Science and Mathematics Education Centre

A SOCIO-CULTURAL STUDY OF LEARNING AND TEACHING SCIENCE IN EARLY LEARNING CENTRES

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This thesis is presented for the Degree of
Doctor of Philosophy
of
Curtin University

February 2013

DECLARATION

To the best of my knowledge and belief, this thesis contains no material previously published by any other person, except where due acknowledgement has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature:______________________________

Date: 07.02.13

ABSTRACT

This study investigated, from a socio-cultural perspective, the science learning experiences of 3- and 4- year old children in three Early Learning Centres in metropolitan Perth Western Australia. The research addressed a major gap in the literature, given that, although there are numerous reports of studies focused on learning by 5- to 8- year old children, more is required in the way of theoretically informed studies of learning by children younger than 5 years, especially in relation to the learning of science. This study was important in the context of the current climate of restructure of Early Childhood Education (ECE) and Early Learning Centres (ELCs) in Australia.

The research was designed to answer four questions concerning: how science learning, for 3- and 4- year old children, is informed by a socio-cultural approach; to what extent science opportunities are provided in that context; what pedagogical strategies could advance current practices; and, the implications of the findings in relation to the enhancement of the learning and teaching of science in ELCs.

Beginning with an intensive review of literature related to learning in ECE, and framed by Vygotsky's socio-cultural theory, a theoretical framework was developed to underpin the study. This framework was elaborated progressively throughout the study, and ultimately named the *Socio-Cultural Approach to Learning and Teaching in Early Learning Centres: Science (SCALTELC-S*).

An interpretative paradigm guided the research methodology and included grounded theory and ethnography with multiple case study design. The researcher collected a wide range of qualitative data from the three ELCs, analysed the data exhaustively and interpreted them in terms of the *SCALTELC-S* to construct seven case studies. A cross-case analysis of the latter was undertaken to reveal commonalities, underlying themes and interrelationships amongst the seven Case Studies. These combined analyses informed the answers to the research questions.

Many factors (including resources, and national, State and local policies), were found to impinge on the learning and teaching of science in the ELCs, yet overall, it was found that although socio-cultural activities were visible the extent to which they were applied, for the enhancement of science learning, relied on the educator. Aspects of the latter which were particularly salient concerned recognition and use of learners' cultural knowledge and experiences, recognition of the interconnectedness of learning and cognitive development in ECE, creation of appropriate science-related learning environments, use of play as pedagogy and the development of effective communication skills.

This study makes a unique and significant contribution to both theory and practice related to the learning and teaching of science for 3- and 4- year old children. Specifically, it has produced a theoretical framework (the *SCALTELC-S*) which has potential to inform both research and practice in ECE; seven rigorous case studies which provide grass roots evidence for practitioners; and a cross-case analysis which takes that evidence to a more sophisticated level. Reflection on the findings reveal implications for ECE practitioners, for undergraduate training of ECE teachers, for professional learning of ECE educators and for future research and theorising.

DEDICATION

I dedicate this book to

Olivia and Amber

who have taught me well

ACKNOWLEDGEMENTS

Although countless hours have been spent on a seemingly isolated and never-ending journey this work could not have been accomplished with the help of many generous people.

The enduring patience and unswerving confidence in my ability by Lloyd, Olivia, and Amber has kept me buoyant as the epic voyage rolled on. Their constant love and whole hearted support has steered me to my academic destination.

I am immensely grateful to Professor Lesley Parker for the wisdom and guidance that led me through the rigours of educational research and composition. Her patient constructive advice has extended my scholarly ability beyond perceived competency. Likewise, I am indebted to Professor David Treagust and Professor Barry Fraser.

Thank you, Associate Professor Christine Howitt for convincing me to begin a research journey. Also, appreciation is extended to the children, teachers, parents and principals who selflessly provided the essential data for this study, and believed in the importance of the work. To the colleagues and workmates who have tolerated my distraction and interminable frustration during the thesis process, my sincere thanks. I have learned much from our conversations and your genuine interest for research into early childhood education.

For all other children who have walked through my life, and especially Sydney, Alexander and Emily, an enormous thanks. The generosity of spirit and inspiration from these children has enriched my days and continue to do so as they question explore and investigate our world.

To my special, long-term friends who have never given up on me, I am especially grateful. You have understood the requirements of my journey and given me room to manoeuvre.

Nothing exists in isolation. Together you have liberated me from my fear of academic achievement. I am blessed.

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FOREWORD

Real life is not scripted – and neither is teaching

"Where's the water gone? Look, it's all gone!" Three-year-old Brian had painted the path with water and between evaporation and porosity, the water had disappeared. As a result, curiosity was aroused and an opportunity to learn, presented.

In step with life, as we strive to understand our immediate world, the study of science responds with investigations, deductions, surprises and debate that seem infinite. As integral to life and connected to all we do, I see science learning and teaching for young children as a creative and intellectual adventure that represents possibilities of systems, patterns, construction, collaboration, measurements, experiences, and the unexpected.

If I can
Ask my own questions,
Try out my ideas,
Experience what's around me,
Share what I find;

If I have
Plenty of time for
My special pace,
A nourishing space,
Things to transform;

If you'll be
My patient friend,
Trusted guide
Fellow investigator,
Partner in learning;

Then I will
Explore the world,
Discover my voice,
And tell you what I know
In a hundred languages.

Pamela Houk (1998, p.293)

Chapter 1

Introduction and overview

1.1 Background

The study reported here was undertaken in Western Australia (WA), in the context of recent national policy changes which aim to bring a more systematic and consistent approach to the education of children in the years prior to compulsory schooling, namely from birth to five years of age. With respect to these recent changes, early childhood education (ECE) researchers and practitioners were quick to realise some of the implications. For example, while there is much valuable research on learning by 5- to 8- year old children, the implementation of Australian ECE changes required much more in the way of theoretically informed research on learning by 3- and 4- year olds, especially in relation to the learning of science.

There is general agreement amongst researchers in ECE that learning, for young children, is instinctive and driven by an inexhaustible curiosity and wonder (e.g. Fleer, 2007; Howitt, Morris & Coville, 2007; Millikan, 2003). Some also argue that science seems to be the natural place to start an educational journey for very young children because, from the curiosity and wonder children possess, educators are provided with clues that help develop the capabilities and intellect of the children they teach (e.g. Conezio & French, 2002; Johnston, 2009; 2011b). Regrettably, however, there is little evidence about the ways in which children's curiosity and wonder can be respected as learning tools and incorporated into the learning and teaching environment of 3- and 4- year old children, especially in the learning and teaching of science. The study reported here addressed this problem, through empirical research in fully operational early learning centres (ELCs), grounded in a comprehensive literature review.

This introductory chapter is sectioned into nine parts: First, the context of the study is explained with reference to ECE and the development of ELCs in Australia and, more specifically, WA. Second, the rationale for the study is presented in terms of gaps in existing research and the ways in which this study addresses those gaps. Third, the aims and questions that guided the research are stated and the fourth section provides an overview of the theoretical position, anchored in a socio-cultural approach. The fifth section presents a brief description of literature reviewed that led to the development of a theoretical framework to underpin this study. In the sixth section the research design is discussed before the findings are presented in the seventh section. Eighth the significance of the study is argued and finally, the ninth section presents a summary of the chapters of this thesis.

1.2 Context of this study

The specific context of this study, namely, three ELCs in Western Australia, evolved from a complex web of State and national government policies, decision-making and social action, reaching back more than a century. This complex web is outlined briefly below, with reference to the early history of Kindergartens in WA, the more recent history (especially in relation to the influence of national policies), some definitional issues resulting from the fragmented and interrupted development of ECE in Australia, a summary of the specific context of this study and, finally, a comment on the position of the researcher in the study.

Early history: WA kindergartens

Davidson (1997) has traced the early history of Kindergartens in WA back to the Legal and Educational Department of the Karrakatta Club in the 1890s. By 1907 pioneers in the Women's Service Guild of WA were campaigning for free Kindergartens to be made available for children in WA. The Guild's advocacy of free Kindergarten in WA was supported by the Children's Protection Society and based on the ideas of pioneering German educational theorist, Friedrich Wilhelm Frobel (1782-1852). Free ECE was at that time available in other states of Australia, namely Victoria, New South Wales and South Australia, but overall, there was a piecemeal and fragmented approach to ECE across Australia. The efforts of Bessie Rischbieth, an influential Vice-President of the WA Women's Service Guild, and those of other pioneering women led to the formation of the Kindergarten Union of Western Australia which was committed to the introduction and spread of Kindergartens across WA. The first free Kindergarten in WA opened its doors in 1912 (Davidson, 1997). During the past century, the notion of 'kindergarten' in WA has evolved under the influence of the State government, national policies, numerous non-government bodies and private individuals. As part of that evolution, the concept of Kindergarten being 'free' became lost. At the time this study was conducted (2008-2012), Kindergarten, unlike primary school education, was not freely available, and not compulsory.

More recent history, including the influence of national policies on ECE in WA

Recent history has seen increasing recognition of the demonstrably inconsistent approach to ECE across the states of Australia, and action by the Commonwealth government to introduce a nationally consistent approach to provide all of the nation's young learners with access to quality ECE. These changes to ECE can be traced back to the 1989 Council of Australian Governments (COAG) Hobart Declaration on Schooling when the goal to find a common age of entry into Australian schools was set, along with other national goals for schooling in Australia. The Hobart Declaration on Schooling was superseded a decade later by The Adelaide Declaration on National Goals for Schooling in the Twenty-first Century that included an emphasis on the status and quality of the teaching profession. In 2008 the Melbourne Declaration on Educational Goals for Young Australians reviewed and refined past goals and set a nationally consistent approach to strengthen ECE (Ministerial Council for Education, Early Childhood Development and Youth Affairs (MCEECDYA), 2008). Enhancing the status and quality of the teaching profession, for example, included reform that governed appropriate tertiary qualifications for ECE teachers and carers in all ELCs (see The Australian Children's Education and Care Quality Authority (ACECQA), 2010a).

Elliott (2006) explained that societal demands for quality childcare and early schooling had been profound in Australia's recent history. These demands reflected global trends and resulted in the current process of changes directly affecting the development of ECE and ELCs. Changes in the area of education and care for young children across Australia have continued to address societal demands, and elaborate the 2008 legislation in which COAG endorsed the National Partnership Agreement on Early Childhood Education (MCEECDYA, 2009).

Reforms affecting ELCs in Australia have been reported widely (see Cameron, 2009; Elliott, 2006, 2012; Fleer, 2008; Kilderry, Nolan & Noble (2004); Tayler, 2009). Cameron for example, noted that in 2008 COAG had "identified as a high priority improving early childhood development outcomes as part of a national collaborative approach" (Cameron, 2009, p.17). This was followed by the development of the national COAG supported framework: Early Years Learning Framework (EYLF) (Department of Education Employment and Work Relations, (DEEWR) 2009b). In accordance with the National Quality Framework (ACECQA, 2010a) the EYLF was launched by Minister Ellis in 2009 as the first practical phase of the National Quality Standards (NQS). The purpose of the EYLF is to inform educators and child-carers of the expected principles, practices and outcomes associated with the 2012 implementation of the National Quality Framework (NQF) for early childhood development (Ellis MP, Commonwealth of Australia July, 2009). The overall aim is to enrich the quality of learning for young children across Australia, and their transition into formal schooling (DEEWR, 2009b; Taylor, Flottman & Main, 2012).

The number of hours that children attend ELCs, their starting ages and the naming of groups of children remain nationally inconsistent. Operational inconsistencies can also be found within ELCs in WA. For example, the cost to parents for children to attend an ELC can differ from centre to centre, as can the number of hours available for them to use the service. Depending on the centre, an ELC can include children attending from one half day per week to 5 full days. Ages in an ELC can vary between birth and 8- years old. The make-up of an ELC attached to a school in WA for example, could include the compulsory years: Year Two and Year One, and non-compulsory years: Pre-Primary, Kindergarten and Pre-Kindergarten (see Cameron 2009; Dowling & O'Malley, 2009; Elliott, 2006 and Tayler, 2009).

Children in WA were, in 2007, beginning to attend Kindergarten (two years prior to compulsory schooling and as 3- turning 4-year-olds) in greater numbers. Pre-Kindergarten, which refers to three years prior to the compulsory Year One, had also begun in the first decade of the 21st century in some WA schools when privately funded places became available for 3-year old children (Cameron, 2009; see also Department of Education and Training (DET) 2010). At the same time, established community based Playgroups were being advocated by a national body, overseen by a state body and managed by parents of children attending the group (Playgroup WA, 2011). Playgroups cater for children from birth to 4-years old with aims that include providing opportunities for holistic social and cultural learning that reflect the local community (Playgroup WA, 2011). Playgroups are not licensed but groups are required to belong to the state body which in turn reports to the national body, Playgroup Australia. Playgroup Australia's roles include offering guidance for state bodies; seeking funding for special projects such as Play-Connect that supports children with Autism Spectrum Disorders and providing training for persons interested in voluntary administration positions (Playgroup Australia Ltd, 2006).

O'Sullivan-Myster (1996), and more recently, Wong (2007) have noted that, during these reforms and developments, the traditional view of ECE containing three distinct units (Year One and two years prior to Year One) was altering so that continuity of learning could occur for children as they moved from one ECE unit to another. At the time of this study in WA, Year One was the first year of compulsory schooling and catered predominately for 6-year old children (OECDL, 2012). Five-year old children have for many years attended government funded Pre-primary schooling in WA (the year before Year One). However, from 2013 that Pre-primary schooling will fall under compulsory attendance regulations (OECDL, 2012). Four-year old children may attend Kindergarten programs, but it is not compulsory to do so (Western Australian Legislation Education and Care Services National Law (WA) Act, 2012). A notable change for Kindergarten programs that has been gradually taking shape in society refers to a national initiative, called Universal Access. That national initiative aims to provide a quality early childhood education program for every child in the year before compulsory schooling from 2013 (Kindergarten in WA). Universal Access entitles 3- and 4- year old children to attend educational programs that are delivered by a qualified, four-year University trained early childhood educator, for 15 hours a week, 40 weeks of the year (DEEWR, 2012). This change will affect the population growth of 3- and 4- year old children in ELCs, and reflects the age group at the focus of this study.

ACECQA, an independent statutory authority that works in collaboration with the state and territory governments of Australia, provides leadership for improvement in ECE and oversees quality control, upgrading the services and the physical requirements as positioned by the National Quality Framework (NQF) (ACECQA, 2009b). Beginning in 2012, National Quality Standards (NQS) overseeing the NQF are being implemented across Australia (ACECQA, 2010b).

Specific context of the ELCs in this study

The three ELCs in this research consisted of two Pre-Kindergartens and one Playgroup attended by 3- and 4- year old children. While an ELC in Australia can cater for both ECE and childcare (Elliott, 2006) for the purpose of this study ECE was the focus and specifically the learning and teaching of science within an ELC. Observations were carried out during the years 2008 and 2009. The two participating Pre-Kindergartens were each part of a larger school, whereas the Playgroup was independent of educational and care centres. A summary of the possible attendance patterns and ages of children in WA's ELCs is presented in Table 1.1.

Table 1.1
Pattern of attendance in ELCs and compulsory schooling in Years 1 & 2 WA 2008

ELC Groupings	Days per week	Hours per week	Child's Age	Funding
Non-compulsory				
Playgroup	1	2-3	Birth- 4yrs	private
Pre-Kindergarten	½ - 4	3 - 20	3 - 4 yrs	private
Kindergarten	1-5	5 - 25	4 - 5 yrs	private & government
Pre-Primary	5	30	5 - 6 yrs	private & government
Compulsory				
Year One*	5	30	6 -7 yrs	private & government
Year Two*	5	30	7 - 8 yrs	private & government

Note: *Currently compulsory schooling. From 2013 Pre-Primary will become compulsory schooling and funding will be provided for 15 hours per week for all children attending non-compulsory Kindergarten.

Definitional issues

For the purpose of clarity, terminology and definition associated with this study are now addressed in three sections. The first section discusses terminology and ages of children in groups attending ELCs. The second defines the developmental domains of those children in the focussed age group of this study, and the third section, brings a common term to those adults who mentor the learning of those young children.

First, then, the complex evolution outlined above in the 'context of this study', has led amongst other problems, to considerable ambiguity in the usage of the terms such as 'Kindergarten' and 'Pre-school' under the umbrella of ECE. Along with the variation in the names of the groups, there also continues to be variation across Australia in the chronological age of children attending ELCs. This ambiguity pervades both official documents and the research literature in this area. In general, both Kindergarten and Pre-school terms are used rather loosely to describe education prior to the legislated compulsory years in different locations in Australia and overseas. Further, much overseas ECE literature reviewed to support this study did not provide specific ages of children. In that situation, the children were estimated to be between 4- and 6- years of age.

Second, to provide definitional clarity in relation to expectations of science capabilities for these young children, the 'developmental domains' approach as described by Campbell and Jobling (2012, pp. 4-5) has helped to situate this study with what might be expected of children in three age ranges: 0-3, 3-5 and 5-8 years. Specifically, and along with Campbell and Jobling, Johnston (2005b; 2009), and Saçkes, Trundle, Bell & O'Connell (2011) generalise that 3- and 4- year old children, in terms of science, would engage the use of their five senses to identify information. These researchers also point out that 3-5 year old children would be curious and interested in objects and living things that are a part of their world, able to make predictions, recognise similarities and change, articulate findings, ask and respond to pertinent questions, own a desire to investigate, formulate patterns, and begin to understand cause and effect.

Third, in this thesis, to describe the people in roles that assisted children's learning in this study and for clarity in reporting, the term 'educator' has been employed. This term was adopted because the qualifications and experience of those adults responsible for events recorded in the case studies of this research were found to vary significantly. Thus, the noun *educator* is used to identify parents, the classroom teachers, the researcher or the education assistant (EA) who made contributions to the children's learning and the verbs *teach* and *teaching* are used to describe the action of an educator in this study.

Position of the researcher in this study

The researcher in this study has been engaged in ECE for more than 25 years in a variety of roles spanning teaching in classrooms, principal of a junior school (with 310 students aged 4- to 8- years), educator of undergraduate pre-service ECE teachers, and provider of professional in-service learning for ECE teachers. During her career, the researcher's passion for and dedication to developing practical science studies for young children, and especially young girls' participation in science, has continued to be pursued in Australia and overseas. With this background, the researcher was one of those referred to at the outset of this chapter, who experienced concern about the impending changes in ECE in Australia, given that these changes impinge directly on learning by 3- and 4- year old children and that there is only limited research available, in relation to the learning of science, to inform the implementation of the changes, especially for children of this age. These concerns led directly to the rationale for the study, as discussed in the following section.

1.3 Rationale for the study

Commenting on the broader nation-wide changes occurring in ECE, Elliott (2006) explained that, while some "early childhood issues find public voice and advocacy, others struggle for recognition" (p. 6). Science in the ECE curriculum is one such area struggling to find voice (see Fleer, 2008). Science tends to be regarded mostly as something to be addressed in the later years of schooling (Fitzgerald, 2010).

The neglect of science education for younger children was recognised in a feasibility study undertaken in Australia by Fleer and March (2008) which recommended that "a national preschool [science, engineering and technology] SET professional learning and resource programme [be] developed to support early childhood professionals working with preschool children" (p. 6). Although this suggestion has not, as yet, been implemented the introduction of the EYLF provides some direction for principles and practices that are in harmony with the development of scientific skills and content.

> The EYLF offers many possibilities for science teaching and learning to occur; but it is up to each individual educator to be open and to search for opportunities to embed scientific skills, knowledge and processes into everyday programming. (Nolan, p.20, 2012)

The purpose of the EYLF was not to direct curriculum and therefore, it does not solve the problem of science neglect for young learners as raised by Fleer and March (2008). Nor was the problem solved with the implementation in 2010 of the new Australian Curriculum: Science (Australian Curriculum Assessment and Reporting Authority (ACARA), 2010). On a positive note, the needs of 5- year-old children in relation to the discipline of science were indeed acknowledged by ACARA and a level called 'Foundation', specifically aimed to cater for children in the year before Year One, was included in the new curriculum design. The Foundation level acknowledged the benefits of interconnectedness of learning for young children in agreement with the EYLF's multidisciplinary approach to learning and teaching.

Although science has been developed for primary school children (aged 6 years or more) in increments, the prospect of science for children younger than 8- years of age continues to be limited (ACARA, 2010; Fleer & Ridgeway, 2007; Fleer & Robbins, 2003; Pearson, 2002). Indeed, as pointed out by Fleer and Ridgeway (2007), research that had been conducted into the learning and teaching of science for young children has continued to fail to significantly improve the development of science for these youngest learners. Further, outcomes of that research have served early childhood professionals and pre-service teachers poorly (see also Fleer, 2009b; Saçkes, et al., 2011).

In terms of longitudinal studies Fleer and Robbins (2003) and Venville (2004) found published research that included science for children younger than 8- years of age was also minimal. One of the few longitudinal studies was undertaken by Saçkes et al. (2011) in the United States of America (USA). This study aimed to find out what, if any, impact young children's early science experiences in Kindergarten had on their science achievement three years later in their schooling. Revealing results of that study included that children who experienced opportunities to engage in science activities in Kindergarten achieved better results in science in Year Three. Saçkes et al. (2011, p. 231) noted that instruction in early childhood science was of "a major concern" and that adequate research into early childhood science learning had not been forthcoming.

From their research Saçkes et al. (2011) produced three major findings. First they indicated the importance of an early grounding in the studies of science for young children. The second findings was raised in the earlier research of Brenneman (2011), Howitt (2007) and others who found that, during their training, early childhood pre-service teachers admitted a lack of confidence and a poor perception about their own skills to teach science in ECE. The third finding identified that more research was required to assist the development of science for young learners. As indicated earlier, that third finding has also been raised by others, for example, Fleer (2009b), Mawson (2011) and Yelland (2011). Each of the three findings emphasised by Saçkes et al. (2011) is relevant, and in line with the direction of this study.

