyse part / whole relationships</td>
</tr>
<tr>
<td></td>
<td>Identify pros &amp; cons</td>
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<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
# Final Coding Scheme

## Creative Thinking

<table>
<thead>
<tr>
<th>Categories</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generate multiple ideas or alternatives (fluency)</td>
<td>CREA-FLUE</td>
</tr>
<tr>
<td>Generate different / varied ideas (flexibility)</td>
<td>CREA-FLEX</td>
</tr>
<tr>
<td>Generate unique or novel ideas (originality)</td>
<td>CREA-ORIG</td>
</tr>
<tr>
<td>Generate detailed ideas (elaboration)</td>
<td>CREA-ELAB</td>
</tr>
<tr>
<td>Imagine</td>
<td>CREA-IMAG</td>
</tr>
<tr>
<td>Invent / design innovative solutions</td>
<td>CREA-INVENT</td>
</tr>
<tr>
<td>Make new connections</td>
<td>CREA-CONNEC</td>
</tr>
<tr>
<td>Adapt ideas – add, expand, change, combine, or recombine</td>
<td>CREA-ADAPT</td>
</tr>
</tbody>
</table>

## Critical Thinking

### Analysing

<table>
<thead>
<tr>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT-AN-FOCUS</td>
</tr>
<tr>
<td>CT-AN-PATT</td>
</tr>
<tr>
<td>CT-AN-COMP</td>
</tr>
<tr>
<td>CT-AN-GAPS</td>
</tr>
<tr>
<td>CT-AN-VIEWS</td>
</tr>
<tr>
<td>CT-AN-ESTIM</td>
</tr>
<tr>
<td>CT-AN-PART</td>
</tr>
</tbody>
</table>

### Clarifying

<table>
<thead>
<tr>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT-CL-IDEA</td>
</tr>
<tr>
<td><strong>Evaluating</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Develop and apply evaluation criteria</td>
</tr>
<tr>
<td>Recognise inconsistencies in information</td>
</tr>
<tr>
<td>Determine factual accuracy of statements</td>
</tr>
<tr>
<td>Recognise ambiguities</td>
</tr>
<tr>
<td>Evaluate arguments, assumptions, evidence, reasoning, or authority</td>
</tr>
<tr>
<td>Evaluate whether conclusions are warranted on the basis of data given</td>
</tr>
<tr>
<td>Question: raising or pursuing root or significant questions.</td>
</tr>
<tr>
<td><strong>Explaining and reasoning</strong></td>
</tr>
<tr>
<td>Justify one's reasoning / conclusions</td>
</tr>
<tr>
<td>Produce arguments, statements and assertions using supporting evidence and reasoning</td>
</tr>
<tr>
<td>Explain a point of view</td>
</tr>
<tr>
<td>Define and describe</td>
</tr>
<tr>
<td><strong>Inferring</strong></td>
</tr>
<tr>
<td>Make predictions or formulate hypotheses based on premises/evidence</td>
</tr>
<tr>
<td>Educe the consequences (e.g. from data and information)</td>
</tr>
<tr>
<td>Deduce logically</td>
</tr>
<tr>
<td>Draw conclusion, e.g. from information or data provided</td>
</tr>
<tr>
<td>Reason by analogy</td>
</tr>
<tr>
<td><strong>Interpreting</strong></td>
</tr>
<tr>
<td>Understand, comprehend, or decipher written materials, verbal or nonverbal communications, data, graphics, questions, etc</td>
</tr>
<tr>
<td>Explain the meaning of or make understandable / paraphrase, summarize, clarify meaning of written material or verbal communications</td>
</tr>
<tr>
<td>Organising</td>
</tr>
<tr>
<td>----------------------------</td>
</tr>
<tr>
<td>Classify, categorise, group</td>
</tr>
<tr>
<td>Sequence</td>
</tr>
<tr>
<td>Prioritize, grade and rank</td>
</tr>
<tr>
<td>Synthesising</td>
</tr>
<tr>
<td>Integrate parts, structures and inter-relationships together as a whole</td>
</tr>
</tbody>
</table>
Appendix L

Process of Analysis of Children’s Data

Draft summary & select excerpts into draft

Sort, review & integrate interpretations

Review data & coding against interpretations

Study memos for salient interpretations

Write memos with interpretations

Identify patterns & themes

Carry out CTA using vignette narratives, cognitive process mapping, & visual modelling

Develop cognitive process mapping technique

Write memos with initial impressions

Read data & coding line by line / units of meaning

Identify typologies & establish initial coding scheme

Add, delete, modify codes

Review with teacher

Review with teacher

Deductive

Inductive
Appendix M

Process of Analysis of Teacher’s Data

Read data for a sense of the whole

Review impressions previously recorded in memos

Read data, identify impressions, and record interpretations in memos

Study memos for salient interpretations

Read data, coding places where interpretations are supported or challenged

Write draft summary

Review interpretations against data on children

Write revised summary & identify excerpts that support interpretations
Visual Model of R’s Lunchbox Menu Project

- Create healthy lunchbox menus
  - Generate ideas
  - Elaborate by generating details

Evaluation criteria:
- Pricing according to size
- “Cannot be too expensive”
- Healthy components

Four types of lunchboxes:
- Components
- Pricing of components
- Total price of each lunchbox
- Names of lunchboxes

Synthesise & invent
Organise by classifying & categorising

Develop title & layout in columns
Construct one menu at a time & by components
Representation in writing & drawings
Names & prices for each box

Estimate / make educated guess
Draw conclusion & deduce logically
Evaluate information, assumptions, & conclusion
Analyse by breaking down into parts
Compare & contrast
Classify & categorise
Evaluate & recognise inconsistencies
Reason by analogy
Make assertions using reasoning
Justify one’s reasoning

Past experience regarding food prices
- Cafes
- MacDonald’s

Current knowledge
- Food prices
- Healthy vs unhealthy food

Adults’ inputs (including conflicting information) on what is considered healthy

Reference list of healthy food
Appendix P

Cognitive Process Map of Discussion on Skim Reading

When you’re flipping through it, what kind of reading is it?

Generate multiple ideas

You’re looking at the pictures  Seeing the text

What have you seen / noticed?

Generate multiple ideas

A play  Poem sort of thing  Weaving  It’s just a story about the web  Making something or other  Experiment to make gloves  An article  I saw something that gives me the itch

What you have done is one kind of reading... What you have done is skim reading
Appendix Q

Cognitive Process Map of Discussion on What is Text

Which ones of these are text?

- Generating multiple ideas
- Explain meaning
- Newspapers
- Magazines
- Like paragraphs
- Books without words
- Sign language
- Computer
- Text means like writing

Text are things that one can look at and get meaning from

One can get meaning from a movie, picture, poster or advertisement

- Make connections
- Sometimes people get confused when they get the word wrong while reading

What would people do in such a situation?

- Generating multiple ideas / alternatives
- You can read it again to understand what it means
- I just read the sentence again to see if I can make out what it means
- You can have a look in the dictionary
Appendix R

Cognitive Process Mapping and Visual Modelling as Assessment Tools
Overall Picture of Thinking and Learning Activities in the Classroom

Some teaching & learning activities observed

Integrated learning activities

Subject content teaching & learning

Play Discourse Inquiry Knowledge acquisition Comprehension Concept learning

Some thinking processes observed

Composition Problem-solving Decision-making Investigation Brainstorming Wondering

Some thinking skills observed

Inventing Clarifying Evaluating Synthesising Analysing Explaining

Generating ideas Elaborating Interpreting Organising Inferring Reasoning
Visual Model of S and E’s Healthy Lunchbox Menu

Create healthy lunchbox menu

Define goals

Aim to create 2 menus

Generate ideas
Elaborate by generating details

Select healthy components: Fruits, vegetables, muesli bars, marmite sandwich, yoghurt
Add in treats to balance out: crackers, biscuits, chocolate

Synthesise & invent
Organise by sequencing & prioritising

Develop title & border
Construct one menu at a time & by components
Representation in writing & coloured drawings

Compare & contrast information
Consider different views / possibilities
Deduce logically & draw conclusions
Justify one’s choice / reasoning

Classify & categorise
Define & apply selection criteria

Selection criteria
• Healthy & unhealthy food, & something in the middle to “balance out”
• Types of food according to appearance, taste & smell

Personal experience
• Taste of healthy food

Current knowledge
• Food categories
• Sugar can give energy, but too much
• Iron in marmite

Working theories of food
• Appearance
• Smell

Reference list of healthy food