Science is seen by many as being related to humans in all they do, who they are, the space they occupy and all living and non-living matter associated with them (Sprod, 2011). From this perspective, science is a natural part of a child's life (Blake, 2010; Campbell & Jobling, 2012; Johnston, 2005a). The central nature of science within the life of a young learner is reflected as an insatiable curiosity that typically accompanies children in their quest to unravel the mysteries of their world (Blake & Howitt, 2009; 2010; Forman, 2010). The view is that when children use playfully interactive and social methods to learn, they effectively seek out the science of everyday living that, in turn, situates them in a place where emergent science skills and general knowledge can be based (Epstein, 2007; Fleer & Ridgeway, 2007;

Johnston, 2005b; Swain, Kinnear & Steinmann, 2010). Yet, despite the development of the Foundation level, the Australian Curriculum: Science and the EYLF, the imperative of science learning and teaching for children younger than 6- years of age remained largely unattended (S. Edwards & Cutter-Mackenzie, 2011).

By focussing on the learning and teaching of science for 3- and 4- year old children, this study aimed to address the gap in knowledge about how young children in ELCs develop their scientific skills, processes and knowledge, a gap alluded to also by Brenneman (2011), Mawson (2011), Saçkes et al. (2011), Yelland (2011) and others. Further, the new national imperative for comprehensive changes to ECE through the EYLF and thus, the NQS (ACECQA, 2010b) and the Australian Curriculum: Science (ACARA, 2010) presented circumstances for fresh and closer comment on science for young children in ELCs.

1.4 Aims and research questions

The primary aim of this study was to establish, through empirical research, learning and teaching practices associated with young children engaged in science activities in ELCs. The secondary aim was to find how these children moved their intellectual understanding of scientific concepts from curiosity through the process of participation and then report their findings. The study was grounded in socio-cultural theory which, as Fleer and others noted gives "new lenses and very different tools for thinking about the nature of children's learning" (Fleer, 2006, p. 5). It was also embedded within the whole learning and teaching program of ELCs. The four Research Questions and their sub- Questions that guided this research are presented and explained below.

1.4.1 Research Question 1

How is the learning of science by 3- and 4- year old children in ELCs informed by a social-cultural approach?

This first Research Question was framed to investigate the possibilities of incorporating a socio-cultural approach to the learning and teaching of science by 3- and 4- year old children. The question guided a thorough review of literature to first establish how young children generally learn when socio-cultural theory is applied. From that position the development of science learning and teaching was researched and a framework to guide this study developed, as described in Chapters 2 and 3.

1.4.2 Research Question 2

To what extent are the science learning opportunities provided in three ELCs for 3- and 4- year old children informed by socio-cultural theory?

Research sub-question 2.1

To what extent does the effective learning and teaching of science take place and under what circumstances?

Research sub-question 2.2

To what extent does the learning and teaching of science appear to be informed by socio-cultural theory?

The second Research Question and sub-questions directed the practical component of this study and guided data collection. From the opportunities and circumstances for learning and teaching science in ELCs for 3- and 4- year old children, and how collected data were informed by socio-cultural theory, seven case studies were constructed. In response to Research Question 2 and its sub-questions information was accumulated for Chapters 4 and 5 of this study.

1.4.3 Research Question 3

How can the learning of science by 3- and 4- year old children in ELCs be advanced by the use of pedagogical strategies derived from a socio-cultural approach.

Research sub-question 3.1

What can be learned to inform the enhancement of learning and teaching of science for 3- and 4- year old children in ELCs?

Guided by the framework developed from researched literature and the actual interpretations in the seven case studies, this third Research Question and its sub-question directed the analysis of the findings of this study. To accomplish this, a cross-case analysis was conducted to reveal existing factors and pedagogical practices in relation to science learning and teaching in the ELCs. Possibilities for enhancements of the circumstances and strategies used were discussed in Chapter 6 as a result of Research Question 3 and its sub-question.

1.4.4 Research Question 4

What implications do the findings of this study have in relation to the refinements of socio-cultural theory and the learning of science by 3- and 4-year old children in ELCs?

As a culmination of the study, and in light of accumulated researched information, the fourth Research Question was composed to address implications that could refine the future learning and teaching of science for young children in ELCs. Remaining mindful of the limitations that surfaced during the study, caution was exercised when drawing out these implications. Chapter 7 provides the study's response to Research Question 4.

1.5 Socio-cultural theory

Socio-cultural theory is attributed to Russian social psychologist Lev Vygotsky (1896-1934). It reflected his belief that the development of a community's culture served to define how children would develop and what they would learn, and therefore, is sometimes referred to as cultural-historical theory (S. Edwards, 2009). Vygotsky (1978), believed that children acquired knowledge through collaborative cognitive activity in their Zone of Proximal Development (ZPD) as a result of the interaction of two planes: the intrapersonal plane (the individual) and the interpersonal plane (between two or more people). He also championed cultural tools (such as language) and play as important contributors to cognitive development (Rogoff, 2003). As such, Vygotsky "has left a legacy of research on how cognitive development can be supported by social interactions" (Roopnarine & Johnson, 1993, p. 139).

In recent decades researchers including S. Edwards (2009), Fleer (2002; 2006; 2009c; 2010) and Robbins (2003; 2005) have argued that Rogoff's (1995) elaboration of Vygotsky's work, that connected the cultural community with the individual's planes of interpersonal and intrapersonal thought, was helpful to conceptualise socio-cultural theory and provide a useful framework for educators. Rogoff called these aspects that connected earning, 'the three foci'. Through the interrelationship of the three foci, individual thinkers are cognitively challenged to increase current knowledge and thus, become capable of transforming information for different situations. Socio-cultural theory therefore, influences learning rather than defines child development. Adaptation of that influence may vary, depending on cultural circumstances (Nuttall & S. Edwards, 2007). Influencing contributors that enhance cognitive development, and other components of socio-cultural theory, are discussed further in Chapter 2.

The fact remains however, that with or without Vygotsky's influence, little has been done to find out what science actually looks like for children under the age of 8-years (Fleer & March, 2008). Papic and Mulligan (2005, p. 211) added that "the complexities of young children's learning" required a holistic view of learning and teaching congruent with 21st century learning and consistent with socio-cultural theory. Similarly, Wilson (2007) explained that, because children had been engaged in scientific thinking and action that aligned intuitively with the relationships of socio-cultural theory before they first entered a classroom, science in ECE is a natural place to expand knowledge by continuing the journey of learning through day-to-day experiences (see also Fitzgerald, 2010; Goodrum, Hackling & Rennie, 2001; Howitt, 2008; Pearson, 2002; Tytler, 2007). Socio-cultural theory was therefore applied in this research to seek confirmation, or otherwise, that pedagogical strategies derived from a socio-cultural approach could be beneficial to the learning and teaching of science in ELCs.

1.6 Literature review and a framework of learning and teaching

At the outset of the study a review of literature was undertaken to establish knowledge about how young children learn, and then more specifically, to reveal how learning and teaching may be associated with the development of scientific skills and knowledge for young children. As is explained in Chapters 2 and 3, this resulted in the development of a framework for this study. Named the Socio-Cultural Approach to Learning and Teaching in Early Learning Centres (SCALTELC), this framework is made up of six major elements. The first cast of the framework (in Chapter 2) encompassed the general learning and teaching of 3- and 4- year old children in socio-cultural terms. The framework continued to evolve (in Chapter 3) to specifically examine science (SCALTELC-S) from a socio-cultural perspective.

The six elements of the framework that underpin this study emerged as an outcome of the author's review and analysis of the literature. The contributing elements were found to be: *interconnectedness*, *communication*, *cognitive development*, *play-based learning*, the *learning environment*, and the *active role of the educator*. These selected elements incorporate relationships that permeate socio-cultural activity and reflect the complexity of early education. An insight into that complexity was reported by Rogoff (2003). She explained that simultaneously cognitive, social, perceptual, motivational, physical, emotional and other processes, regarded as aspects of socio-cultural activity, interrelate and enable individuals to change their thinking through the shared endeavours and processes of learning that are built upon cultural practices. These six elements are now briefly introduced.

Interconnectedness encapsulates evidence that children do not learn in isolation but in connection with all else in their life. The dynamic and holistic learning that respects a child’s well-being, prior knowledge and cultural understanding are accentuated along with the interrelationships between people, objects and the environment (Robbins, 2005a; Rogoff, 1995).

Communication contributes important concepts for thinking that constructs and changes cultural views (Rogoff, 2003). Described as a reciprocal action by Luke and Freebody (2007), communication is about understanding or comprehending intended meaning. The complexity of communication being received and transmitted includes, among other mediums, verbal and non-verbal exchanges and is in a constant state of renewal. It captures multifaceted new technologies and forms a significant part of learning. Torr (2005) argued that the acquisition of “language is the currency of learning” (p. 95).

Communication naturally exposes the complex nature of *cognitive development*. This element of the framework helps thought processes, memory, recall, questioning skills and forms the connection and arrangement of information into understandable parts (Johnston, 2005a). Cognitive development encompasses the skills of thinking that attends to theoretical and practical learning (Vygotsky, 1978). Comprehending and processing information is a life-long cognitive task (Swain et al., 2010).

The notion of an amalgamation of play and intentional teaching to develop science was distilled for the element of *play-based learning* and contributed an essential part of the framework. Play, as a fundamental and “powerful learning medium” brings together all aspects of the framework through the alliance of children’s investigative skills, curiosity, social and intellectual growth (Degotardi, 2005, p. 145).

The *learning environment* in which young children play and learn is a crucial addition to the elements of the framework in this study. Whether natural or thoughtfully constructed, the physical attributes of a learning environment can act as a provocative and powerful teacher through interactive circumstances and contributing parts (Fleer, 2008; Malaguzzi, 1998).

There is no one dominant element within the SCALTELC-S framework. However, the *active role of the educator* is a compelling one. For children to benefit from this socio-cultural inspired framework, the educator’s role is one that actively supports and encourages the competencies, potential, resourcefulness and relationships that advance children’s learning (Arthur, Beecher, Harrison & Moranindi, 2003).

1.7 Research design and data gathering

The interpretative paradigm of this research was derived from a Vygotskian socio-cultural viewpoint that acknowledged, as implied earlier, that children do not learn in isolation.

Research design

Consistent with an interpretative approach, this study pursued a qualitative and pragmatic approach, incorporating grounded theory and ethnographic research approaches. Multiple case study design and multiple methods of data collection were considered appropriate and necessary when young children are the focus of data collection for research purposes (Einarsdóttir, 2007). Children, at the age of the participants in this study, are described as being typically energetic, social and spontaneous (Talay-Ongan & Ap, 2005). That energy, Einarsdóttir (2007) argued, is also likely to be associated with relatively impulsive, unpredictable behaviours and other characteristics as social acumen is developed and emotional intellect formed within the multifaceted activity of an operating ELC.

Data collection, analysis and interpretation

The researcher in this study was the sole instrument of data collected from within the reality of day-to-day experiences for young children in ELCs. Merriam (1998) cautioned that an awareness of researcher-bias was required during the analysis and interpretation of data collected when the researcher was the primary instrument. This position is explored further in Chapter 4.

Methods included passive and active observations, casual conversations and semi-structured interviews, along with photographs and artefacts. Notes made by the researcher, along with ideas and comments related to the science experiences observed in three independent ELCs, were collected into a field research journal at the time of occurrence, and reflected upon later, for elaboration and validity. The accumulated data were validated by adult participants, analysed exhaustively, interpreted in terms of the emerging SCALTELC-S framework and presented in seven case studies, each of which represented an example of the learning and teaching of science in an ELC. The seven case studies were then synthesised in a rigorous cross-case analysis, again referenced to the SCALTELC-S framework, to reveal both unique and common factors. Interpreted strengths and weaknesses associated with the learning and teachings of science in ELCs emerged from the findings.

Recognising strengths, weaknesses and possible limitations of the research

As described in more detail in Chapters 4 and 7, the approach outlined above carried with it some strengths (for example participants' perception of the researcher as an experienced, authentic and highly credible ECE educator), but also some weaknesses, with the latter contributing to possible limitations of the study. While steps were taken, as described in Chapter 4, to mitigate these weaknesses, it was nevertheless recognised throughout the study that some were particularly important and needed to be taken into account when considering the findings of the research.

For example, being the single researcher in this study held twofold limitations: First, there was the possibility of researcher bias in both the recall of events, and through personal opinion that could have been coloured by her past experience of working with young children. Second, it was likely that, with extra researchers, accumulated data would have represented a more finely grained view of what science looked like in ELCs. To address the limitation of having one researcher with extensive experience in early childhood education, this researcher's general beliefs and understandings about science learning and teaching were discussed and clarified with participating classroom teachers and parents and the study's supervisor, throughout the data collection period.

Relinquishing the role of teaching science by the classroom teacher to other persons was found to limit authentic data collection in two case studies. Also, when a classroom teacher cancelled a planned science learning experience, the collection of data was further limited.

The variety of educator qualifications working with children in this study brought limitations in association with making generalisations about expectations associated with training and delivery of science experiences. For example, during data collection it was found that the Education Assistants (EAs), who had minimal experience in their role, were the only adults in the two ELCs attached to schools that had specific ECE training. However, the classroom teachers had had several years of experience working in ECE. On the other hand, parents who were the educators in the Playgroup situation brought expertise, without ECE qualifications, from their intimate knowledge of their own child. The variation of educator qualifications reflected in this study continues to undergo change across Australia and is affected by political changes described earlier in this chapter. Additionally, those policy changes brought distractions that were notionally affecting the operation of an ELC.

Considerable reform within the educational landscape of ELCs in Australia was underway when this study was being conducted. That developing landscape placed extra demands on an educator's time for the related professional learning required to address the imminent changes to the practices and principles associated with ELCs. This, in turn, occasionally represented limited time for discussion with the researcher. These circumstances were respected by the researcher who, like the classroom teachers, also needed to be informed about the impending restructure for ELC principles and practices, and sympathetic to any pressure this brought to bear for the participating educators.

Incidental limitations were found to surface during the study due to the multidimensional characteristics of activities that, at times, led to the unsettled nature of the children or changes of plan by the educator. Sometimes these unplanned actions produced incomplete science activities, yet illuminated the complexities associated with pragmatic research in an ELC context. Along with limitations already mentioned, the unpredictable nature of this empirical study highlighted further the need to exercise caution when considering implications arising from reflections. A limitation can also be drawn from there being only three ELCs represented in this study, and that they are all found in metropolitan Perth WA, thus possibly limiting the extent to which the findings of this study are generalisable to other ELC contexts.

1.8 Findings

Although, as discussed in detail in Chapter 6, many factors impinged on the learning and teaching of science in the three ELCs, overall, it was found that the role of the educator was of paramount importance. This involved, in particular, the extent to which the educator implemented a socio-cultural approach and acknowledged that children were competent, resourceful individuals and capable of contributing to their own learning. Especially critical factors for the educator included recognition of children's prior learning, recognition of the interconnectedness of learning and cognitive development in the context of young children, creation of appropriate science-related learning environments, use of play as pedagogy and development of effective communication skills. Further, children's interactive engagement, guided by a socio-cultural approach, was advantageous for new and functional science-learning. That advantage was found to be magnified when educators intentionally and knowledgeably contributed to the learning experiences.

It was also found that the SCALTELC-S framework was helpful in distinguishing elements of learning and teaching that made explicit the interrelationships occurring between the people, the environment and resources when children were developing their science know-how. Additionally, the findings indicated that science could be the catalyst for interdisciplinary learning in ELCs by 3- and 4- year old children. From the synthesis of the case studies it was found that teaching, like learning, is multifaceted. Similarities and differences in pedagogy and practices permeated the learning and teaching of science, and the strategies used were found to be more successfully applied in some instances than in others. Thus, the investigation found that consistent patterns of science learning and teaching in ELCs did not appear to exist. In some instances the educator either led or guided science experiences, while in others children built their own understanding of scientific concepts. Convincing evidence regarding a collaborative approach between the educator and the children, or prevailing value of and inclusion of science learning and teaching in ELCs was also not found. These findings are elaborated in Chapter 6.

1.9 Significance and implications of the study

Due to the nature of this study, and the limitations outlined above, caution must be exercised in drawing out its significance and implications. Nevertheless, as a consequence of this practical research, more evidence is now available regarding in-situ science experiences for children under the age of 5-years and the findings suggest also that science may not be well represented in ELCs in WA.

Overall, in light of there being negligible pragmatic evidence recorded about the emerging science skills of young children, this research makes a substantial and significant contribution on four counts. First, empirical evidence has been gained from diverse and fully operational ELCs. Second, findings from this study contribute to closing an acknowledged gap in research related to the learning and teaching of science in ECE. Third, a supporting theoretical framework has contributed to the understanding of how young children learn within a socio-cultural environment, while developing early skills in science. Fourth, the study reveals the imperative for specific reforms in ECE and ELCs across Australia.

The significant and original basis of this study with in-situ evidence brings both practical and theoretical information about what science looks like for 3- and 4- year old children in ELCs. Elaborating previous research in this field, the study found that the active role of the educator is pivotal for the success or otherwise of science learning and teaching in the early years of education. Also, the importance of educators understanding the fundamentals of learning and teaching scientific concepts to achieve this is obligatory training (Sprod, 2011). Further, the knowledge that science in ELCs needs to be "re-imagined" (Tytler, 2007, p.67) and integrated into the lives of young children as they develop their scientific skills for future schooling is significant.

To support those findings, the SCALTELC-S framework highlights how science learning and teaching can be readily re-imagined and amalgamated within children's general learning capabilities. The potential of the SCALTELC-S framework is intensified when considered for its significance in pre-service training of undergraduate educators and used as a helpful tool for educators, already working in the field of ECE, to define science learning and teaching.

As indicated earlier in this chapter, this study is situated in the context of national changes underway in ECE and brings a significant new voice to advocate science in ELCs. During the current changes, the circumstance to address the reported gap in knowledge about how young children develop their science knowledge and skills, and herald its importance in the curriculum, was seen by the researcher as both fortuitous and constructive. This study then is significant. It has added to the reported limited empirical evidence from ELCs describing the relationship between young children and science. Details of the implications of the research for theory, practice and reform in ECE education are discussed in detail in Chapter 7.

1.10 Overview of the thesis

This first chapter has described the process of this research and, from a national perspective, contextualised ECE in ELCs within WA. The rationale for undertaking the study, the research questions that guided it and the significance of the study were also introduced.

Chapters 2 and 3 present an appraisal of literature that informed a view of socio-cultural theory in relation to ECE in general and in particular, science in ELCs. These chapters trace the development of the initial theoretical framework, SCALTELC that underpinned this study and its progression to become SCALTELC-S, as science was emphasised and the study advanced.

Details of methodology and the practical, multiple methods of data collection are explored in Chapter 4. Seven case studies are assembled from data collected and the ELC context from which they are constructed are presented in Chapter 5. A discussion about the opportunities provided for children to develop their skills and knowledge associated with science is also presented in Chapter 5.

Reflecting the SCALTELC-S framework, Chapter 6 presents a synthesis of commonalities and unique factors that occurred across the seven case studies. Those factors emerged from a cross-case analysis to provide interpretations and the findings of the study. Implications, in relation to the analysed findings, are elaborated in Chapter 7 in response to each of four Research Questions. The culmination of those implications, including ideas for future research and theorising is presented before the concluding comments of this thesis.

Chapter 2

Socio-cultural theory in early childhood education

2.1 Introduction

As the first of two literature review chapters this chapter reviews research bearing on the application of socio-cultural theory to learning and teaching in ECE. It starts with an overview of socio-cultural theory then presents this study's unique, conceptual framework (SCALTELC). The framework is based on six key practical and theoretical elements that emerged during the process of this review: *Interconnectedness*, C*ommunication*, *Cognitive development*, *Play-based Learning*, *Learning Environments* and the *Active Role of the Educator*. These six elements are discussed in relation to their potential to inform learning and teaching in ECE. This sets the scene for the next chapter wherein the implications and specific applications of socio-cultural theory in relation to the teaching and learning of science for young children in ELCs are discussed.

2.2 Socio-cultural theory

According to Vygotsky (1978), during the process of developing new knowledge, children learn first on a social level then on an individual level, in line with cultural understandings. This two stage learning (described as 'planes' of interpersonal and intrapersonal in Chapter 1) suggested that children require social interactions where meaning can be clarified with others (Robbins, 2005a), and times of contemplation (Millikan, 2003) when stored cultural understandings can be reconceptualised. Vygotsky (1978) articulated this socio-cultural position of learning as when children spontaneously processed and transformed old information with new information.

The old information, he elaborated, accompanies children from their past experiences and cultural understandings to new knowledge. Goodfellow and Hedges (2007, p.192) argued these transformations can be represented as voice, metaphor or dialogue when new knowledge is established. Robbins (2005a) held that the connection, between old and new information, helps young learners understand new situations and thus, their current place in the world. Whereas Fleer and Robbins (2003) reasoned that children create their new knowledge when past social and cultural experiences are aligned with new social and cultural positions.

Rogoff (2003) emphasised that the interconnectedness of learning and the interrelationships between social contact and cultural artefacts (including signs and symbols of language) come from within learning environments. The collective name Rogoff gave to the three major contributors of socio-cultural theory was the 'three foci' (Anning, Cullen &Fleer, 2009). Rogoff emphasised that the three foci: the intrapersonal focus, interpersonal contacts and the cultural influence of physical objects and the environment, were not segmented parts but were constantly interrelated and interdependent of each other as social relations and cultural experiences transformed thinking, and created new knowledge. Fleer (2002) argued that Rogoff's (1995) research gave new lenses to socio-cultural theory that provided a useful framework for the teaching and learning process and planning, in early education. Robbins (2005a) added later that where the flexible elements that contribute to learning, from the perspective of the socio-cultural theory remain fixed, interrelationships can change.

An ELC embedded in socio-cultural theory is a place where learning is influenced by the environment and a community of people who acknowledge the social interactive nature of children's learning, and their cultural differences. Kaesing-Styles and Hedges (2007) explained that a learning community using socio-cultural activities would recognise how the complex daily interplay between policy, curriculum and philosophies, connects the multiple viewpoints of the children, teachers, parents and management. This, in turn, creates the interrelationships that unite the cultural differences into which children are born, and continue to grow (Talay-Ongan & Ap, 2005). Within communities designed for learning, Greenman observed that it is the "people and program [that] will determine whether the connections and relationships are put to good use" and benefit developmental learning for children (2007, p. 94). S. Edwards (2009) explained that socio-cultural theory influences, rather than defines, child development. She continued that, although a learning community may espouse socio-cultural theory, a complete shift to this model would be questionable because developmental theory, which has been entrenched in ECE for many years, mostly remains the focus of learning and teaching in Australia.

In making socio-cultural theory visible, S. Edwards argued that "[t]he work of Vygotsky, Rogoff and Gardner and the project work in Reggio Emilia, Italy, have added depth and understanding to the way teachers view work with children and their families" (2009, p. 5). It is through socio-cultural lenses that Millikan (2003) viewed children in the Reggio Emilia model, as contributors to their own intellectual and personal cognitive growth because of their innate curiosity, ability to self-regulate and their genuine desire to learn. It is from their own existence, Millikan continued, that children are capable of advancing their own intellect due to their curious, natural playfulness and grow to become independent creators of new culture and knowledge. S. Edwards found that although different in intent, Reggio's interpretations of socio-cultural activities "point to a shift in the traditional reliance of developmental theory" (2009, p. 9). In support of that view, references are made throughout this study to the Reggio Emilia interpretations of socio-cultural theory.

2.2.1 Theoretical components of the socio-cultural learning theory

Vygotsky placed the interrelationship of cultural information and social engagement at the centre of socio-cultural theory and accentuated the important role of intergenerational history and the sharing of knowledge between home and the school to acknowledge cultural differences and the effect these differences had on learning (Rogoff, 2003). A key component of the socio-cultural learning theory is recognising that social and cultural development is dynamic and that children themselves are also constantly changing (Anning et al., 2009). As interpreted by Klein (cited in Tytler, 2007, p. 34) learning relates to an "adaptive phenomenon" in that new understanding is influenced by characteristics of learning such as the transformation of information, significant and positive effects, thinking skills and individual endeavor. Because the present is constructed by components of past cultural and historical knowledge, Swain et al. (2010) argued that Vygotsky's theory of learning was in a constant state of being "simultaneously new and old" (p. x). It is therefore implicit that all parts of learning are continuously being renewed and impacted by social and cultural influences (see also Robbins, 2005a; Rogoff, 1995; Tytler, 2007; Wong 2005).

Wong (2005) identified that key theoretical components of socio-cultural theory would help educators recognise the dynamic and complex nature of learning individual children bring into the school setting. Yet, while socio-cultural theory gains momentum in discussions about its inclusion in contemporary early childhood, curriculum questions are being raised regarding different interpretations of the theory that exist in literature. Interpretations have caused some confusion between developmental stages of learning and the mutually constructed socio-cultural approach to learning (Kaesing-Styles and Hedges, 2007). These researchers hold that rather than having an influence on learning, socio-cultural theory should be seen as the driver of development itself. S. Edwards (2009) argued that while socio-cultural theory can be overt in planning, it is usually covert in practice. She added that a complete shift to socio-cultural theory in ELCs would be questionable because of a maintained and strong influence of developmental learning that is evident in many learning institutions. While in a process of change, Edwards reasoned, a combination of theories would more likely advantage children's learning and the teaching curriculum than would one traditional model.

2.2.2 A new conceptual framework

Rogoff (2003. p.284) found that learning "is a process of changing participation in community activities." Positioned in six practical and theoretical learning and teaching elements that have emerged from the review of literature are overt and covert examples of community activity that closely reflect socio-cultural theory in early education. As explained in Chapter 1, these six elements represent the complexity that is young children's learning and, through their multifaceted connections, they underpin this study's conceptual framework. The framework, Socio-Cultural Approach for Learning and Teaching in Early Learning Centres is named SCALTELC and is presented in Figure 2.1.

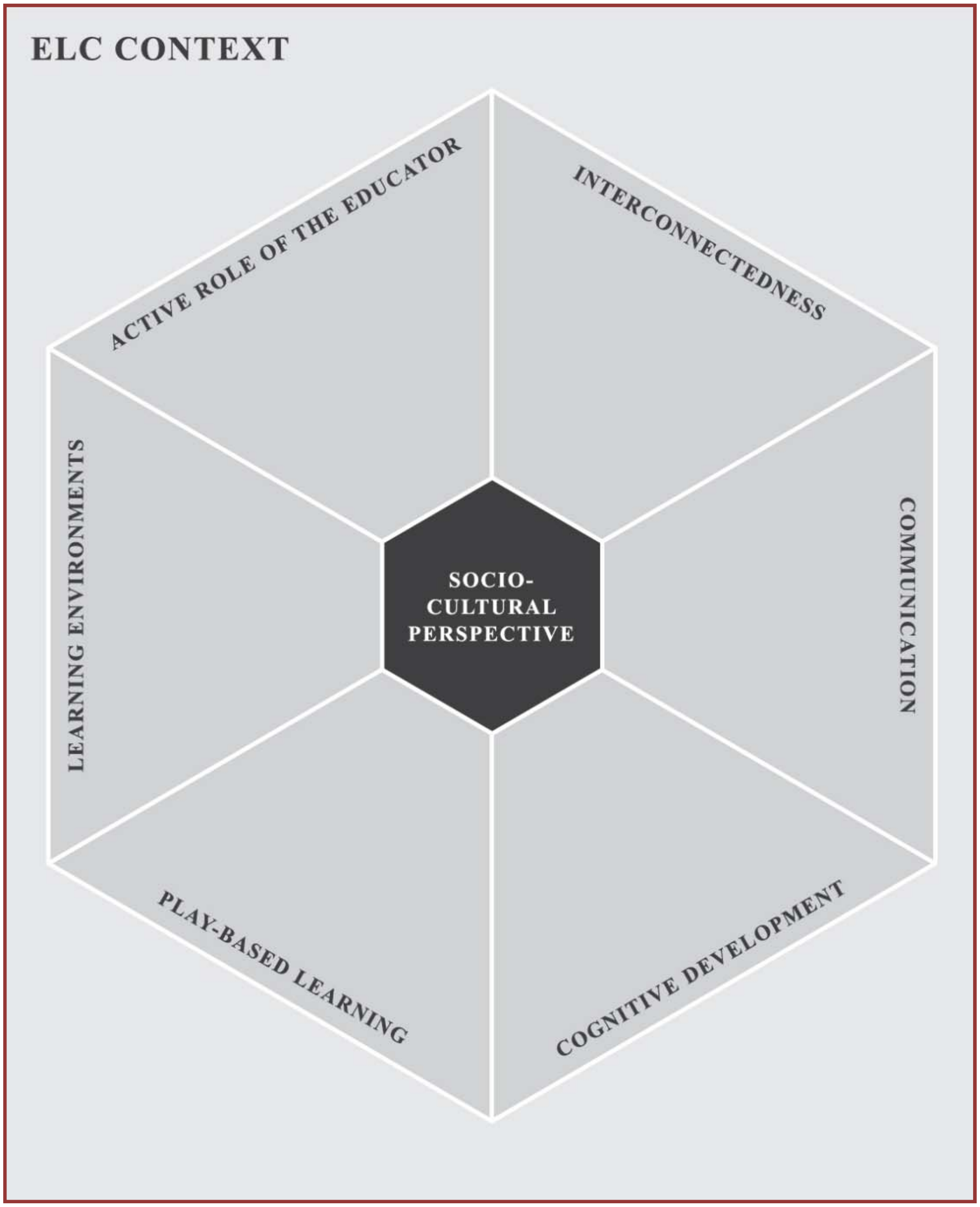

Figure 2.1 The SCALTELC framework: Initial representation

2.3 Conceptual framework

The six key practical and theoretical elements in the SCALTEC framework are *Interconnectedness, Communication, Cognitive development, Play-based Learning, Learning Environments*, and the A*ctive Role of the Educator* as included in Chapter 1 (p.15). As discovered in the literature review these elements are interdependent and not intended to represent a specific order of priority, preference or importance. The elements of the SCALTELC framework, and the concepts that elaborate each element, are discussed in the following sections.

2.3.1 Interconnectedness

The socio-cultural view of the interconnectedness of learning posits that "[h]uman development is a cultural process" and therefore, new knowledge is not formed in isolation but is always connected to the multisensory elements contributed by people, places of learning and cultural objects (Rogoff, 2003, p.3). According to Vygotsky's theory, "the efforts of individuals are not separate from the kinds of activities in which they engage and the kinds of institutions of which they are a part" (Rogoff, 2003, p. 50). Proponents of Vygotsky's theoretical approach, such as Rogoff (2003), Fleer and Robbins, (2003) and Johnston (2011a), argued that the inclusion of information about the diversity of children's cultural heritage, learning styles, and their capabilities are important components of thoughtful pedagogy, found within the connectedness of young children's learning and socio-cultural activities. Although these combinations may produce multifaceted challenges for some educators when learning is analysed, children's learning is more likely to be connected, meaningful and continuous when their prior knowledge, derived from their historical cultural perspective, foregrounds educative situations (Fleer, 2007; Robbins, 2005a). These researchers also predicted positive consequences for both children and educators when shared learning situations were undertaken from the socio-cultural perspective.

Fleer and Robbins (2003), Johnston (2005a) Elias (2009) and Katz (2010) agree that learning does not exist in isolation, and that the crux of children's social and emotional development, and cognitive and academic growth, is reliant upon the interconnections that come from their experiences and cultural being. Culture, Rogoff explained, is not static but rather a part of the interconnectedness of learning as it is "inherited and transformed by successive generations and involved with historical developments to communities". Interconnectedness in the SCALTEC framework is also dependent upon other elements derived from circumstances within an environment. Circumstances can include the potential and capability of children, their desire to learn, to associate and form relationships, their objects of interest, and the thoughtfully planned and implemented teaching and learning opportunities that incorporate appropriate cultural tools (Zeece, 1999; Robbins, 2008).

To further elaborate key theoretical and practical components of interconnectedness, three subsections are now discussed: social and emotional intelligence, culture and diversity, and the use of cultural codes and symbols.

Social and emotional interrelationships

Wells (2000) defined social development as being associated with forming and valuing relationships with others, while emotional development referred to personal feelings about self and others. Rogoff (2003) related social and emotional development to transitions and phases of developing social attitudes, social interactions and social forms that are reliant upon cultural traditions. Whereas DEEWR (2009b) reported that because children's overall wellbeing is seen as a strong predictor of academic achievement, along with health and citizenship, social and emotional developments required fostering (see also, Graczyk, Matjasko, & Weissberg, 2000; Queensland Government DETA, 2011).

Lapsley and Power (2005) discussed the formation of social and emotional development as a learned behaviour, according to cultural traditions (see also Rogoff, 2003). Lapsley and Power added that evolving social skills and communication, along with emotional self-regulation, goal setting and perseverance associated with school communities, are attributed to relationships. Indeed, Elias (2009) argued that the very nature of school based learning is connected, relational and dependent on emotional intelligence for character building skills that are correlated with the essential development of education in social situations. Recent influential documents and research (including the EYLF, DEEWR, 2008) hold that children's "social emotional intelligence appears to be the essential cornerstone of genuine progress" in the field of education (Elias, 2009, p. 843).

In the early years of education, emphasis placed on developing positive social and emotional skills was considered by Blair (2002) to be as important as early cognitive and intellectual development. Cognitive development is described by Rogoff (1995) as the process of gaining knowledge and skills with the help of others, whereas intellectual development is explained by Katz (2010) as having the capacity to attend to reasoning and predicting in a quest to understand how to apply new knowledge and skills. Arguably an understanding by the educator, of the health and wellbeing of children in relation to their social and emotional intelligence, can inform pedagogical processes in ECE. Elias (2009) argued the combination of social emotional development and cognitive and intellectual processes can come from pedagogical interactions. Durlak, Wiessberg, Dymnicki, Taylor and Schellinger (2011) agreed with Elias and added practical, cultural examples such as intentional teaching, guided play or monitoring actions used with shared social activities, that echoed encouragement and conversation it was more likely that positive learning occurred.

Research into effective pedagogy used by educators in the Foundation Stage of ECE was conducted in 14 ELCs in the UK by Siraj-Blatchford, Sylva, Muttock, Gilden and Bell (2002). That study reflected teaching strategies used with 3- to 5- year old children and found that, when social and cognitive development were seen as complementary to shared learning experiences, the best outcomes are achieved. In reality however, these researchers also found that, in the ELCs of their study, “practitioners used cognitive pedagogical interactions more often than social pedagogical interactions” for education in the early years (p. 46). From a socio-cultural perspective, socially mediated learning would reflect how relational influences and shared understanding are helpful for children who are developing new learning (Siraj-Blatchford et al., 2002). Relational influences are attributed to the well-being of children as they "actively construct their own understandings and contribute to others' learning" (DEEWR, 2009b, p. 9). Lapsley and Power (2005) argued that, in an ideal sense, society's respect for children as natural learners encourages the formation of strong relationships to assist wellbeing and offer for children, a balanced opportunity to comfortably learn within their own cultural construct.

Because intellect and emotions work together when early influences toward learning are formed, Mayr and Ulich (cited in Government of South Australia, 2008) held that the quality of relationships most beneficial for young children's learning are attuned to their social, emotional and academic needs and found at the heart of their culture a socio-cultural community. Within that socio-cultural community "people develop as active participants in cultural activities which in turn changes cultural communities" (Rogoff, 2003, p. 37). Advocacy for children's learning associated with socio-cultural activities help them establish cultural renewal, independent thinking, a maturing sense of self-regulation, attention and cooperative engagement (Berk & Winsler, 1995).

Laevers (2005) argued that when children are connected to and confident in the company of those with whom they learn they will thrive because fundamentally learning is premised on socially acceptable self-regulation and relationships, as introduced by culture. Katz (2010) reasoned that the social and emotional skills that support the intellectual and cognitive development of new learning and independence should not be taken for granted. For young children, these competencies emerge from a gradual accumulation of actions and reflect cultural experiences that direct their life. To enhance those experiences, Ashaibi (2007) explained that applications of wise pedagogy would enable opportunities for children to develop their social and academic learning as they rehearsed new ideas and imitated life's situations through planned socio-cultural activities such as role-play.

Several researchers (e.g. Durlak et al., 2011; Heidemann & Hewitt, 2010; Mustard et al., 2007) have pointed out that, should trauma and stress be a feature of a child's life, the resultant emotional reaction could impair the ability to react appropriately and think clearly. Further, these stressful situations could have long term effects on learning. However, as noted by Lapsley and Power (2005) the promotion of healthy social and emotional dispositions, by informed educators, can lessen the impact on learning that is attributed to trauma and stress. Mustard et al. (2007) explained that circumstances for balanced wellbeing would include the development of trust with adults so that children had comfortable and safe encounters in which to articulate emotions. For a balanced sense of wellbeing, functional pedagogy would acknowledge the nuances of children's cultural being, their social nature, diversity and immature learning skills. In addition to those authors already referred to, the principle of socio-cultural relationships between the people, places and objects that benefit social and emotional development and learning is reflected in the writings of Cutter-Mackenzie and S. Edwards (2006), S. Edwards (2009), Dowling and O'Malley (2009), Moore (1991) and Zeece (1999).

Culture and diversity

Banks (1993) explained the individual traits displayed by children relate to multidimensional diversity and although diversity can be influenced by cultural features in association with race, gender or ethnicity, it also includes personal characteristics such as preferred methods of learning, ability or disability. Rogoff elaborated that "[c]ulture is not static" but rather "it is inherited and transformed by successive generations and involved with historical developments and communities" (Rogoff, 2003, p. 51). Wong (2005) argued that culture, built on family and past experiences, relates to a person's perception of the world and is a learned human behaviour that influences thought, emotion and action. For example, children who live within nomadic tribes in North Africa would have different cultural perceptions than those of children who live in suburban Australia. Robbins (2005b) further defined culture as being that which is transmitted across generations and within a community through the use of symbols and tools, such as language and artefacts, to communicate and establish heritage. Vygotsky believed that the diversity of social and cultural contexts into which children are born define how they would develop and how they would grow (S. Edwards, 2009).

Siraj-Blatchford, et al. (2002) and Kaesing-Styles and Hedges (2007) noted that when the importance of family is acknowledged by educators, it demonstrates a respect for the diversity and culture that have influenced the thoughts and actions of children since their birth. Arthur et al. (2003) suggested that to understand home culture and the goals that parents have for their children, open dialogue between families and the child's educators was necessary to discuss the implications that learning and teaching has to transform that culture. Research, undertaken in Australia by Wong (2005), explored the relationships that exist between young children, their family, cultural and social contexts. She found that, when confident in the cultural values of their family situation, children have a strong sense of identity. It was reported in the *Analysis of Curriculum/Learning Frameworks for the Early Years: Birth to Age 8* (Victorian Curriculum and Assessment Authority, 2008) that learning and culture are seen as inseparable, and children are recognised as being literate within the cultures of their family and the local community long before they join an ELC.

Robbins (2005b) argued that a starting place for educators to develop the well-being and learning of children acknowledged the culture, diverse learning styles and the capabilities of those children. This position, supported by John-Steiner and Mann (cited in Robbins, 2005b), claimed that diverse pedagogy, along with visible sensitivity to the cultural tools and artefacts from the children's community, was the epitome of a successful socio-cultural environment. Therefore, cultural tools and artefacts should be used in learning situations to acknowledge diversity and contribute to the transformation of knowledge rather than to simply transmit knowledge. Arthur et al. (2003), drawing on the earlier works of Vygotsky (1978) and Rogoff (1995), suggested that when the prior knowledge and experiences of children were added to the diverse pedagogies used by educators, a tapestry of cultural differences was created. Saçkes, Trundle, Bell and O'Connell (2011) found that children's engagement in culturally diverse communities, where they experienced a broad brush view of the world, contributed a powerful ingredient that assisted future learning and achievement.

Cultural tools and symbols

Although young children are mostly occupied by their own inquisitive nature and imagination, they remain reliant on others to offer cultural tools and language that enable intellectual and emotional growth (Robbins, 2005b). Known codes and symbols that develop language, for example, assist children's instinctive desire to find out, and communicate, why things are the way they are and how things work the way they do (Fleer & Robbins, 2003). Rinaldi (2003) referenced the early work of Vygotsky when she discussed how the symbols of mathematics and language created high level thinking to gather meaning, and from one another in social situations, children communicated their understanding in a meaningful way while assisting others to make cognitive connections. Supporting that claim, Greenman (2007) referred to the thoughtful adaptations children brought to new knowledge regardless of where they live or the methods used to discover new meanings. He concluded that children are adaptable learners and their learning was enriched when assisted by others to help decode cultural tools and symbols, thus, establishing deeper cultural understanding. Choosing the appropriate tools and symbols to bridge cultural differences and the learning capabilities that children bring to learning situations can, at times, be a complex challenge for educators. This reflects a required sensitivity of diversity and cultural aspects (Rogoff, 2003).

The position of socio-cultural theory on diversity and culture is closely aligned with sensitive communication and the social and emotional development of children (Victorian Curriculum and Assessment Authority, 2008). For young learners these connections support confidence building and wellbeing when educators build on the known cultural heritage and language of the children they teach. Therefore, essential beginnings within socio-cultural learning communities rely on the interrelationships of known tools and symbols in the context of the learning environment (Robbins, 2005b), social interactions and open communication (Heidemann & Hewitt, 2010) and the important connectors between home and school that articulate and respect differences aligned with culture, social development, and a diversity of capabilities (Johnston, 2005b; Millikan, 2003).

2.3.2 Communication

Following from the above discussion, communication is a key practical and theoretical concept that informs and connects learning and teaching in ECE through messages that are an expression of cultural significance. Vygotsky (1978) believed that communication, in its varying forms, offered children guidance through which culturally meaningful activities influence the way they think. In respect of words and symbols being cultural associated with communication, (Bakhtin (1986) found that

> "A word, or in general any sign, is culturally individual. The word cannot be assigned to a single speaker. The author (speaker) has [their] own inalienable right to the word, but the interpreter also has rights, after all, there are no words that have belonged to no one." (pp. 121-122)

Berk and Winsler (1995) argued that culturally constructed words, that are modelled and shared, help children, in social situations, develop and communicate thought patterns associated with different relationships. Those acts of communication bridge cultural gaps and connect understanding within their respective communities. The work of Booth and Thornley-Hall (1991) held that communication, as a sophisticated and cognitive action of giving and receiving, includes listening, speaking, writing, reading, drawing, singing, miming and sculpting, together with developing a sense of audience, initiating conversation, manipulating thought processes and recognising clues about when to (and not to) engage in discussions. Researchers, including Bruce (2011), Craig and Muller (2007), Wilson (2010) and van Oers (2012) discussed that the complexity of children learning to communicate effectively involved shared experiences and skills that can be used for any number of occasions to convey meaning, according to their understanding. These occasions included expressing concern, explaining game rules, comforting others, delivering instructions, asking questions, telling a story and, responding in forms of criticism, praise or celebration.

Within society, cultural influences are often expressed through narrative. Hall and Robinson (2003) noted that oral narrative, that used speaking and listening activities, can offer opportunities to share socio-cultural information. They added that forms of narratives, other than oral, can also occur. For example, narrative can be written, recorded or read. Narratives can be conversational accounts of an occurrence and told in association with cultural aspects derived from pictures, via information communication technology (ICT) or explained with props, such as manipulative artefacts. Brooks (2009) explained that the use of props, during a verbal presentation, added a dimension of non-verbal inference for the audience and helped communicate meaning. Newly formed communication skills for children, such as speaking to an audience, writing, singing, or sequencing stories that tell to personal or vicarious experience, will reflect the cultural environment in which children grow and transform thinking as those skills are created (S. Edwards, 2009). Paciotti and Bolick, (2011) held that an essential pedagogy to inspire the development of communication comes when educators encourage children to converse during day to day activities and in playful creative games such as expressive role-play. In line with socio-cultural activities, Berk and Winsler (1995) found that when educators shared a common understanding of cultural diversity and recognised that children needed to feel at ease when developing communication skills, learning environments would welcome children's contributions and questions.

Millikan (2003) explained that questioning, talking about personal experiences and being respectful listeners were fundamental social aspects of communication that were developed through cultural experiences. To explain, she added that when the communication skill of active listening is modelled by the educator, and expected from the audience, a shared meaning was gained and social respect for the child as a speaker, and as a listener, demonstrated. The shared learning experiences provides, for the child presenting information, a sense of place in a community and an opportunity to gain confidence from knowing that active dialogue, including questions and responses, is a part of creating or continuing learning. Further, children's social and emotional intelligence has an opportunity to grow when respectful communication pedagogies, including non-verbal communication, are modelled by the educator (Millikan, 2003). Talay-Ongan and Ap (2005) considered every-day communication skills, for young children, evolve from words learnt and when watching, listening and imitating the communicative actions of others.

Diversity in the ways that communication is conveyed offers for children individual expression and collaborative thought to conceptualise meaning. Laevers argued that "communication is most fruitful where there is diversity and persons can complement one another, challenge and question, surprise, enthuse and empower one another" (2005, p. 24). Acceptable forms of communication in learning and teaching situations also include making available time for respectful cultural understanding, thinking, listening, thoughtful questions and negotiations (Szarkowicz, 2006). Making meaning of communication, verbal or non-verbal signals and self-talk, each have bearing on the early development of communication. These are now discussed.

Making meaning

A socio-cultural activity is a "mutually constituted process" to make meaning and reflect shared understanding in learning communities (Rogoff, 2003, p. 52). As young children role-play life's skills, follow a line of investigation and interact with others in social situations, they conceptualise cultural meaning and become skilled in everyday communication. Ingram (2000) elaborated that contextual social interaction, presented during every-day situations, enabled information to be collected, mentally sorted, refined and added to a bank of knowledge for future learning. Thus, meaning was made from information communicated and transformed through a cognitive collation of internal and external processes.

Robbins (2005b) held that clues from cultural tools, such as words, expressions, movement and artefacts, were used to convey messages that are absorbed and redefined as children transform information and communicate new meaning. In doing so they defined their own cultural understanding of a situation or experience. With this reconstruction of knowledge to convey new meaning, Wright (2007) noted that "adults must be sensitive to children's shifts between various subjects positioning and the multiple functions that may be assigned to their depicted objects and events" (p. 37). In an effort to make meaning of situations, Heidemann and Hewitt (2010) observed that during role-play, for example, children often imitate adult talk and gestures to test the skills of communication within relationships. These researchers argued that while children may not always fully understand the meaning of communication used during play, the children were in fact contributing to their own learning as they rehearsed behaviour and language that had been previously modelled.

Verbal and non-verbal communication

Norris (1998) advanced that children used a combination of verbal and non-verbal communication, in much the same way that adults do to make cultural conceptualisations and meaning. Norris added that culturally acceptable verbal communication is a learned behavior that is extended with new experiences. Increased vocabulary, fluency and comprehension are part of that extension (Konza, 2003). Segal (2008) described non-verbal actions as body-language that conveys communication through the positioning of body parts or engaging facial expressions for a dimension of meaning. Rogoff (2003) found that non-verbal communication is extensively relied upon by communicators as they construct and convey meaning.

Community members and artefacts that reflect local culture can be helpful when children are developing body language as a form of communication (Robbins, 2005b). Communication skills that are consistently modelled across the curriculum, and include verbal and non-verbal methods, echo socio-cultural activity that can bring shared meaning, provision of social structure and confidence during the acquisition of literacy skills (Zeece, Harris and Hayes, 2006).

Forms of artistic expression used by early learners to communicate meaning and illuminate understanding include role-play, drawing, singing, story-telling, dance, the symbolic constructions of maps or the use of 3D objects. In support of Rogoff's (2003) belief that communicating meaning relied heavily on non-verbal contributions of social learning, Brooks (2009) held that non-verbal and practical methods of expressing ideas enabled children to visualise what they are thinking and thus, help them to clarify meaning and explain their thoughts. Brooks added that a young child without verbal language, or who is culturally unfamiliar with the language being used, will devise non-verbal ways of communicating, such as pointing to an object, or deliver an object such as an empty cup, to indicate thirst. The many possibilities and forms of verbal and non-verbal communication that assisted children to construct meaning, develop new information or express their understanding were articulated by Malaguzzi (1998) in his poem, *The Hundred Languages of Children*. These included gesticulating, drawing, inventing, playing, singing, explaining, sculpting and reasoning. Laevers (2005) agreed that the Hundred Languages of Children are an indispensable tool for children to communicate "their full potential that otherwise would remain unarticulated and unshared" (p. 24). Because of children's natural propensity to integrate their learning, Laevers added that educators would benefit from understanding these various forms of expression and shared meaning for the potential they held to assist future planning.

As children are introduced to both verbal and non-verbal communication skills from their first carers, and typically within their own home, Hall and Robinson (2003) emphasised the importance of educators being aware of the functional literacy used at home, and the culture in which it is developed. Communicative acts between home and an ELC can inform the educator about cultural diversity within a group of children and learning needs of a child. Essential communication between an ELC and home presents rich opportunities for both parents and educators to assist learning. Arthur, Beecher, Death, Dockett and Farmer (2008) added that when opening the lines of communication between home and the ECE teacher, a professional partnership can be formed.

Self-talk

Research by Buie Hune (1997) found that conversing with self is a behavior that can be related to self-management as well as problem solving and is necessary for successful engagement in social situations that are independent of adult guidance. To deepen communication skills and understanding of a situation, children often talk to themselves silently (in thought), or engage in oral self-talk. Piaget called talking aloud to self 'egocentric speech' that helped develop cognitive understanding, whereas Vygotsky interpreted self-talk as 'private speech' and associated it with social language that helped clarify ideas and enhance thinking skills (Rogoff, 2003).

Szarkowicz (2006) found that often, when practising communication through self-talk, children can become 'lost in the moment' as they experimented with words and express with their own feelings, thoughts and ideas. Being lost in the moment, Szarkowicz explained, comes when uninterrupted opportunities enable time for children to consolidate new thought, review a recent encounter, think out loud, or use pretend and imitated talk. A useful pedagogy to help children sequence their thoughts is modelling the action of thinking aloud. Robbins (2008) reasoned that for children to achieve levels of competence in language use, silent thought and thinking aloud were actions that often occurred as thoughts were being processed prior to carrying out a physical or verbal action. Brooks (2009) argued that when children talk about their learning it enables them to 'see' what they are thinking and better understand information as it is being processed. It is therefore presumed that children employ self-talk to better understand their own thinking, to rehearse experiences and to consolidate knowledge of situations they have encountered (Buie Hune, 1997). Mercer (2000) argued that, when children are learning in collaboration with others, they amalgamate their knowledge of language and thinking skills to find common understandings. Fleer and Robbins (2003) agreed that central to the early development of communication skills are thinking skills. To hone the logical and sequential thinking that assists reliable communication, Brooks (2009) argued that children engaged the skills of thought processing during both intentional and unintentional learning and teaching experiences.

Communication in everyday lives, in different communities, creates thinking that clarifies meaning according to cultural tradition and contributes to adaptation of that culture (Rogoff, 2003). Heidemann and Hewitt (2010) agree that a good grasp of communication skills assist a broad spectrum of intellectual skills such as clarifying perception, conversation, rehearsing, reporting, thinking, and sorting a sequence of events, all of which prepare children for new situations. The following section explores the notion of cognitive development.

2.3.3 Cognitive development

Rogoff considered that "Vygotsky focused on cognitive skills and their reliance on cultural interventions such as literacy, mathematics, mnemonic skills and approaches to problem solving and reasoning" (2003, p. 50) to develop new learning. Laevers (2005) explained that cognitive development, or high levels of thinking, happens when current understandings are reviewed. He added that these advanced levels of thinking were engaged through a dual action of receiving and adjusting cognitive information and this often occurred when new dimensions of learning were encountered along with opportunities to articulate the effect of those incoming stimuli. Robbins (2005a) agreed that a learner’s understanding of an experience tends to deepen when the actions can be talked through. Johnston (2005b) pointed out that when children were coming to terms with a new concept or a situation, they tended to engage multisensory experiences to interpret their understanding. She added that when tangible and intangible evidence is combined and connected with a current understanding, cognitive development is heightened.

C. Edwards, Gandini and Foreman (1998) argued that vicarious learning added to the theoretical development of cognition through watching a demonstration, listening to sounds, internalising and rehearsing instructions, and comprehending explanations. Because young children appear to have an ongoing quest to 'demystify and rearrange' their world that purpose can be a great source of motivation for them to engage in deep thinking and develop cognition (Berk & Winsler, 1995; van Oers, 2012). For a sophisticated level of thinking to occur, van Oers noted that Vygotsky had discussed how the twofold action of receiving and constructing information was required, and that the combination of these actions caused children to think about their ideas and feelings on an abstract level.

Cognitive development is discussed below in terms of the complexities of developing thinking skills, semiotic mediation, the zone of proximal development (ZPD), and scaffolding.

Complexities of developing thinking skills

Vygotsky (1978) argued that new information is interacting consistently with existing knowledge at a cognitive level; thus, creating new knowledge is a dynamic action that relates to deeper and more thoughtful understandings about previous encounters (see also Wood, 1998). Gardner (2008) advanced the notion that, due to the diversity of thought processes that children might use, learning contexts should be designed to include opportunities for broad and multiple levels of thinking. Gardner (2006) held that because people think and learn in different ways, in accordance with their cognitive ability, past experiences and various methods of learning are used by children to construct meaning. He also argued that a variety of aspects which cause children to consider alternative views of a situation was necessary when seeking solutions. Accommodating new ideas and changing current perceptions, Gardner added, are not always straightforward acts. Robbins (2005a, p. 27) explained that the complexities of thought processing called on a variety of information sources that are "embedded in socio-cultural contexts, and reflect local practices, beliefs, values and goals." To further explain the dynamic and multifaceted reconstruction of knowledge, Robbins added that the use of concrete objects, pictures, and related open-ended questioning to prod memory can stimulate thought functions and be helpful when moving new ideas about and establishing higher order functioning. (see Robbins 2008) .

According to Laevers (2005), as mental capacity grows, the mind becomes more "refined and capable to take information on board, figure out, imagine, discern more shades, substructures and tastes, and colours, and moods and ideas and imaginary things… than ever before" (p. 24). Further, for young children to expose their changing thoughts with confidence, Worth (2010) pointed out that they need opportunities to rehearse and test their ideas in safe encouraging environments. As previously discussed (see Elias, 2009), the growth of social and emotional intelligence is heightened when children confidently participate in learning situations.

Rogoff (1995) insisted that, when the action of thinking is engaged, children require unhurried opportunities to focus on how to process information and further, that assistance was often required as children learned to transform new knowledge. Venville, Adey, Larkin and Robertson (2003) argued that adult assistance is necessary as young children learn to manipulate the complexities of skilful, logical thinking and held that cognitive development occurred through these actions. Additionally, assistance required adults to model how to think out loud, and encourage children to put an effort into their own thinking. Venville et al. (2003) pointed out that when adults were on hand to support children's thinking together they could talk through a problem, discuss ideas and question each other's thoughts. As children participated in thought provoking sessions with adults, confidence born of knowledge was also developed. Additionally, Fleer (2007) found it important that educators know how children think because the ideas that children hold can influence their participation in activities that educators have organised for them. Johnston (2005a) noted that, with adult encouragement, the development of logical and sequential thinking was helpful for children to make connections between experiences they have encountered and, as they sorted ideas, thoughtfully consider alternative perceptions. Szarkowicz, (2006) considered that when thinking is constructed and ordered, other important yet complex systems associated with memory and mental behaviours such as remembering, concentrating, perceiving and reasoning are activated.

Semiotic mediation

Chandler (1998) explained that semiotics was the nature of signs and the laws governing those signs that assist the translation between the mediums of incoming information and previously accumulated cultural understanding. Those signs, according to Chandler, can relate to words, actions and physical objects and become redefined to suit a circumstance. Hasan (2001, p.1) explained that semiotic mediation "foregrounds a fundamental relationship between mental functions and discourse." Whereas Wells (2006), calling on previous studies of Vygotsky, defined semiotic mediation as relating to signs that include visual aspects as well as tools, such as language. These tools and signs are then connected to provide cognitive meaning. Robbins, Bartlett, Jane and Hawkins (2009) also referred to Vygotsky's work when they discussed semiotic mediation as a method of educators assisting children to develop cognitive thought. Being knowledgeable about the function of semiotic mediation, they reasoned, was important when helping others understand the process of thought. In line with socio-cultural theory, Robbins (2008) claimed semiotic mediation related to the interpersonal and contextual influences that clarified and updated original thoughts when children were influenced by people, places and the objects in their vicinity.

To assemble and transform theoretical information into new learning and memory Robbins et al. (2009) advanced that semiotic mediation is about constructing abstract thought from a collection of evidence gained during actions, discussions and personal experiences. As an example, they explained that connections made between the word *key* and its attachment to the physical object of a *key*, form a cognitive understanding. Likewise, social mores and cultural understanding can attach other meanings and abstractions from the word *key* (such as a *key* idea or, *key* to your heart). To understand the cognitive meaning associated with each variation of the word *key*, more clues are required: a picture, an object or other related information.

Millikan (2003) reiterated that guided learning was an especially helpful strategy for semiotic mediation as educators could direct children to a variety of clues that support new learning, which those children may not otherwise find. Additionally, Millikan explained that, for young learners, the development of semiotic mediation required time so that fresh information could be thoughtfully aligned with what children currently knew. Venville et al. (2003) agreed that learning would be hampered if dedicated time was not made available for children to construct their thoughts and elaborated that a suitable interval enables learners to internalise new information. Once ordered, that information could be used to inform others, formulate questions or, construct valid answers. Further connections that illustrate semiotic mediation are discussed later in this chapter when scaffolding is introduced as a teaching strategy.

Zone of proximal development

According to Vygotsky (1978) the Zone of Proximal Development (ZPD) is a dynamic developmental state in which the process of maturing in both mental and physical capability occurs when challenges are posed to extend learning. The concept of the ZPD, defined by Vygotsky is “the distance between the actual development level as determined by independent problem solving, and the level of potential development, as determined through problem solving under adult guidance or in collaboration with others” (1978, p. 68).

Millikan (2003) saw the ZPD as facilitating the developmental learning capacity of children through interpersonal and intrapersonal interactions. Johnston (2005b) added that, when skilled educators acknowledged the social, active learning nature of children and encouraged their potential, the concept of a ZPD was used to benefit cognitive, intellectual and emotional development in children. In 2006, Fleer, S. Edwards, Hammer, Kennedy, Ridgeway, Robbins et al. referred to the ZPD as being a hypothetical learning distance in which learning was provoked. Swain et al. (2010) extended the definition of the ZPD by adding that culturally symbolic and material artefacts, such as language, beliefs, attitudes, and books could also act as the “expert other” and challenge children to extend their learning (p. 21).

Consistent with a socio-cultural approach, the use of the ZPD would see educators, or more capable peers, guiding children so that thinking could be transformed while they are actively engaged in their own learning, as distinct from being passively involved in new learning (Rogoff, 2003). Berk & Winsler argued that, "for Vygotsky, instruction [was] a major contributor to children's growing consciousness and regulation of their own thought processes" (1995, p. 106). Skillful, collaborative pedagogy at opportune times enabled children being challenged to move their own learning beyond their comfort zone. Malaguzzi (1998) argued that a traditional teacher-centered style of instruction is inconsistent with socio-cultural theory. Robbins reasoned that when educators held “preconceived ideas of what children know and can do” a ZPD would not be used to its full advantage (2005b, p. 152). She added that within the socio-cultural approach to learning and teaching, the concept of a ZPD could benefit children with diverse learning abilities.

Daniels (2001) (cited in McLachlan, Fleer & S. Edwards, 2010) described in detail four versions of the ZPD: Assessment ZPD, Scaffolding ZPD, Cultural ZPD and Collectivist ZPD. Assessment ZPD refers to what a child can do with guidance so that goals may be set for future engagement but at a more challenging level. Scaffolding ZPD is where the child's performance is guided or modelled in small steps by someone more competent which in turn leads to independent engagement. Cultural ZPD refers to “the distance between the child's everyday experiences and the body of cultural knowledge that is typically embodied in a formal curriculum" (McLachlan et al., 2010, p. 108). The Collectivist version of the ZPD refers to when more than one person has contributed to a new body of knowledge or skill that a child has developed. Also building on Vygotsky’s initial ZPD, Kravtsova (2008) (also cited in McLachlan et al., 2010) conceptualised a Zone of *Potential* Development. Kravtsova noted that, as learning never ceases, the Zone of *Potential* Development continues to evolve because there will always be potential to persevere with learning. The Zone of *Potential* Development of the learner, akin to Vygotsky’s ZPD, is accompanied by modelling, scaffolding (see next section) and teacher guidance.

Overall, Laevers (2005), Szarkowicz (2006) and McLachlan et al. (2010) held that interrelationships associated with the implementation of the ZPD emphasised a socio-cultural approach and teacher-guided-learning that encouraged the potential of children to be resourceful competent learners.

Scaffolding

Raymond (2000) advanced that pedagogical strategies are individualised and measured when scaffolding is applied and serve to advantage various learning capabilities in a specific manner. Methods used by the teacher to implement scaffolding include prompting, shared thinking, demonstration, questioning, and providing clues to simplify a task to match the learner's present capabilities. Scaffolding was defined by Van Der Stuyf (2002) as continued educational support for a learner until competency was achieved. Attributing its design as a teaching strategy associated with Vygotsky's socio-cultural theory, and as an extension of the ZPD, Van Der Stuyf went on to explain scaffolding as a metaphor for assisted learning. Szarkowicz (2006) extended Van Der Stuyf's position further when she added that scaffolding is an action where the more knowledgeable person offers support to develop learning for the less knowledgeable person through the provision of small, explicit teaching steps, demonstration and thinking out loud. Chang, Chen and Sung (2002) found that educational scaffolding was the connection between guided sequential thinking, verbal instruction and physical activity that promotes learning. From this view, scaffolding is a position closely related to semiotic mediation, as previously discussed.

Van Der Stuyf (2002), Szarkowicz, (2006) and McLachlan et al. (2010) were of the same mind in that the teaching strategy of scaffolding elaborates Vygotsky's concept of the ZPD. Both models are collaborative, employ an educator to augment learning, develop thinking strategies and are interactive. Fleer (2008), and Bruce (2011), differentiate the concepts of ZPD and scaffolding. Fleer described the ZPD as a hypothetical area of potential in which educators challenge children to go beyond current achievements. Whereas for Bruce, scaffolding is explained by as a strategy of intense guided teaching designed to help a learner who is struggling to improve current skills. Ven Der Stuyf (2002) linked ZPD and scaffolding by arguing that scaffolding was the result of ascertaining a learner's ZPD. Fleer et al. (2006) however, noted that where the ZPD provided direction and often, independent pursuit for the learner, the strategy of scaffolding helped children's education through supporting structures that were applied one step at a time. Then, just as those steps were built up in increments, the support structures are removed, one step at a time, as independence is gained. These researchers saw scaffolding as guided learning and direct instruction that offered a mixture of both support and encouragement for the learner. Scaffolding, then, provides clear and precise direction, in areas of weakness, so that further confusion or misunderstanding, on the part of the learner, is reduced.

An example from the works of Ven Der Stuyf (2002) described how scaffolding helped a young child learn to successfully pour liquid from a jug into a container. The educator first directed the child to the handle of the jug and then demonstrated how to hold that handle before prompting the action of lifting and pouring. For another child with less control, the same task may include the previous actions but require more steps, such as how the jug may require two hands for balance: one to support the weight of the jug by holding the handle and the other, held under the jug to support and guide the tilt so that achievement is gained. Van Der Stuyf, (2002) also explained how scaffolding can be a helpful strategy for children with complicated learning capabilities, for example, those struggling to develop the skill that involves fine motor skills, such as handwriting. de Vries (2003) added that scaffolding can also be used in playful situations, independent of an educator, when children help one another. In each of these situations, a balance of independent risk and support to achieve new skills acknowledges children as resourceful, capable and involved learners (DEEWR, 2009b).

2.3.4 Play-based learning

Play-based learning is not left to chance, but is "sustained through complex reciprocal and responsive relationships, and is situated in activities that are socially constructed and mediated" (Wood, 2009, p. 29). Considerable research documenting the vital role of play to support learning and social development, in line with socio-cultural theory, has provided a plethora of interpretations and definitions of the concept of play-based learning (see, for example, Fleer, 2008; Katz, 2010; Millikan, 2003; Robbins, 2008; Rogoff, 2003; van Oers, 2012; Worth, 2010; Yelland, 2011).

In 2010, Heidemann and Hewitt referred to Vygotsky's socio-cultural theory when they described play-based learning as an assistance to abstract thought and social and emotional growth through the use of both physical and intellectual interaction with objects and people. Katz (2010) considered play a random yet essentially creative pursuit used by children to spontaneously react to their environment in accordance with their own learning agenda. Johnston (2005b) noted that from the platform of play children develop a sense of conceptual awareness and are constantly extending their mental and physical capabilities.

It has been acknowledged widely, in ECE literature, that early research conducted by educational theorists Frederick Frobel (1782-1852) and Maria Montessori (1870-1952) shaped the value of play in the curriculum (see Bredekamp, 1990; Mooney, 2000; Millikan, 2003; Heidemann & Hewitt, 2010; Fleer, 2008; Robbins, 2008; and others). Supporting Vygotsky's ideas about the benefits of play being a provocative and innovative learning tool, Fisher, Hirsh-Pasek, Golinkoff and Gryfe (2008) and Worth (2010) added that play-based learning was a natural way for children to confirm, or transform, their ideas about cultural and social day to day experiences. Rogoff (2003) and van Oers (2012) reflected Vygotsky's position and argued that play was a leading activity in the ZPD and enabled the gradual development of intellect through involvement and inquiry. Canning (2011) added that play, as an essential part of learning, could successfully be used by an early childhood educator as an interactive and social learning opportunity to provide starting points, chances to rehearse skills or to consolidate knowledge.

To illustrate this view, Milteer, Ginsburg and Mulligan wrote:

> Play is essential to the social, emotional, cognitive, and physical well-being of children beginning in early childhood. It is a natural tool for children to develop resiliency as they learn to cooperate, overcome challenges, and negotiate with others. Play also allows children to be creative. It provides time for parents to be fully engaged with their children, to bond with their children, and to see the world from the perspective of their child. However, children who live in poverty often face socioeconomic obstacles that impede their rights to have playtime, thus affecting their healthy social-emotional development. For children who are under resourced to reach their highest potential, it is essential that parents, educators,

> and paediatricians recognize the importance of lifelong benefits that children gain from play. (p. 1, 2011)

The central tenet of play

The central tenet of children's play-based learning is that children are curious, intelligent people and full of wonder and a natural desire to learn and that, through connections of tangible and intangible aspects of play, thinking is activated and the learning process continues (Vygotsky, 1978). Van Oers (2012) argued that play is a leading activity for learning for children aged between 2- and 8- years of age. Based on the works of Vygotsky, van Oers concluded that a play-based curriculum depended largely on cultural and historical conditions that included rules, involvement and degrees of freedom. Foreman (2010) added that children are capable of independent thought and construct their own knowledge as they investigate, explore and learn through playful situations. Play in the socio-cultural framework derived from relationships that echo cultural-historical knowledge by the players and is rehearsed in situations at home, at school and in the community. These relationships are connected to developing new skills and knowledge (see, Fleer & Ridgeway, 2007; Millikan, 2003; van Oers, 2012; Wilson, 2007).

Although play as pedagogy connects diversity and prior knowledge with new experiences, and is currently reclaiming its place in the learning environments of ECE, alongside thoughtful and intentional teaching (DEEWR, 2009b; Fleer, 2010), there remain some doubt about its value. Benefits for and against play-based learning in early childhood education have long been contested (Arthur et al., 2003; Hirsh-Pasek, Golinkoff, Berk & Singer, 2009).

O'Sullivan-Smyser explained that, when used for its true worth as a learning tool, children were wise about their own learning and "seem[ing] to know instinctively how to acquire information at a level that is useful to them" (1996, p. 20). Lambert pointed out that with too many restrictions, play could not be used for its true worth. For example, if perceived as a concentration of procedures "being algorithmic, closed, specific and (too focused) on problems prescribed by the curriculum" (2000, p. 32) play benefits are misinterpreted. Therefore, play-based learning through explicit educator design does not accommodate direct instructional teaching when understanding is expected to occur. Epstein (2007) explained however, that a significant determinant of the developmental outcomes of children can relate to how adults guide and interact with them during playful learning. She added that, through engaging activities, guided learning in playful situations can reflect sound practice. This position was echoed in the work of Rogoff (2003) and Fleer (2007) in that properly directed and guided teaching through play encouraged cognitive development and social and interactive learning in harmony with socio-cultural theory (see also Berk & Winsler, 1995 and van Oers, 2012).

Whether or not play reflects genuine benefits for children's learning is a continuing debate (see, for example, Fleet & Robertson, 2004; Hirsh-Pasek et al., 2009; Johnson 2005a; Lambert, 2000; Tullis, 2011 and others). This debate sees on the one hand, learning to be essentially teacher directed where instruction is presented for cognitive purposes from a prescribed curriculum. On the other hand, child-centered, play-based learning sees children as contributing their own cognitive and intellectual learning while consolidating early social and emotional skills, and often in playful situations. Though questions remain about the value of play-based learning, much contemporary research evidenced in changes to policy regarding the principles of learning and teaching of young children continues to support its inclusion in ECE (DEEWR, 2009b; McLachlan et al. 2010; Fleer 2010).

Challenges for play-based learning

Play-based learning in ECE, however, is not always seen as beneficial. For example, the research by McLachlan et al. (2010) revealed aspects of play, in relation to cultural-historical early childhood curriculum, were not widely accepted by parents as beneficial to learning. Researchable questions considered by others (see for example, see Greenfield, 2004 and Yelland, 2011) asked how play could be structured to advantage learning; how much play should be in the curriculum; and whether or not play actually benefited children's learning. Concerns also included the level of risk that may be involved and the extent to which product or process was the emphasis of play-based learning.

The focus of play as a vehicle for learning has, from time to time, also received unfavourable scrutiny from policy makers and the broader community (Miller &

Almon, 2009). However, in their earlier research, Fleer and Robbins (2003) claimed that negative perceptions about the value of play as a learning tool can often be linked to educators who are not good about conveying to the wider community understanding about the skills and meaning children acquire when playful learning is engaged. Tullis maintained that the community and parents in particular need to be informed

> …that 'just playing' is in fact what nearly all developmental psychologists, neuroscientists and education experts recommend for children up to age seven as the best way to nurture development and ready them for academic success later in life. Decades of research have demonstrated that their innate curiosity leads them to develop their social skills... through play. (p. 37, 2011)

Addressing some of the perceived challenges associated with play in the curriculum, research by Gill (2007) found that the inclusion of purposeful play would comprise intentional teaching about the differences between a hazard and a risk. Gill pointed out that too much regulation and management associated with risks does a disservice to the benefit of learning through play. He argued that the best classroom in which to learn about risk management was the one where situations provided 'real world' experiences and that fears parents may hold in relation to risks in the playground can be lessened through close communication between school and home. Little and Wyver (2008) concurred that play-based learning outweighed foreseen play-based risk and that managed risk, during challenging and playful learning encounters, was found to benefit learning when adults were in attendance.

Play as pedagogy

Play, described by S. Edwards and Cutter-Mackenzie as a "pedagogical practice that connects with children's learning" (2011, p. 52), is supported as early learning pedagogy by other researchers including Fleer et al. (2006), McLachlan et al. (2010), van Oers (2012). Fleer et al. (2006), for example, held the view that children learn best when engaged in playful and social experiences in which educators enabled meaningful connections to be made between the people, places and objects in their environment. While Connor and Link (2008) emphasised that play, used as a learning tool by children, enabled them to disentangle cultural information about the world in which they live and how people interact within that world. Further, Katz (2010) found that play as pedagogy occurred through the experience and guidance of educators who use this strategy specifically for children to improve actions that, for example, involve problem solving, decision making and thought processing.

Szarkowicz (2006) pointed out that, while educator input was essential, there were times when the educator had to be an onlooker, rather than a participant in children's play. Interruption during planned or incidental play, Szarkowicz explained, can sometimes stop the flow of imagination and detract children's learning. Greenman (2007) agreed that children do not always require direct input from adults, and Hirsh-Pasek et al. (2009) emphasised that spontaneous 'make-believe' play by very young children does not always enable them to adapt their current setting or hastily change the direction of their thinking. Social interactions, for example, that are more often than not an integral part of play, ought not to be interrupted. Neither should action that involves self-talk (Szarkowicz, 2006). Therefore, McLachlan et al. (2010) noted that for an educator, essential pedagogy comes from knowing when to and when not to interrupt children's play-based learning.

On the one hand, situations of play-based learning that called for interactive and contextual engagement would see the educators' role as helping children develop accurate conceptual knowledge. On the other hand, and without educator guidance, interactive engagement could undermine a learning situation (Johnston, 2005a). Either way playful participation engages interrelationships between the three foci of socio-cultural theory at a cognitive level, and thus, new information is formed (Rogoff, 2003). Depending on the social and cultural maturity of young children, affecting those relationships sometimes call for scaffolding by the educator (Heidemann and Hewitt, 2010). These researchers explain that, for example, children can feel anxiety when mixing with unfamiliar people and hence, will require some assistance during play-based learning. Likewise, adult engagement during play-based learning can redirect engagement to alleviate encounters of aggression and/or frustration as a result of emotional immaturity. Socio-cultural engagement can reflect a child's ZPD as adults help children solve social and emotional problems that may be beyond their current means (Canning, 2011) Canning elaborated that by using the pedagogy of play, "[c]hildren's qualities, their expressions of interest, their likes and dislikes, how they explore, imagine and how they learn" are revealed to help the educator plan future learning experiences (2011, p.175).

Interpretations of play

In general, play is described by Szarkowicz (2006, p. 16) as something children do "alone or with others, it can be quiet or loud, slow or fast, a single activity or an experience (that is) returned to time and time again" Although there are many interpretations related to the purpose and benefit of play in education that have already been mentioned, engagement in the activity of play can generally be grouped into three levels: social or free play; purposeful, modelled and guided play; and, directed play (see Cohen, 2006; S. Edwards & Cutter-Mackenzie, 2011; Gmitrová & Gmitrov, 2003). Social or free play is initiated spontaneously and voluntarily by children according to their own direction, interest and purpose. This play can be individual, or with others and usually involves the addition of objects. Sandberg and Arlemalm-Hagser (2011) add that social or free play could also include role-play where imaginary items and others are employed by the children. Purposeful, modelled and/or guided play is undertaken with an educator or another leader who guides, encourages and engages with the children. This form of play is utilised when activities are being created for the purpose of teaching and enables children to be playfully engaged as they are guided to achieve specific outcomes. Directed play relates to a controlled environment where engagement by the children is directed by rules (for example, football) or prescribed tasks as directed by a teacher of the game, to achieve a task. For the purposes of this review, these three levels of play are summarised in Table 2.1.

Table 2.1
Three levels of play engagement

Types of play	Definition	Researched by
Social or free play	Play occurs spontaneously and is determined entirely by interest of the children. Play can be individual or social using found objects. Adult intervention only if safety or social issues require attention.	S. Edwards & Cutter Mackenzie (2011); Rogoff (2003)
Purposeful, modelled or guided play	Collaborative situation: an educator attends during play to explain or model how materials are used or to offer suggestions to enhance participation, knowledge and skills.	S. Edwards & Cutter Mackenzie (2011; Rogoff (2003)
Directed play	Children play a passive, directed role as the teacher focuses on an activity for a specific outcome. Includes games with rules of engagement.	Rogoff (2003) Gmitrová, V. & Gmitrov, G. (2003)

Hirsh-Pasek et al. (2009) argued that children learn from a balance of each of these levels of play. When a propensity to goal oriented and a playful learning is presented with sensitivity toward capabilities and cultures, all areas of learning are improved because new and transferable skills such as communication and benefits from social interactive engagement are rehearsed. It is essential, when goal oriented play is presented, that children feel involved with some degree of freedom (van Oers, 2012). An example of using the three levels of play (Table 2.1) to develop space and basic geometry in mathematics would begin with children freely investigating easily manipulated objects that represent shapes. Next scaffolded instruction would guide new investigations into patterns of simple tessellation. Finally, children are directed, perhaps to copy a modelled, and more challenging, tessellation that directs precise patterns aimed at the set goal of the experience (Hirsh-Pasek et al., 2009). These authors added that "playful learning seems to capture children's attention and offer opportunities for both knowledge acquisition and flexible experimentation" in social situations (2009, p. 37) and concluded that, from engagement in all levels of play, attention spans, sustained concentration and symbolic representation (for example when a car is represented by a block) is improved.

Within the many types of play the Department of Education and Training in WA (DET, 2008) discussed six: social play, cognitive play, playing games with rules, spontaneous play, socio-dramatic play and rough and tumble play as being fundamental to a child's learning. Overall, Chung and Walsh (cited in Edwards & Cutter-Mackenzie, 2011) discovered there were up to 40 different interpretations of the concept of play-based learning. In this review, a collection of 9 variations of play is shown in Table 2.2. Variations of play are determined by many factors including resources, purpose and the environment. In line with Vygotsky's inclusion of play in socio-cultural theory, Heidemann and Hewitt (2010) pointed out that play, and especially role-play for children, can help them think about and adjust the social and cultural experiences of their life's circumstances.

Table 2.2
Interpretations of play types

Type of Play	Definition	Author	Learning outcomes
Open-ended play	Children use materials to create spontaneous understanding	S. Edwards & Cutter-Mackenzie (2011)	Problem solving
Modelled play	Teachers model using materials prior to children using them	S. Edwards & Cutter-Mackenzie (2011)	Manipulation skills
Purposeful play	Teacher provides opportunities and materials then participates in play	S. Edwards & Cutter-Mackenzie (2011)	Sequential skills
Free choice	Children choose objects and purpose for discovery learning	DET WA (2008)	Investigate materials and properties
Guided play	Directions or suggestions are provided by the teacher to enhance an outcome	DET WA (2008)	Specific information
Directed play	Teacher directed, children passively engaged	DET WA (2008)	Specific skill
Play as work	Rote learning and repetitious play focused on specific learning outcomes	DET WA (2008)	Specific skill
Social play	Children play by themselves or with others: incidental learning	DET WA, (2008)	Social/emotional skills
Cognitive play	Including functional, constructive and symbolic play: problem solving	DET WA (2008)	Thinking processes and problem solving

2.3.5 Learning environments

From literature reviewed, the learning environment is a key practical and theoretical element in learning and teaching in ECE. Fleer (2008) explained that like play, educational learning environments never exist in isolation but always in circumstances related to something else. Fleer's description reflects socio-cultural emphasis in line with interrelationships formed by Rogoff's three foci to influence cognitive learning. Also, DEEWR (2009b) took the position that the purpose of learning environments for ECE was to promote both collaborative and individual pursuits, meaningful interactions and to commonly endorse opportunities for shared thinking and cooperative learning. Warden (2010) found that physical attributes and people within learning environments can provide if necessary, the reminders that help children unite current knowledge with their new experiences. United at a cognitive level, those actions then transform cultural understanding for children (Ridgeway & Hammer, 2006). Fleer and colleagues (2006) elaborated that, as children engage in learning, the environment and the objects found within it provide multisensory methods of learning that support individual capacity and the complex integration of learning that young children own.

The association between specifically created environments and the learning of young children was recorded in the 18th and 19th centuries by Frobel (1782-1852) and Montessori (1870-1952). These educators documented the importance of appropriate learning resources and child-centered environments as the fundamentals that provide opportunities for children to follow their curiosity and investigations through playful interactions and relationships with others (see also, Mooney, 2000; Pope-Edwards, 2002; S. Edwards & Cutter Mackenzie, 2011). Malaguzzi (1998) in particular acknowledged the essential work of these early educational theorists and their insightful understanding about how the environment could advance the learning of children. With socio-cultural theory in mind, he added that when children socialise with other learners they bring with them prior knowledge and a range of capabilities. Therefore, as Robbins (2003) noted, educators prepare learning environments with consideration for what children can do, as opposed to what they cannot do, particularly in relation to the needs of children with special gifts and abilities.

The following provides a synthesis of research on the characteristics of socio-cultural activity within ECE learning environments, giving particular reference to indoor and outdoor learning environments, limitations placed on learning environments and nature based environments.

Characteristics of learning environments

What constitutes the most appropriate learning environment in which young children acquire their essential ECE knowledge has undergone broad discussion (see S. Edwards & Cutter-Mackenzie, 2011; Elliott, 2010; Fleer et al., 2006; Greenfield, 2004; Kennedy & Barblett, 2010; Pope-Edwards, 2002). Elliott, for example, pointed out that the characteristics of an educational environment are the "theatre for the child's imagination" and provide opportunities to develop skills of learning associated with the cognitive, physical, social and cultural growth (2010b, p. 16). Greenman's (2007) position was that learning environments ought to be flexible enough to be easily transformed to meet a range of child capabilities and interests, yet sensitive enough to acknowledge cultural aspects and diversity. Ridgeway and Hammer (in Fleer et al., 2006) saw learning environments as dynamic and constantly evolving. They argued that, from a socio-cultural perspective learning environments should be designed for multipurpose learning and teaching in that they accommodate cultural diversity, spontaneous play and/or guided teaching, social interactions, self-directed learning, and contain resources that provoke curiosity and can be manipulated with confidence. Overall these researchers insisted that dynamic learning environments should always reflect the presence of children and be ready to educate. Interactive learning environments remain therefore, "responsive to the interests and (learning) abilities of each child" (DEEWR, 2009b, p. 15) that are easily transformed to meet the diversity of skill and interest of the users.

The physical attributes of learning environments in the Reggio Emilia model of early education were considered by Malaguzzi to be of such importance for a child's development that he named them the 'third teacher'. Malaguzzi, considered the inspirational educator of Reggio Emilia schools, so named the learning environment the third teacher because he recognised children as determined young learners whose curiosity and active nature sought new knowledge from any space they inhabited and any objects they encountered (Gandini, 1998).

Learning environments can, in theory, be constructed from natural and/or synthetic properties and accessed through an ELC to activate wonder and create thoughtful engagement through open-ended activities in safe yet challenging experiences (Elliott, 2010a). Environments can be created by nature itself, small or large, created by children, by adults, or as a collaborative effort between children and adults, but importantly they are interactive and thoughtfully address cultural differences. Continuing the description of learning environments, educational practitioners, Curtis and Carter (2003; 2008) urged that the use of tunnels, curtains, mirrors, mud patches, dolls and climbing frames can reflect cultural nuances, and that large moveable structures that offered inviting challenges, such as a rowing boat, enabled all children to creatively and socially participate in learning. Fleer (2007) concluded that, the extent of children's engagement in a learning environments is mostly "determined by both what is in the environment that can be explored and what adults or significant others around them, point out about that environment" (p. 11).

In a practical sense Johnston (2005b) reported the use of various loose pieces (movable objects) in the learning environment can be most effective when specifically placed to develop the joy of discovery and skills related to observation, problem solving and conversation. Broda, (2011) added that no matter how small and seemingly insignificant the loose pieces may be, they can create for children valuable learning opportunities and higher order thinking as they find what Millikan described as "the extraordinary in the ordinary" (2003, p. 62). Johnston (2007) argued that attentive placement of imaginative objects into an interactive learning environment has the prospect of being a provocation that stimulates thinking past curiosity and leads investigations by those children who may otherwise be reluctant participants.

Multipurpose learning environments serve children in different ways. Laevers (2005) pointed out that the extent of learning that happens within specific environments will relate directly to the richness of the surrounds, the interest of the child and the input of the educator, regardless of child competence. That richness, Laevers added, could be tested in two ways: the first related to the diversity of possible experiences the place offered and the second related to how much there was to be discovered when the opportunities, activities and experiences speak to the diverse cultural understanding, needs and capabilities of children.

Fleer (2007) argued that, regardless of explicit planning and age of children, it is what they pay attention to in the environment that creates the catalyst for learning. Johnston (2005a) noted that it is the role of the educator to plan and create inviting and purposeful places where children could harmoniously develop skills of engagement and help others while extending their own learning. Johnston continued that, with flexibility in the planning and setup of a learning environment, an educator can offer children, regardless of chronological ages and ability, open-ended problems to solve and opportunities to become interested in a range of topics or activities. Invitational challenges within that learning environment can also provide occasions for children to test and refine their understanding according to their social and emotional skills, physical and cognitive ability.

Arthur (2010) noted that, with extension of learning in the mind of the educator, early childhood settings should include rich and challenging environments that are flexible enough to enhance both the daily lives and learning potential of individual children. Adopting those views, Arthur concluded that learning environments need to be collaborative places where children can rehearse "cooperation, persistence and reflexivity as well as deep learning and higher order thinking", either as individuals or within a group (2010, p.13). Worth (2010) proposed that children have much greater potential to learn from their environmental situations, than is sometimes given them credit.

Indoor and outdoor learning environments

The elements and implications of the educational value of indoor or outdoor learning situations have been debated by scholars from a variety of perspectives related to fittings, furniture, lighting, air flow and aesthetics (Millikan, 2003); natural and constructed areas (Warden, 2006); space and purpose (Elliott, 2010b); community views (Heard & McDonough, 2009); design and risk (Davis, 2010); sustainability, relationships, capabilities, respect and responsibility (Cutter-Mackenzie & S. Edwards, 2011). In a debate about indoor or outdoor environments for learning, Malaguzzi reflected that what counts is "…not so much the space as what happens in it" (1998, p. 63). Fleer et al. (2006) claimed that the set-up of learning environments for intentional teaching purposes, whether indoors or outdoors, natural or constructed by people, the engagement should be overseen by an educator for best learning results. The spaces, they added, should aim to invite interaction, entice curiosity, and develop the interrelationships for the children they serve, as expected within socio-cultural activities.

Millikan (2003) argued that maintaining evidence of prior works such as paintings and constructions would invite children to visit a prepared space to reflect past accomplishment, thus having a sense of "being connected with and contribut[ing] to their world" (DEEWR, 2009a p.25). When taking a closer look, and from a child's perspective, Szarkowicz (2006) noted that children often feel more comfortable in smaller, confined areas to advance new ideas, as opposed to large open spaces. Greenman (2007) extended Szarkowicz's findings by adding that where small spaces offered privacy, larger transitional places offered crowds, and that whether large or small, quiet or busy, children will choose a space for different purposes.

Usually designed for interconnectedness; indoor learning spaces can be flexible or static in positioning (Fleer, 2007). Curtis and Carter (2008) noted that these indoor learning spaces are sometimes called 'learning stations' or 'learning centres' and are most often presented as themed uncluttered places that offer social collaboration and multidimensional tasks that have small risks and challenges to address the outcomes of intentional teaching (DEEWR, 2009a). Arthur et al. (2008) added that despite educators' intentional purpose of a learning environment aspects within these defined spaces, should also welcome spontaneous creative play that can demonstrate variations of thinking and cultural influence.

In Australia, where there is usually ample outdoor space, however, as Millikan (2003) pointed out there can be confusion about whether or not the play-ground attached to a school constitutes a learning environment. Greenfield (2004) supported the use of school playgrounds as learning environments and claimed that permanent fixtures, and their apparently restricted investigative and explorative nature, can be transformed by either children or adults into inspirational places to learn with the addition of loose pieces (such as bed sheets, logs or old tyres) and manipulative tools (such as digging equipment, hammers, funnels and magnifying glasses). To make the most of what may appear an uninspiring play space, educators could first ask themselves what flexible qualities and cognitive opportunities are indicated and then investigate what learning can be achieved through collaborative design and planning with children. Heidemann and Hewitt (2010) reflected that sometimes the value of a large outdoor learning environment may be overlooked and undervalued, as learning spaces, by educators. Too often, according to Walker (2011) these open areas are seen as a place to 'let off steam' and 'use up excess energy' rather than to develop learning associated with cognitive competencies. Broda (2011) proposed that, educators view all spaces as learning spaces where children can engage in collaborative learning through 'rough and tumble' games, learning to write letter symbols in the sand or trying to figure out how environmental tools work. Tannock (2011) described rough and tumble play as activity that includes running, fleeing, climbing, rolling, falling, chasing and play-fighting but is not associated with aggression.

Limitations

Limitations for learning environments can relate to area, safety, risk and inflexible spaces. Greenfield (2004) also saw an emphasis on electronic media as a limitation when the wider interactive environment was forsaken for passive engagement. Johnston (2007) pointed out that outdoor learning environments are not always available for children and added that, with imagination, indoor learning environments can be reframed to acknowledge that limitation. Robertson (2010) argued there should be no status difference between indoor and outdoor learning environments, nor should there be hard and fast rules about how those areas are positioned in an ECE learning program. Robertson added that regardless of the places in which children engage their learning, adults are most helpful when they are responsive to the needs and innate curiosity that children carry with them. In support of the theory’s contextual position for learning environments, Fleer and Robbins (2003) argued that, when in the company of others, children will utilise whatever learning spaces and cultural tools are available in their day-to-day experiences as they connect information and construct new understanding, whether from intended or incidental learning situations.

Safety and risk of injury to children that may occur during learning situations has been widely discussed and is considered, by some, to be an unfortunate limitation when the outdoor environment is considered for learning (see Chapman, 2010; Davis, 2010; Greenfield 2004; Kennedy & Barblett, 2010 and Warden, 2010). Furedi (cited in Chapman, 2010) went so far as to suggest that an aversion to risk, and concern for safety, was at times, bordering on paranoia by some caregivers. However, Gill (2007) and Louv (2005) are among contemporary researchers who encourage pedagogy that helps children learn to manage risk and teach them to come to know the difference between a risk and a hazard. Educators can arm the children with information that acknowledges their intelligence and demonstrates trust in them to exhibit caution when necessary, especially in outdoor learning environments, where perhaps, more risky challenges are presented. Chapman (2010) added that rudimentary knowledge about how to manage risk and 'read' the natural environment is a life-skill that can begin in early childhood. (See also section *Challenges for play-based learning.* p.51*)*

The National Quality Standards (NQS) for Early Childhood Education and Care and School Age Care (COAG, 2009) guides and strengthens early childhood education and care in Australia by encouraging members of ELCs to reflect on the quality of experiences and settings in which young children learn. Of the seven Quality Areas of the NQS to be addressed by educators, Quality Area 2 (ACECQA, Guide to the National Quality Standards, 2011) specifically refers to children's health and safety and encourages educators to support opportunities for children's confident and involved engagement in physical activities. From Quality Area 2, sub-section 2.3.2 states that, "reasonable steps will be taken to identify and manage risks, and every reasonable precaution is taken to protect children from harms and hazards" (COAG, 2009, p 14).

Greenfield (2004) expressed that the increasing concern of carers about risk and safety may be denying many children opportunities to gain confidence and the competencies, such as problem solving, associated with managing risks. Nonetheless, Little and Wyver (2008) called attention to the safety audits that are required by regulatory bodies within an ELC and cautioned that "the provision of opportunities for risk-taking in children's outdoor play does not mean that safety is ignored" (p. 35). It is arguably wise for administrators to ensure safety is prioritised and risks managed within both constructed and natural learning environments (Kennedy & Barblett, 2010). However, Chapman (2010), Davis (2010) and Gill (2012) agree that too much regulation and limited engagement can tend to reduce, rather than improve, opportunities to gain skills associated with problem solving, risk management, self-regulation and resilience when engagement in a learning environment is over-managed. S. Edwards and Cutter Mackenzie (2011) proposed that when children were recognised by their educators as capable learners who create an affinity with and responsibility for their environment, children's risk can be minimised.

Greenfield (2004) noted that cultural changes associated with cities becoming larger, back-yards becoming smaller and open venues for investigative and unstructured spontaneous activity becomes rarer for children, limitations are placed physical development, as well as the aforementioned influences on cognitive thought is seeing an adaptation of cultural history. Other researchers who have expressed concern about limitations related to opportune outdoor play for children include Elliott (2010), Greenman (2007), Louv (2005), Warden, (2010) and Zeece (1999). The apprehension is that challenge and wonder related to children experiencing nature first hand could become sterile and orchestrated.

Nature based learning environments

Davis and Elliott (2001) claimed that experiencing a secondhand view of nature (via media rather than in reality) has the potential to debilitate learning and stifle imagination. This claim is linked to other researchers who call for children to learn from, and become more closely associated with the natural world, as opposed to constructed and synthetic experiences. Louv (2005) and Warden (2010) agreed that regulations and restrictions, often imposed upon natural learning experiences, are reducing the richness that outdoor environments can bring to children's early learning. Chapman (2010) pointed out, for example, that before children can make informed decisions about the weather, and their own safety in outdoor settings, authentic exposure to the elements and the dynamic conditions of this environment are required. The impression that children are missing important qualities of learning, and knowledge building, when not exposed to outdoor learning (especially in natural learning environments) has been broadly discussed and the analysis of what contributes to and influences appropriate early childhood learning continues to be a debate (see also, S. Edwards & Cutter-Mackenzie, 2011; Heard & McDonough, 2009).

Louv (2005), responding to what he perceived as a loss for children when they were not exposed to play in natural settings, coined the phrase, 'nature deficit disorder'. The phrase was born of concern that children would not recognise, nor be responsive to, their connectedness with Earth. Davis (2010) brought to the fore a concern about an erosion of children's relationships with the natural environment and used the Kahan (2009) term 'generational amnesia' to describe that concern. Kahan pointed out that, with each passing generation, the wonder and value of a natural learning environment appears to be diminishing. Davis (2010) added that what was once associated with the reality of nature is now often clinically represented or misrepresented via electronic and other media. Heard and McDonough (2009) were mindful that open spaces and unspoiled environments do not always occur within the location of ECE, for example, in areas with high density residential accommodation or within industrial regions. Even so, Davis (2010) explained that compensatory experiences can be attained through the use of a potted sensory garden and paths to secret places. An atrium, places to hide, and connections made through investigation of collected natural objects (plant matter, shells and bones) or by conducting a 'window watch' for birds in the area are other ideas that can connect cause thought processes to be activated and offer a taste of nature based learning.

Heard and McDonough (2009) were mindful that open spaces and unspoiled environments, sometimes, do not naturally occur within the location of ECE, for example, in areas with high density residential accommodation or within industrial regions. Even so, Davis (2010) explained that compensatory experiences can be attained through the use of a potted sensory garden and paths to secret places. An atrium, places to hide, and connections made through investigation of a collection of natural objects such as plant matter, shells and bones or by conducting a 'window watch' for birds in the area are other idea that can connect children with nature based learning.

2.3.6 The active role of the educator

Typically, an educator in this study refers to a person mentoring young children's learning and can refer to a parent, a qualified classroom teacher, a researcher, a peer, and/or a qualified education assistant. "Vygotsky believed that as more mature partners - both adults and peers - offer guidance to children mastering culturally meaningful activities, the communication with these partners becomes part of the children's thinking" (Berk & Winsler, 1995, p. 19). The result of children's thinking becomes cognitive meanings that are bound within their culture. However, as "social interactions and social experiences drive what children might learn", McNaughton posited that, from a socio-cultural perspective, meanings are mostly constructed by those who have the most cultural power (2009, p. 55). The basic premise of positions of power is "that children construct meanings in situations in which power relations have already been accomplished and in which competing meanings vie for power (McNaughton, 2009, p. 61). As the literature review unfolded, and the prominence of each element of the SCALTEC framework became more visible, the element that clearly held a position of power over children's learning was the role of the educator.

A robust body of literature attracted many definitions about the role of the teacher. Pope-Edwards (2002) defined an educator's role in terms of being the reciprocal connector between a learner and an educator, and that sometimes the child would lead the direction of new learning and at other times the lead was taken by the educator. From another view, the fundamental role of an educator in a position of power was similarly described by Hattie (2003) and later by Epstein (2007) as one that purposefully and intentionally instructed the novice so that learning occurs. Kalantzis and Cope (2008) described the educator as being a dynamic agent of change who worked with the learner, rather than simply being a transmitter of knowledge. From a more socio-cultural approach to the social interaction between educator and learner to construct new meaning, the EYLF contributed that the "holistic nature of early childhood educators' professional practice... [and] professional judgements are central to their active role in facilitating children's learning" (DEEWR, 2009a p. 11). Brenneman (2011) pointed out that the fundamental skill of an educator of young children is to know what to teach, and how to teach. Additionally, that the ECE educator's role would be to address the needs and interests of individual learners from a perspective of holding a solid understanding about their cultural diversities, how children generally learned, and the complexities of child development. Sprod (2011) portrayed the educator as one of an experienced thinker whose role is influenced by societal, cultural and political change.

Elaborating the 2002 Pope-Edwards' definition of the educator as one of reciprocity between the learner and themselves, Bruce named that connection ‘interactionism’ to reflect socio-cultural theory (2011, p. 10). For Bruce, interactionism was the result of the brain working on two planes that networked internally with self, and externally with other people and situations, and the two key characteristics of interactionism are relationships and active learning. Relationships referred to children interactively engaging interpersonal and contextual circumstances to advance their cultural understanding. Rather than applying a one-size-fits-all approach, Bruce argued that interactionism supported sound pedagogy designed to meet and extend individual learning needs. This pedagogy led to "increased sophistication in early childhood teaching practice through better understanding of the ubiquities that remain at the heart of early childhood practice in an increasingly diverse and complex world" (Bruce, 2011, p. 39).

To further elaborate the active role of the educator the following sections describe the educator in relation to keeping pace with change, knowing the children being taught, pedagogical play and learning, and teachable moments and assessment.

Keeping pace with change

According to Vygotsky (1978), everything, is in a state of change and none more so than the evolving intellect and skills of young children. Perplexing changes in the social and emotional well-being of children are often related to transformations that stem from their health and physical capabilities, intellect, prior learning and culture (DEEWR, 2009b). Along with the changing combinations associated with children's developing learning needs, Fleer (2007) pointed out that, in the field of education, there are also changing expectations of the educator from societal and political influences. Mawson (2011) found these circumstances impinge upon the role of the educator and added changes that the dynamics of contemporary living bring to the complex characteristics of each young learner.

As an example of the dynamics of the educator keeping pace with change, DEEWR (2010a, p.10) reported that “early childhood teachers have been found to make 936 curriculum decisions in a six hour day.” These constantly changing learning needs of young children had earlier been described as a process of 'becoming' and explained in the EYLF as a “…process of rapid and significant change that occurs in the early years as children learn and grow” (DEEWR, 2009b, p. 7).

Epstein (2007) found that, to accommodate the complexities of learning and provide optimal learning opportunities for young children, the onus is on educators to keep pace with current policy, societal demands and the constantly changing, multifaceted nature of the world that children occupy. Mawson (2011) and Mackenzie (2011) argued that educators required a repertoire of successful pedagogical practices to meet the dynamic needs of their young learners, and a professional outlook for contemporary approaches to ECE.

Jones, Kervin and Macintosh (2011) explained that contemporary concepts relating to trends and commercially presented teaching designs can be highly beneficial in the ECE classroom. However, they cautioned that the popularity of some contemporary trends and commercial items also have potential to obscure valuable past practices and cloud the immediate needs of children. In earlier research linked to similar concerns, Pope-Edwards (2002) and later Epstein (2007), found the unease to be mostly unwarranted because thoughtful educators used deliberately chosen pedagogy and questioned parallels and contrasts of good practice in teaching.

Knowing the child

Fleer and Ridgeway (2007) suggested that information about what a child does and does not know, can be revealed by both the child and others who know that child. These researchers maintained that innovative learning would be meaningless if not situated within the context of the children being taught. Elaborating that notion, Arthur et al. (2008) argued that, when learning begins from where the children are, in an educational sense, the educator can design levels of challenge and scaffolding, as required, to promote learning. Mackenzie (2011) explained that for intentional teaching purposes, useful background information, based on capabilities and cultural beliefs of children, came from children's existing ‘fund of knowledge’. Gonzalez et al. (cited in Hedges, 2011) defined children’s funds of knowledge as dynamic information that children have accumulated (and continue to do so) from life's daily experiences.

Booth and Thornley-Hall (1991) found aspects of teaching can be delivered to meet a child's specific needs by either subtle or explicit means. Either way, Koles, O’Connor and Mccartney (2009) found that knowing the children being taught is evidenced when appropriate pedagogy is used to make children feel comfortable in their learning and confident when they participate. For example, when cultural perspectives and diversity are respected (Fleer & Robbins, 2003); when specific needs are met through intentional teaching (Hattie, 2003); when signs of success are acknowledged (Fleer, 2007); and when the complexity of a challenge is attuned to a child's ZPD (Elias, 2009).

Studies by Foreman and Fyfe (1998) that explored learning and teaching strategies used in Italian ELCs for children under the age of 5-years found that learning was enhanced when negotiation occurred, between the educator and the learner, to establish a common ground to begin new learning. In later research, Foreman (2010) pointed out that, as the educator and learner were equally curious about each other, a negotiated partnership provided helpful knowledge for both parties.

As “a mediator between the child’s everyday understandings and ‘schooled’ concepts” a pivotal point for the educator to obtain effective knowledge to assist learning and teaching is provided through communication between the home and the ELC (McLachlan et al., 2010, p. 220). Yelland revealed another example that helps the educator know the child relates to being attuned to the "resources and playthings that children [use] prior to coming to school and in after-school activities [that] are becoming increasingly influential in shaping what [children] are able to do" (2011, p. 10). Similarly Mackenzie (2011) pointed out that contemporary modes of literacy are mostly unavoidable as they permeate the day-to-day lives of children and that these pervasive trends can help the educator discover more about the children they teach. Mackenzie explained that to do this, one avenue was to communicate with the children's home educator about contemporary literacy and, if possible, incorporate the contemporary trends in the classroom.

Pedagogical play and learning

As indicated earlier, the work of S. Edwards and Cutter-Mackenzie (2006) and others, brought disquiet to the harmony of teaching in ECE when they claimed that a current commitment by educators to play-based pedagogy was problematic. They argued that ECE educators do not deliver enough visible content knowledge when play was the emphasis in learning. Nonetheless, Katz (2010) and Yelland (2011), who had also agreed that play can be a problematic pedagogy, established that a natural medium for learning was playful experiences. Debatable as it may be, evidence from literature associated with pedagogical play by researchers such as Heidemann and Hewitt (2010) and Walker (2011), demonstrated that playing and learning go hand-in-hand and that, as a part of the curriculum, collaborative play presented for educators an avenue to help children understand the interconnectedness that transforms both knowledge and intellectual development.

Fleer and Robbins (2003) explained that tacit misunderstandings about the value of play to develop learning, and the place of play in ECE, can often be attributed to poor public perception of the pedagogy. Therefore, in the context of children's learning, the onus is on the educator to deliver purposeful playful experiences that will support that learning. Additionally, that educator must be prepared and able to explain that "play is purposeful and engages children's minds, bodies and emotions" (Epstein, 2007, p. 130). Therefore, and as considered earlier in this chapter, Bruce (2011) and S. Edwards and Cutter-Mackenzie (2011) identified that effective and efficient pedagogy would focus on the processes of learning through play and not just the products of playful learning. Even so McLachlan et al. (2010) held that issues related to play as pedagogy, remained contentious in some learning communities (see also Miller & Almor, 2009).

Teachable moments and assessment

Heidemann and Hewitt (2010) held that educational benefit, for both child and educator, were gained when advantage was taken of the 'teachable moments' that frequently occur during play. They explained that, through the use of an unplanned strategy that is embedded within the context of a learning experience or activity, teachable moments transpire when children and educators spontaneously collaborate to advance learning. This impulsive interaction can occur during planned (or unplanned) activities or discussions. Point of need assistance, that reflects a teachable moment can occur, for example, when an educator helps a young child describe an object or explain an achievement to an audience. Thus, teachable moments can provide for the educator, unexpected and contextual assessment opportunities that deepen their knowledge about a child's knowledge and capabilities.

Additionally, Venville, Rennie and Wallace (2009) considered integration across curriculum subjects provided incidences where teachable moments could support the individual learning needs of children. Other substantial research (see Szarkowicz, 2006; Epstein, 2007; Tytler, 2007; DEEWR, 2009b) also supported the notion that educators are best placed to address teachable moments when they were actively engaged in supporting children's learning needs and helping them consolidate learning while their skills and content knowledge are developing.

When assessment for young children was undertaken, it is considered part of an "on-going cycle that includes planning, documenting and evaluating ... and includes a diverse array of methods to capture and validate" children's achievement DEEWR (2009b, p. 17). Bruce (2011) noted that, because learning is connected in so many ways and presents a complex and dynamic occurrence, the assessment and measurement of a young learner's achievement is neither neat nor easily dissected. Bennneman (2011) also recognised the complexities associated with the task of assessing young children as they go about developing their life's skills in complex ways. She made four important points about assessment: first, that assessment in ELCs "justifiably concerns many people" (p.10); second, that the perfect tool for assessment remains contentious; third, that assessment is not optional; and fourth, that emphasis be positioned on 'how' achievement is assessed rather than 'if' achievement is to be assessed. In support of those points, Yelland (2011) called for common sense to prevail when young learner's capabilities were assessed.

Summarising the role of the educator

Arthur, et al. (2003) argued that, to cope with evolving ECE expectations and the diversity of children's learning, educators first acknowledge children's competencies, then let go of preconceived ideas about what children ought to learn, and finally, stop planning with a focus on predetermined experiences. The complexity of assessing early learning, as seen in the previous section, remains contentious and an action that cannot be easily compartmentalised as children tend to learn as a whole experience. Torr (2005) pointed out that, as well as enabling significant learning opportunities for children, educators were to engage in open communication with both the child and their family. Torr elaborated that open communication revealed to the educator children's learning needs and wide-ranging opportunities to accommodate those needs. Mackenzie (2011) argued that thoughtful planning and intentional instruction were essential tools of trade for an educator because, for the learning needs of children, "teacher priorities, actions and expectations do make a difference" (p. 338). Additionally, Mawson (2011) determined that, before an educator can develop an intentional teaching program that engages young learners, their role required two major capacities: first, the ability to identify the needs and interests of the children (Hedges, cited in Mawson, 2011) and second, sufficient content knowledge to effectively use those interests to enhance children's learning. Therefore, the skills and knowledge of an educator who can facilitate interrelationships within complex learning environments, while being aware of power of position, responsive to culturally diverse contexts and the learning needs of children, is indispensable.

2.4 Conclusion

The socio-cultural theory, in which young children construct meaning from learning situations in social and playful groups, has been demonstrated through literature reviewed and reported for this chapter. The review has also illuminated the use of practical and theoretical elements of early education that underpin the developing SCALTELC framework. Throughout, the interdisciplinary nature of young children's learning reflected diverse cultural sway, multidimensional settings and the complex influences that contribute to early education. With that complexity in mind it was not surprising to find that some controversy was revealed in this review. Such controversy included researchers questioning the purpose of involving play in the curriculum, the value of outdoor environments for learning and, the purpose of assessment in ECE.

The review of literature has confirmed that reserves of cultural knowledge, accumulated by children since their birth, play a primary role in the acquisition of new learning. The manifestation of new learning begins at the cognitive level where cultural knowledge is held and simultaneously engaged with intrapersonal, interpersonal and environmental information to frame complex reconstructions of cultural knowledge. The review also demonstrated the important influence of an educator to facilitate learning. Vygotsky saw the reconstruction of current cognitive knowledge by young children as occurring within a child's ZPD. Within that ZPD more experienced educators (including adults and peers) scaffold new relationships and manageable challenges. Facilitated learning requires meaningful communication and can occur in intentional teaching situations, in playful situations, through connections between families and school and from the wider community.

Significantly, the initial stage of the SCALTELC framework has been expanded. The elements of *Interconnectedness, Communication,* C*ognitive Development*, *Play-based Learning* and L*earning Environments* and the influential *Role of the Educator* have each been elaborated through socio-cultural lenses, within an ELC context, and illustrated on the following diagram, Figure 2.2. The SCALTELC framework will be developed further in the next and subsequent chapters.

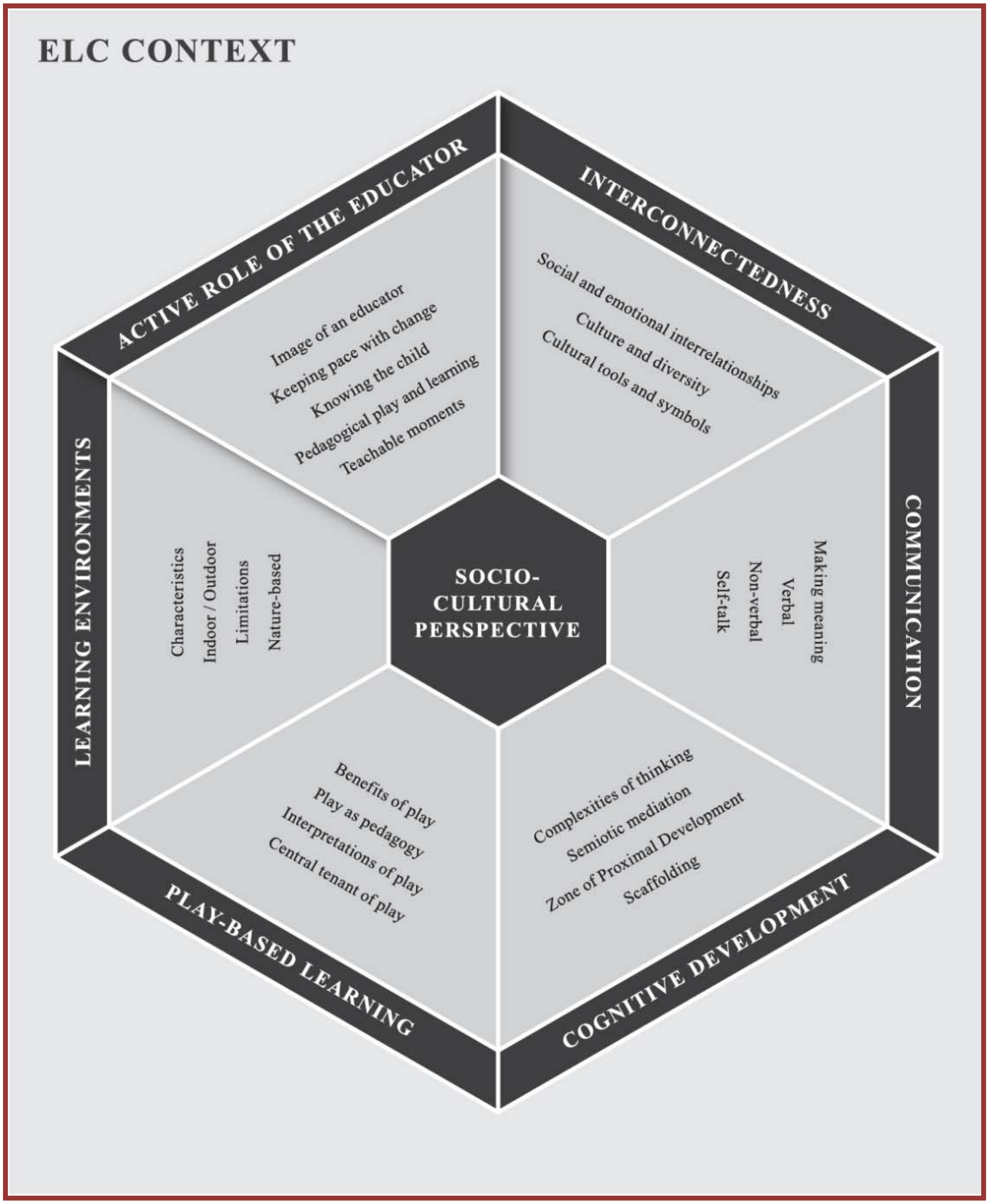

Figure 2.2 The SCALTELC framework: Elaboration of the six elements

The rationale of this review has been to position learning in ECE prior to examining how science fits into that locus, specifically within ELCs for 3- and 4- year old children. Thus, the next chapter reviews literature bearing on the extent to which the learning and teaching of science in the context of young children has been informed by socio-cultural theory.

Chapter 3

Informing the development of science in early learning centres (ELCs)

3.1 Introduction

The previous chapter received researched evidence concerning the extent to which early childhood learning and teaching is informed by socio-cultural theory in the general context of early learners, and distilled six key elements which collectively constitute the SCALTELC framework for learning. In this present chapter, the focus narrows specifically to finding what science looks like for 3- and 4- year old children in ELCs. Where there are many world views about pedagogy associated with the development of scientific knowledge and science concepts for young children, this study limits those views to Western perspectives.

When referring specifically to science for children between the ages of 3- and 4-years old, the literature reviewed has not been overtly helpful for this study in that finding examples of current learning and teaching practices is rare. Indeed the review has revealed there is typically insufficient research into the teaching and learning of science for children under the age of 8 years. Even focussing the literature reviewed to relate to children under the age of 8 years, it was found to generally refer to children who had attained an age of 5 or more years. Further, the research reviewed tended to support the theory of learning and teaching from the educator's point of view rather than revealing evidence from a pragmatic view of how children developed science learning in the context of an ELC.

Exceptions to this situation, as cited later in this chapter, include insightful research by Brenneman and Luro (2008), Fleer (2006; 2009a; 2009b; 2009c), Fleer and

Ridgeway (2007), Foreman (2010), Johnston (2005b; 2009; 2011a; 2011b), Robbins (2005b; 2008), Saçkes et al. (2011) Siraj-Blatchford (2002) and Yelland (2011) Also, in this review, where studies have not referred specifically to 3- and 4- year old children extrapolations from science-related research relating to children aged 5-years or more has been cited where relevant to this study.

It is also noted that, as argued by Einarsdóttir (2007) explicit research involving very young children is not without problems. Problems such as immaturity due to limited life experiences, a shy disposition that makes communication difficult, or rapid changes of mind and other impulsive behaviour could offer possible reasons for limited work in this field. Other explanations that may explain narrow research relate to science having only recently gained prominence in ECE; or that increased numbers of 3- and 4- year old children have recently joined educational institutions.

Nonetheless, from literature available, the following review has accumulated evidence upon which this study was prepared and presents an overview of the evolving SCALTELC framework that focuses on science. An elaboration of each of the six elements of that framework, in relation to science learning and teaching is made before the Active Role of the Educator is discussed for its prominence within the framework. Dilemmas, found to affect the learning and teaching of science in ELC are then interrogated. Preceding the summary, a brief discourse to illustrate the integration of science into the day-to-day learning and teaching in operational ELCs is presented to demonstrate implicit and explicit interrelationships between the elements of the SCALTELC framework, and socio-cultural theory.

3.2 The framework for learning and teaching science

As previously explained the SCALTELC framework is foregrounded by a socio-cultural perspective and specifically relates to the complexities of learning and teaching in an ELC context. To identify the evolving nature of the framework, now with an emphasis on science, the letter S to represent the Science focus of the study, has been added to the original acronym. The acronym now reads SCALTELC-S and represents: Socio-Cultural Application of Learning and Teaching in Early Learning Centres - Science. The six major elements of the framework remain *Interconnectedness, Communication, Cognitive Development, Play-based Learning, Learning Environments,* and the *Active Role of the Educator.*

As described in Chapter 2 these elements are underscored by a number of related concepts that serve to empower practice and pedagogy within the context of an ELC. From a socio-cultural perspective, it remains that no element in the framework is mutually exclusive. The strength of the framework comes from the interrelationships that connect all elements and provide a milieu for the learning and teaching for 3- and 4- year old children. From the review of literature, each theoretical and practical element of the SCALTELC-S framework is now discussed to illuminate science in ELCs.

3.2.1 Interconnectedness

Referring to the complex interplay of learning, interconnectedness now relates to the ability of young children to grasp new scientific concepts when additional information is added to a current understanding. These new understandings, tempered by current cultural information, previous knowledge and experiences, and the social and emotional well-being that children bring with them to the ELC, are mostly situated in natural phenomena and science connected to familiar resources and everyday circumstances (National Research Council, 2007).

The interconnectedness of ECE was discussed in the research of Robbins (2003; 2005a; 2005b; 2008) that studied how young children, from a socio-cultural perspective, developed their thinking to unlock an understanding of natural phenomena. Studies in pre-school situations with educators and children (specific ages were not given yet pre-school suggests the children would be under the age of 5 years) have concluded that interconnections made within children's learning were both complex and dynamic. Robbins (2005a) explained that the best opportunity for young children to develop science knowledge occurred when they were supported by educators and the use of known cultural tools (such as language and artefacts). Also related to the interconnectedness of science learning, Robbins pointed out that Rogoff's reference to contextual learning, as proposed by a socio-cultural approach, encourages multiple directions of learning and concept development. Robbins also found that contextual learning was developed when everyday experiences and natural phenomena were the focus of children's investigations (Robbins 2003).

The work of Vygotsky (1998) revealed that new learning called for interaction between implicit and explicit information. Fleer and Robbins (2003) argued that to develop science understandings the implicit and explicit information required to connect a new concept with what was already known by children was influenced by the circumstances of the learning, the maturity of children and their cultural implications. Their argument was elaborated in research conducted by Swain et al. (2010) to find the connections between socio-cultural theory and the development of new languages. Swain and colleagues also pointed out that relationships formed between children and adults, and the environments in which they learnt needed attention paid to the inclusion of cultural artefacts (described as all human-made objects, both material and symbolic). They saw those components as instinctively combined when young children respond to a curiosity or connect ideas for the benefit of new understanding, including understanding of science. To entrench new knowledge, Swain et al. suggested that several views of a concept were required and that new skills required rehearsal. This could be achieved when science concepts were integrated with other learning areas. Fleer (2007) proposed that, when a variety of science related activities and experiences are rehearsed over an extended period, vital connections responsible for constructing new learning are enhanced and enduring conceptual knowledge was established.

In research associated with the science of sustainability, and conducted in a variety of international locations, Siraj-Blatchford, Smith and Samuelsson (2010) found that the social and emotional development of young children were important characteristics that supported intellectual learning. The study concluded that socially aware young children could readily relate to the science of sustainability and the concept of an 'ecological footprint' when circumstances connected to their daily lives brought for them, meaning and balance. Further, the study found that the balanced approach these children brought to their learning enabled them to develop critical appreciation of the sciences and technologies associated with sustainability. It was pointed out however, that adult interaction was an essential feature in the effective development of a healthy attitude toward sustainability. Siraj-Blatchford et al. (2010) used as an example, work done in Australia at the University of Melbourne's Early Learning Centre (2008) when 4-year-old children vicariously investigated scientific aspects of Antarctica. This investigation saw children integrate art, mime, story, photography and role-play to present their understanding about the fragility of Antarctica. Through the day-to-day learning experiences of children, the results of this experience for 4-year-old children demonstrated how a depth of involvement in an investigation was dependent upon the way adults reacted to the early learning needs of children. This outcome supported the work of Johnston (2005b) who explained that connections to provide enduring educational benefit in science for young children came when they were immersed in an investigation through multiple methods of discovery.

Culture and diversity in science learning

As indicated in Chapter 2, it has long been recognised that cultural influence can direct much of what children learn (see Fleer et al., 2006; Robbins, 2003; Vygotsky 1978). Johnston (2009) referred to the value of cultural influences as a part of the prior knowledge children brought to school. She added that knowledge (by the educator) of the culture and diverse learning styles of children could establish, and benefit, new science investigations. Fleer and Ridgeway (2007) explained that children looked for evidence of connections between one object and another and then linked information with knowledge outside of the current experience. However, they explained that sometimes, children cannot understand conceptual connections because culturally they cannot link an item to a concept. Fleer and Ridgeway used, as an example, wet suits that surfers wear to insulate their bodies in the ocean. They explained that young children may wear a wetsuit when surfing without holding any understanding of the science of insulation. Instead, they see the wetsuit as part of the culture of dress for the activity of surfing. Epstein (2007) suggested however, that information to connect cultural awareness with new information had the potential to shape science in the lives of children. Presenting this connection would take on different perspectives, such as samples of artwork, or tools, discussions and items used in relation to an investigation. For example, an examination about how local weather patterns affect children's day-to-day existence could include, for example, investigations into clothing, ultra-violet ray protection and rain gauges so that children become aware of the scientific context in which they live. The connection children make between culture and how science contributes to their daily life was revealed when research undertaken by K. Edwards and Loveridge (2011) in a childcare community in New Zealand with 35 children between the ages of 18 months and 5-years old, found that local knowledge (or cultural awareness) contributed significantly to learning when the animals and plants, native to the children's home and school area, were investigated.

To explore relationships between cultural influences and scientific understanding Johnston (2011) did a comparative study that investigated the way children in UK and Brazil viewed natural phenomena. The study revealed that children, who are interacting in a second language or confronted with a conflicting view of an object or processes, can become perplexed when the information provided is outside of their cultural understanding. Given this finding, Johnston recommended that educators act as facilitators and assist children with their early understandings of science concepts because "alternative conceptions" can accumulate when experiences cause cultural conflict or a concept is misunderstood (Johnston, 2005b, p. 76). From a different viewpoint, Fleer and Robbins argued that any limitations presented when discussing cultural implications that hamper science learning were simply borders that "can be transcended when socio-cultural tools (such as language and symbols) are used" (2003, p. 425). However, Johnston (2005b) reiterated that unless skilled teachers acted intuitively and sensitively, ignorance and cultural aspects could see new learning remain scientifically inaccurate and culturally insensitive. The earlier work of Mulholland and Wallace (2003) had also found evidence about the significance of the essential role of skilled educators to support developing science concepts in accordance with cultural understanding.

As a cautionary note Robbins (2005a) added that the nature of scientific investigations through the use of cultural artefacts should be inclusive of the culture of all children, regardless of their background, capabilities or cultural persuasions. Similarly, for "children to learn content in different modes that make meaningful [and accurate] connections" Epstein, (2007, p. 42) argued for the use of multiple methods of investigation. Johnston (2005a) had earlier pointed out that this pedagogical approach could alleviate perceived problems associated with cultural issues, intuitive beliefs and alternative conceptions about science knowledge. Robbins (2005b) elaborated that, with a range of thoughtful pedagogies, devised and deliberately implemented to recognise children's diverse learning capabilities, developing scientific concepts became meaningful for young children.

3.2.2 Communication

Vygotsky (1978) proposed that processes contributing to communication are delivered through a relationship of words and actions. Similarly as emphasised by Wellington and Osborne (2001), communicating science is more than just words. Konza (2006) argued that communication skills accumulate as children grow and that those skills include verbal and non-verbal examples with many guises that relate to expressing meaning and transmitting information in a variety of ways (see also Ehrlen, 2009). As examples of words and actions, Bruce (2011) included listening, speaking, writing, reading, drawing, singing, miming, sculpting, and the use of body or props as means of transmitting communication. Transcribed through the dual actions of graphic representation and verbal explanation Malaguzzi (1998) pointed out that, communicating findings and understanding typically related to the experiences and capabilities of young children. Therefore, for the interpretation of other people, multiple forms of communication were used.

To elaborate the combination of strategies used to communicate knowledge, Robbins argued that the interpretation of what young children know, when they are engaged in explaining their development of a scientific concept,

> …is not merely the words children use in their explanations, nor the product of their thinking, but the processes and the additional subtleties within the dialogue, such as pauses, gestures, and references to other things in the environment or seemingly unrelated happenings, and the personal and social narratives in which many of the children situate their explanations, that are of interest. (p. 423, 2003)

The language of science communication

Wellington and Osborne (2001) argued that learning the vocabulary of science, as children engage in science activities, is the important step toward developing a firm understanding about the processes and knowledge of science concepts. They explained that often a barrier that confuses children's best effort to learn a science concept is a lack of understanding of the language of science. Wellington and Osborne concede that children can and do use scientific terms in communication, however, "this does not imply that they understand them [nor] …does it imply that we [educators] should skirt around it or try to avoid the language of science" (p.6). In a similar vein, Custance, Dare and Polias (2011) found that, in the context of young children, language specific to science evolves when experiences and circumstances, unique to scientific investigations, are transmitted between the educator and the children. New words, that may include, for example, 'balance', 'test', 'report', 'thermometer', 'stagnant', 'buoyancy' 'decay' and 'contrast' are best presented in context so that the semiotics of science language are developed accurately (Custance et al., 2011; Wellington & Osborne, 2001). Because the skill of reporting scientific findings to an audience is a developing skill, Wellington and Osborne (2001) suggested it should be started early in education. Deighton, Morrie and Overton (2011) pointed out that children also required opportunities to rehearse the skills associated with reporting. They found that the consolidation of conceptual understanding was assisted when learning included the use of appropriate language for science equipment and processes, when children presented reports.

Communication skills support the integrated nature of learning in an ELC and highlight the importance of questioning and dialogue when developing the strong and linked vocabulary required for developing science skills. Custance et al. (2011) explained that, from a common-sense understanding about the purpose and workings related to their world, children develop a repertoire of language and much of this comes from questioning. Earlier, Wellington and Osborne (2001) had proposed that while children are reading or listening to information, 'silent questions' often arise which are not articulated, but do indeed cause wonder. To anticipate the silent question, or an exposed curiosity, shared thinking can help. The strategy of sustained shared thinking is described by Siraj-Blatchford, et al. (2002, p. 8), as "an episode in which two or more individuals work together in an intellectual way". In collaboration, both parties contribute thoughts to find an answer for a conundrum or to clarify a concept. In the settings of their study to find effective ELC pedagogy for young children, Siraj-Blatchford, et al. (2002) found that questioning "is associated with better cognitive achievement", and hence, language development. Regrettably, however, they also found that open-ended questioning that would develop shared thinking, and therefore help children understand the language and process of science, “made up for only 5.1% of questioning” (p.11).

Swain et al. (2010) argued that complex tasks required to develop conceptual language can take many avenues and include graphical representations, conversing with other people, and talking to self. Reporting the findings of a scientific investigation to others is one such complex task for young children and depends on a range of maturing capabilities such as an awareness of audience and skills to initiate, or join, a discussion. Ability to recognise clues that invites opinion could be complicated for young children, as can knowing which information to offer, when it is best contributed and how it relates to the culture of the audience. These communication skills are all associated with increasing maturity and cognitive development. The developing skill of conversation tends to grow as children become experienced in using associated and culturally appropriate language to demonstrate their knowledge about a topic. Thus, acquired and purposeful language associated with science concepts is helpful when children communicate, say, a complex operation. For the accumulation of new meaning, purposeful language assists in the reconstruction of associated cognitive knowledge, topic information and cultural understandings (Rogoff, 2003). Being reflective of the importance of socio-cultural theory that supports cognitive and conceptual development, Berk and Winsler (1995) and McLaughlan et al. (2010) also discussed the use of appropriate and deliberate questioning associated with language development.

In a bid to analyse appropriate questions that could be used to develop higher order thinking for young children, it was found that questions are asked for different purposes and there are several types of question that an inquirer can ask. Differences in types of questions asked are explained in Raphael’s (1984) ‘question-answer-relationships’ and Blank’s ‘Levels of Questioning’ (in Miller, 2008). These provide examples for open-ended and closed questions that are used in a variety of purposes for developing cognitive and conceptual knowledge. Therefore, responses to the same contextual question can present a variety of answers from different children because a response is usually dependent on the level of cognitive development and cultural understanding the child has to mediate the question. Mediation can be assisted when purposeful teaching occurs in social contexts and educators model conversations, shared thinking and open questions to "foster high-level thinking" (DEEWR, 2009, p. 15).

Manipulation of complex thought is related to maturing communication skills. The complex integration of implicit and explicit information that forms communication was described by Wellington and Osborne (2001) through the theory of semiotics. They accounted that the use of semiotics, when meaning is made from a combination of action and words, would be well known to an educator as a strategy to develop new language "in the right place at the right time" (p. 7). Custance et al. (2011) found the strategy of integrating new words in context was essential for young children's language development. New words accurately placed in language can embellish findings and are especially useful when contributing scientific knowledge for the learning of others. The complexities between the practical and theoretical components of communication to develop science language presented in this section highlights the notion of integrated teaching and learning, as accentuated in the development of the SCALTELC-S framework.

3.2.3 Cognitive development

The SCALTELC-S element of Cognitive Development acknowledges the advantages of sequential higher order thinking, reasoning and remembering in the complexities of learning associated with science development. Again, interrelationships between elements of the framework become evident as information that facilitates cognitive development in a sequential and responsive manner, encompasses interaction between the intrinsic and extrinsic signals that are alerted during the learning experiences of children. Robbins (2008) described the conceptual tools that children use as they collate information as a scheme of framed thinking. Framed thinking involves tangible and intangible actions that references new action and knowledge that in turn assists concepts to "come together in meaningful ways" (Robbins, 2008, p. 2). These actions help children make judgments and gain the key to new knowledge through both individual investigations and when the help of others is enlisted (Siraj-Blatchford et al., 2002). Indeed, observations of interpersonal and interactive connections led Fleer (2009b) to propose that science learning in ECE cannot always be isolated from general learning.

Complex thinking skills to develop science concepts

Johnston (2005a) argued that learning science skills required a capacity to think deeply, and that this capacity was enhanced when two or more people worked together to assist one another in a purposeful and scholarly manner. Wilson (2007) explained that cognitive development places a complicated yet crucial focus on the intellect associated with scientific knowledge, concepts and skills. Cognitive resources such as memory, procedural knowledge, investigative questioning, and a complex ability to integrate dispositional characteristics and cultural orientations are all components when science information is accumulated at the cognitive level (Tytler, 2007). Wilson (2007) argued that methods used by young children to engage higher order thinking included social and active involvement. Further, that conceptual understanding from physical and mental actions surpassed learning by rote, the facts of science, or being told about outcomes for recall. Wilson added that, when actively engaged in learning, young learners seemed to spontaneously engage cognitive functions that helped each other think scientifically, make judgements and establish ways of viewing and dealing with their world. Sprod (2011) argued further that cognition emphasised the significance of higher order thinking required to develop complicated processes and useful new knowledge. The importance of developing higher order thinking such as ordering and reasoning, he concluded, applies equally to the development of science learning for young children as it does to older children.

Following her study in the UK that involved 57 children aged between 4- and 11-years Johnston described emergent science skills as being associated with the early development of observation, participation, sequential thinking, reasoning and decision making. Further, that emergent science skills and critical thought are promoted when familiar every-day objects and occurrences are used (Johnston, 2005b, 2007; Fleer & Ridgeway, 2007). Siraj-Blatchford, cited in Johnston (2009) found that a comfortable context was created for children to engage in complex thought processes when investigative learning was related to their cultural understanding. To further inspire critical thought through the use of every-day objects, Johnston (2005b) also found that the placement of a familiar object in an unfamiliar location encouraged children to make mental connections between their real and imagined world. This implied that concrete items found in unrelated situations could not only evoke complex thinking and curiosity, but also help children rehearse the skills of observation and prediction associated with problem solving in the development of scientific content knowledge (Johnston, 2005b; 2007). Robbins (2008) argued that, for deeper understandings and new knowledge, children transformed thinking from intermental to intramental. She elaborated that this was achieved when signs and tools offered opportunities to create and substantiate knowledge. Fleer pointed out that, along with knowledge that children held about a concept, "it is important [for educators] to know about children's thinking in science, because these ideas influence how children make sense of learning" (2007, p. 12). Although active engagement in science is encouraged, Wilson (2007) flagged that children are not being helped to develop the cognitive aspects of scientific concepts unless they know how to follow a logical thinking process.

As Johnston (2005a) studied children's learning associated with emergent scientific skills, she found that the skill of thinking involved a flexible process. She explained that, because thinking is fluid, skillful pedagogy and long-term goals were required by the educators so that children could be helped to develop effective and sequential thinking skills. Further, to ensure that accurate concepts were being developed considerable practice on behalf of the children was also required. Lambert (2000) had earlier pointed out that to make visible the explicit teaching of thinking skills for children, proficient educators would ask of children probing questions, and overtly use appropriate scientific language to build cognitive intelligence associated with memory, perception, transfer, reason, induction/deduction and self-monitoring. With respect to challenges associated with developing effective thinking skills, Johnston (2007) supported the findings of Lambert and added that support, presence and precise scientific knowledge were essential qualities of an ECE educator when teaching early learners how to think scientifically (Johnston, 2007).

Wilson (2007) argued that the basis of children's scientific content knowledge was a representation of what they currently understood from a cultural perspective about the world in which they live. Johnston (2009) offered observation skills as an essential key to develop critical scientific thinking. Observation, she explained, required children to activate current knowledge and engage the readily available senses of sight, hearing, touch, smell and taste. To develop observational skills, shared learning between educators and children would model thinking that encouraged a thorough inspection at a point of investigation. This called for collaborative learning where senses are challenged, thinking is verbalised and found details are communicated using verbal or non-verbal symbols. Children's memories and cultural understanding of past experiences, she continued, are reconstructed at a cognitive level when collaborative activities are employed (Johnston, 2011). Higher level cognitive understanding is developed by children as they matured and communicated with others to confirmation thoughts, or to appease their quest for new knowledge. It is with the assistance of others that children learn to think scientifically and reconfigure, if necessary, cognitive positions held (Rogoff, 2003; Wilson, 2007).

Fleer and Cahill (2007) had previously called on 15 years of research to explain the complex nature of questions that children ask. They found that questions provided not only an insight into prior learning, but also clues that indicated how children think and connect their knowledge. When linking these findings to the development of science they concluded that questioning provided an authentic method of identifying the contexts in which children used thinking to interlace scientific concepts and make meaning of their everyday activities. Davis (2010) argued that, although children portrayed an instinctive desire to disentangle the complications of their scientific world and engaged thoughtful processes to do so, thought patterns were not transparent and were therefore difficult to analyse. Davis also found that, as children transferred new knowledge and explicitly demonstrated skills within more complex situations, their thinking became more visible when they commented on the process, asked questions or responded to the questioning by adults.

Thinking clearly and critically are learned skills that are important for making decisions and judgments throughout a learner's life and Wilson (2007) reasoned that child-centered scientific inquiry, based on questioning and the guidance of knowledgeable others, helped focus critical thinking. Young learners, Wilson argued, typically predicted outcomes, collected data and demonstrated an intuitive desire to respond to situations. They discovered and connect their findings through the practical processes of observation, trial and error, construction and discussion. Therefore, Wilson established that children acted as thoughtful scientists rather than consumers of science when they critically assessed circumstances to satisfy their curiosity. When Foreman (2010) followed a similar line of research into the patterns of thinking used by children, he also found that, when prompted by an intuitive desire to construct meaning, the collective actions of both internal and external information came together before children made thoughtful comments. His research showed that the first phase of scientific thinking for young children occurred when they became curious or saw a situation as a problem; the second phase happened when children thoughtfully planned a strategy to actively solve the problem (Foreman, 2010). This process then can be applied to other situations to advantage learning prospects. Although Foreman (2010) had argued that the application of “scientific” should not be assigned to all of children's cause-and-effect thinking, he confirmed that as "[s]cientific thinking involves both a prediction and a method of testing that prediction; it comes about when a child both predicts and plays with the outcomes" (Foreman, 2010, p. 1).

Continuing the idea that a curiosity or problem commences for children a chain of thought processes, Campbell and Jobling (2010) pointed out that the early learning skills associated with actively solving problems required logical thinking. During this action, thinking out loud was found to be helpful as children moved their thoughts in a bid to gain understanding. In a study conducted to find how dialogic teaching supported early years scientific development, Johnston (2011a) found that when educators invited children to explain the process and result of their activity, thinking, cooperative skills, planning, speculating and how the activity was evaluated becomes a logical development for scientific inquiry.

Sprod (2011) concluded that both practical and theoretical aspects were required to develop science and that, since the beginning of the 21st century “minds-on science” has been the focus of the learning and teaching science (p. *xiii*). Although Sprod’s study related mostly to older children than those who are the focus of this present study, his point of view was interesting in that rather than simply recalling facts, or engaging in discovery and hands-on science, minds-on science was explained as contributing a higher cognitive dimension to help the understanding conceptual science. Minds-on science, Sprod continued, moves learners into the territory of critique and self-correction, corresponding with cognitive development and requiring the assistance of accomplished educators. In recognition of the way that young children commence their science learning journey, Sprod concluded that, with the science of their every-day lives, the active construction of scientific understandings started from an early age was essential (Sprod, 2011).

3.2.4 Play-based learning

This element of the SCALTELC-S framework enables children to test and rehearse processes and understandings in collaborative situations that highlighted the way children naturally learn. Although the review of literature into play-based learning revealed common threads about how the pedagogy of play can support learning, questions have arisen about how children are supported in the acquisition of content knowledge when play-based learning is used (see, for example Hedges & Cullen, 2005; E. Wood, 2009; L. Wood, 2010). As established in Chapter 2, the function of play-based learning is for children to "create social groups, test out ideas, challenge each other's thinking and build new understandings" (DEEWR, 2009a, p.15). While for the educator, the pedagogy of play-based learning is to provide purposeful opportunities where learning can be guided and constructed in a manner that is meaningful and pleasurable for children (Heidemann & Hewitt, 2010). For young children playful situations were found to support the social, collaborative and integrated learning of socio-cultural activity that suited their complex learning styles (E. Wood, 2009).

Foreman (2010) argued that for children of differing abilities, play-based learning provided multiple entry points for them to perform their tasks. He noted that, for the educator, there were multiple points of entry to deliver teachable moments when play-based learning was used as pedagogy. Additionally, dialogue created during play could be either supported or redirected so that science investigations and conceptions remained relevant to the learning and teaching at hand. In research involving children aged between found 15- months and 9- years that looked at how children’s play was supported in science learning situations, Johnston (2011b) reported that the level of adult, peer and contextual support during play could not be predicted because children’s learning needs were different (e.g. younger children tended to require greater adult input than older children). However, it was found that educator knowledge about a balance of adult, peer and contextual support was essential in play pedagogy. Play-based learning offered for young children opportunities to consolidate science knowledge in a natural and uncomplicated way when they were not rushed (Epstein, 2007). Therefore, refocussing the value of play-based learning through stressing the importance of the unhurried time required by children to rehearse skills appears to be an important part of the pedagogy delivered to help young children attend to cognitive requirements associated with gathering new information.

O'Sullivan-Smyster (1996) took the view that young children know what they are curious about and without defining a purpose, playfully set about to find answers for their self-imposed investigations and rehearsal of skills. Howitt et al. (2007) also found that children were naturally playful investigators and when responding to their curious nature, they acted like scientists. It was during 2007 that there appeared to be a move away from a notion of incidental learning through play to a strategy where play was used, by educators, as a strategy to guide new learning. While continuing to be promoted by authors such as Heidemann and Hewitt (2010) and Walker as “children’s natural way to learn” (2011, p. 12), Fleer and Ridgeway (2007) and Johnston (2007) had earlier began to discuss the value of play-based learning to develop science for younger children. Fleer and Ridgeway, and Johnston also noted the advantages for science learning and teaching that came when adults were on hand to assist concept development in those natural learning situations. Epstein (2007) established that, although children freely and autonomously explored connections important for their own independent curiosity, the influence of other people (children or adults) helped them make significant connections and gain an understanding of new and accurate knowledge. Johnston’s (2007) findings agreed with those of Epstein, and others, in that children had a natural desire to learn. Johnston reiterated that skills associated with solving science related problems, such as observation, classification, creative and critical choice, are considered highly important aspects of emergent science that were advantaged when adult assistance helped children avoid the formation of incorrect knowledge. Science content knowledge, skills and processes Johnston concluded, could be achieved through play-based learning when an educator first planned the learning experience and was then on hand to assist, when required, the interactive engagement of a science investigation.

Fleer and Ridgeway (2007) proposed that, with assistance from more knowledgeable others, children were able to explore science concepts. They added that a battery of experiences and opportunities for playful repetition assisted children to imbed a deeper understanding of a concept. Fleer and Ridgeway maintained that educator input was essential pedagogy. Wilson (2007) agreed that, when playful engagement in purposeful science learning was guided by an educator, useful strategies could be employed to ensure lines of investigation were modelled, associated conversations developed and collaborative social interactions encouraged, in line with a socio-cultural perspective of learning and teaching. Foreman (2010) added that when children were testing ideas in a range of playful situations prepared by the educator, the children were given tangible opportunities to rehearse ideas and move their understanding about for clarification in uncomplicated and unhurried situations.

The value of play-based investigation to enhance science

Forman's (2010) study in Massachusetts, USA that looked into whether or not 2- and 3-year old children followed a purposeful line of thinking, like scientists, is pertinent to the debate about the value of delivering science learning and teaching opportunities for young children.

> [S]mall experiments, inventions, strategies and pauses in young children's play reveal a legitimate form of scientific thinking. Science and play both represent a frame of mind, an attitude toward the events one observes. From the simple "Can I make this happen again?" to the more complicated, "Does this cause negate the effects of that cause?", the child thinks like a scientist trying to find the pattern, the structure, the cause, or the degree of the events that happen during ordinary moments of play...in the partnership of another mind. (p. 5, 2010)

Arguably, one such partnership is the use of a ZPD to improve children's level of achievement and offer for them a chance to challenge their own thinking. Fleer (2008) argued that when this line of pedagogy was used to assist the development of children's current capabilities and understanding, an educator needed to be on hand to assess the appropriateness of scaffolding the ZPD presented to challenge and assist children. In a study by Fleer, Jane and Hardy (2007) to find the impact of learning through play, they described learning that occurred from the interest of children, and used playing with fridge magnets as an example. They argued that, although children experience forces as the objects are manipulated, the scientific explanation of the push/pull forces is unlikely to be understood by the children without adult help and repetitious experiences.

From another point of view, Duckworth (2006) argued that it was better for children to go through the active processes of 'finding-out' through play rather than have someone give the correct answer to a problem they may be trying to solve. Duckworth maintained that the process of finding-out helps children construct their own ideas and that this was an important part of learning science unrelated to the correctness of an answer. She did not imply that adults and other children do not participate, because she advanced that when wrong ideas were corrected collaboratively, new depths of thought and scientific understanding could be constructed. Although Duckworth (2006) concluded that individual engagement encouraged a variety of alternative possibilities and thoughtful processes that were provoked through the element of wonder and experimentation, she also noted the value of a supportive environment to avoid frustration.

Counterbalancing the prospect of individual, social or adult led playful learning situations, Heidemann and Hewitt (2010) held that the purpose of the play was the critical point. If for example, play was deliberately arranged for children to gain an experience that fostered new and accurate knowledge, then it would be essential that adults, who planned the experience, are on hand to guide and assist as necessary. Heidemann and Hewitt (2010) concluded that any form of play, spontaneous or guided, can be seen as a useful learning tool that will significantly improve the cognitive growth of children, consolidate knowledge and creatively help them to develop new skills.

Focusing on creativity, Connor and Link (2008) suggested that when investigation was encouraged through play, opportunities to develop innovative thought were possible. Connor and Link elaborated that people who have had major scientific influence on the world, such as inventors, chemists, engineers, explorers and designers, have taken a leap outside of what is known to discover something new. Children, like influential scientists, are able to work without theoretical boundaries, to explore new possibilities, creatively transform understanding and increase ingenuity. Innovation was more likely to take place in collaboration with others, as reflected in socio-cultural theory (Connor & Link, 2008). Encouraging young children's creative ways of seeing fresh perspectives demonstrated learning outcomes of the EYLF, and specifically Outcome One: Children have a strong sense of identity, and Outcome Two: Children are confident and involved learners (DEEWR, 2009a).

Connor and Link's (2008) thoughts about creative learning through play are supported by Gardner (2008) who argued that creative discovery can never be achieved individually because new discovery is always the result of a combination of factors that include the objects, a cultural domain, previous encounters and social interactions. Gardner's research echoed the imperatives of socio-cultural interactions that enable children to test their ideas in a playful manner, to have scope enough to rethink what they know, and conduct inspirational learning in a supportive environment. Foreman (2010) added that, rather than trying to fit new learning into a discipline, integration and collaboration, mostly through play, will see children seek solutions to problems within provided (or found) learning environments.

3.2.5 Learning Environments

Adding to literature reviewed in Chapter 2 concerning the role that learning environments play in ECE generally, environments are now discussed for their potential to support science learning and teaching in ELCs.

Fleer and Robbins (2003) found that when pursuing a curiosity, young children tended to utilise whatever tools and learning spaces are available to gain understanding, regardless of purposeful planning. For the development of scientific knowledge, Degotardi (2005) argued that learning environments, placed indoors or outdoors, can be planned and adjusted by educators for children to develop salient learning points. Johnston (2005b) added that deliberately selected spaces and equipment, designed to enhance the science concepts of young children, contribute only a part of the learning. Within a purposefully planned and specific learning environment, Johnston pointed out that the inclination of young children appeared to be to discover unintended resources or follow unintended lines of investigation and that they achieve results in addition to, or other than, the educator's intended outcome. Therefore, Johnston (2009) maintained it was important for educators developing science concepts to recognise the full potential of a learning context, and provide pedagogical support for both intended and unintended teaching that can add value to child-directed, as well as teacher directed learning.

Greenman (2007) established that, rather than constructed parts of learning such as specifically developing science, it was the whole learning experience and the entire environment that provides and improves learning potential. Thus, to achieve learning and teaching goals, the educator can manipulate the contents and aesthetics of a learning environment for the best learning opportunities but cannot always predict, or monitor, the entire learning experiences gained. Greenman also noted that children like to reveal their conceptual knowledge to other children and/or the adults in the space where new learning was developed, as often, young children do not have the words to explain their knowledge out of context.

Greenfield (2004) considered that, although not always used to their full advantage, outdoor learning experiences for children are not only crucial for science education but in addition delivered benefits for other characteristics of learning, such as "intellectual, social, emotional, physical and spiritual development" (p.1). In line with Greenfield's thoughts, Hocking (2010) added that when children were engaged in self-directed learning they tended to routinely use their five senses and, without the constraints of walls, seemed to gain other complex information that developed a more complete picture of learning. Warden (2010) explained that, from her learning and teaching experiences with very young children in outdoor environments, those children, when in the company of others, seemed more likely to establish a scientific understanding as they collaborated information about natural phenomena and learned to 'read' the environment. For example, children can take appropriate action when they develop an understanding about changing weather conditions, such as finding shelter or wearing clothing to suit those conditions. Warden also explained that when children felt confident with a skill, for example using a whittling knife, or with knowledge such as how to drain a puddle, they seemed to have no trouble trying to replicate those findings in other learning situations (Warden, 2010).

S. Edwards and Cutter-Mackenzie (2011) emphasised that practical knowledge gained in the natural environment can add to the multilayered learning about natural phenomena children encounter in their daily lives. They argued that this practical, unplanned knowledge building was helpful to develop a connectedness between scientific conceptual knowledge and the Earth. Further, this connection had three advantages: the first helped children discover how to live in harmony with natural phenomena, the second enabled children to appreciate the scientific notion of sustainability and biodiversity, and the third advantage of learning outdoors was to avoid an over-reliance on the "textual, visual, virtual and highly digitised worlds" to inform new learning (S. Edwards and Cutter-Mackenzie, 2011, p. 52).

Recapping that the specifics of incidental components of different environments can provide for young children both a wealth of investigative opportunities and complexities beyond their capabilities, Greenman (2007) concluded that the value of integrated learning should not be overlooked by the educator when purposeful spaces are developed specifically for the interrelationships of interpersonal and intrapersonal learning undertaken to develop science knowhow. In summary, the research evidence suggests that an environment designed to foster scientific thinking can be presented either indoors or outdoors. It is a place where children have time to think, space to move and materials that exercise their curiosity (Wilson, 2007), freedom to playfully engage in explorations with others (Hocking, 2010) and opportunity to discover potential solutions as the children come to understand their place in the world (S. Edwards & Cutter-Mackenzie, 2011).

3.2.6 The active role of the educator

The active role of the educator emerges as the essential link between children's scientific investigations and their learning about science. Numerous references bearing on this role have been woven into preceding discussions in this literature review, and while the author is mindful that different interpretations of socio-cultural theory, and socio-cultural activity, exist in literature (and brought about by a closeness to developmental theory), it is generally understood that socio-cultural theory influences, rather than directs development (see for example, Kaesing-Styles and Hedges, 2007; S. Edwards, 2009). This section now brings references together and builds on them to illustrate the *Active Role of the Educator* in relation to the practical and theoretical elements in the SCALTELC-S framework.

Vygotsky (1978) took the view that what children can do with the assistance of others is more conducive to improving their mental capacity than what they can do alone and unassisted. He further reasoned that fluid experiences embedded in reality stood to gain the most meaningful understandings for children when information was transferred to other areas. Vygotsky's perspective influenced research by K. Edwards and Loveridge (2011), Fleer (2007; 2009a), Johnston (2005b; 2007), Robbins (2005a; 2005b) and Swain et al. (2010). Drawing on these and other studies, the imperative Role of the Educator to assist science learning for children will be briefly discussed.

When research by Swain et al. (2010) explored how a socio-cultural narrative influenced cultural and historical knowledge in relation to a range of disciplines, they did not reveal the age of the participants but indicated that data were collected from Japan, Canada, and the USA. From the collected data by Swain and colleagues, and acknowledging the variety of cultures represented, three key science related ideas were established and found to be reflective of Vygotsky's theory. These ideas, describing the value of amalgamating scientific and every-day concepts in the context of children's culture, are:

- Scientific concepts are conscious (and therefore consciously applied) in that they are systematic and not bound to a context.
- Every-day concepts are intuitive, unsystematic and situated.
- Every-day and schooled scientific concepts combine to work together, not one replacing the other.

As commented earlier in this study, socio-cultural theory can be reflected differently in different cultures, but overall, the Swain et al. research, like others (see for example, Robbins, 2003; Fleer & Ridgeway, 2007) found that essentially, science for young children stemmed from their day-to-day encounters and that educators who provided guidance for science learning needed to provide accurate information.

Other research to support the indispensable connections essential between the every-day experiences of children and science learning is found in the work of Arthur et al. (2003), Fleer (2007) and Chaulfour (2010). Arthur et al. (2003) found that the link between scientific investigation and scientific learning is evidenced when educators acknowledge "socio-cultural perspectives that suggest children learn best when the curriculum is connected to their every-day lives and interests" (p. 10). Fleer (2007) agreed and continued that the intentional integration of science concepts with every-day concepts is considered the ideal solution for children under the age of 8-years because every-day concepts were most meaningful for children and enabled science to be effectively interwoven into their learning. Fleer also accentuated the importance of the intentional role of the educator to achieve this action. Chaulfour (2010) elaborated that new information tended to remain meaningless if not related to the current understanding of children; thus a bank of knowledge about the prior experiences and capabilities of a child was an important starting point for educators to support that notion. Other research by Brenneman (2011) also established that "...teachers need to be well versed in the kinds of foundational knowledge that preschoolers already have about science topics, the reasoning skills they possess, and the potential limits of those skills" (p.4). In addition Wilson (2007) found that a by-product of educators presenting science information that is meaningful to children is growth in their confidence which in turn can assist their sense of well-being.

Wellington and Osborne (2011) pointed out an important role of the educator when developing science was to extend the children's skills of communication through modelling the language of science. They proposed that cognition was extended when children were armed with correct words to help them describe and explain their position. Worth (2010) added that vocabulary, which might be overlooked by the educators, was an essential part of science learning and teaching that required intentional development. He noted that with extended vocabulary, children could confidently apply learning to alternative situations. The ability of children to amalgamate learning and transfer knowledge for new learning is a useful learning tool that, according to Heidemann and Hewitt (2010), cannot be underestimated by the educator. This skill enables children to become independent learners as they practise solving different kinds of problems, in different situations. However, to accomplish the skill of transference, children required a level of confidence that came from the satisfactory knowledge that their vocabulary would make sense to others (Wellington and Osborne, 2011). McLachlan et al. (2010) found that when the educator engaged in dialogue with a child, modelling occurred and knowledge was gained about past capabilities and thought patterns that help children develop transference. Likewise, as also found by McLachlan et al. (2010) conversations with children's parents and carers can help an educator determine levels of current knowledge and understanding about concepts, culture and vocabulary (Each of these actions that develop communication skill, and therefore, the language of science demonstrate both complex learning that requires actions, and guidance by knowledgeable educators.

After the capabilities of young learners have been explored and acknowledged by the educator, cultural influences, skills and the prior experiences of children could still be indeterminate due to limited information from home. This adds to the complexities of learning. Swain et al. (2010) pointed out that the task of determining prior knowledge can be difficult for educators because the actions of thought processing that indicate whether specific knowledge has been gained or transferred is not transparent, and often, skills to impart that knowledge is beyond their capacity of young children. Consequently, Swain and colleagues recommended that an effective educator would continue to seek visible clues and ask children pertinent questions to ensure the intention of an investigation is clear, and that internal thought processing has taken place.

Heidemann and Hewitt (2010) emphasised that children often take their time to internalise thoughts prior to an action, and an essential skill of the educator is to know when to intervene. An effective educator would then be alert to the capabilities of the children and aware of teachable moments without unduly interrupting learning. Teachable moments presented as either spontaneous opportunities or during planned teaching are used to help children extend their ideas at point of need, consolidate knowledge or to encourage growth through strategies such as guided teaching, ZPD and scaffolding.

Fleer and Hardy (1994) explained that purposefully designed, authentic learning experiences prepared by educators with the aim of causing children to thoughtfully consider their actions, and the resultant consequences, had the potential to help young learners cope with daily decision making, deliberate actions and improve scientific knowledge. They illustrated that, when information about dangerous products, such as poison, was discussed openly and thoughtfully children became better informed about making decisions for both personal safety and a sustainable environment. Research by Cutter-Mackenzie and S. Edwards (2006) that examined educators' perceptions about decision making by young children found that, when pedagogical practices modelled and encouraged decision making, authentic learning occurred.

Before scientific inquiry for young learners can move past the sense of natural curiosity and onto conceptual knowledge, Johnston (2005b) pointed out that educators would know that a solid understanding of scientific concepts does not occur in single experiences. Fleer and Ridgeway (2007) reasoned that multiple learning experiences were required and that educators should be on hand to scaffold and articulate a higher level of scientific understanding during those experiences if meaningful understandings were to be made by the children. They also added that for this purpose educators would be alert to teachable moments that were presented during the daily, playful encounters of children. These strategies, presented by the educator entrench science learning (Fleer & Ridgeway, 2007).

S. Edwards and Cutter-Mackenzie (2006) considered that, through the learning and teaching of science, children are empowered to become ethical, resourceful and imaginative learners. Sprod (2011) however, argued that this outcome would depend largely on educators who "are at the heart of science education" being well-informed (p.167). The position of numerous educators (e.g. Brenneman & Lauro, 2008 Greenfield, 2004;) is that an effective educator would concede that science was an essential inclusion in their ELC teaching program, and reveal early to children the importance of scientific knowledge that shapes both their daily lives and the values of society. Therefore, the role of the effective educator of science in an ELC has been found to be one that provides appropriate opportunities so that children can make connections that will enhance scientific knowledge. Those connections are possible within the daily context of children and educators when the socio-cultural approach to science learning and teaching enable collaborative strategies and decisions, to be taken from fresh and ethical perspectives (Greenfield, 2004).

The evolving SCALTELC-S framework

This review has found that the active role of the educator is an element in the SCALTELC-S framework that has a commanding opportunity to influence, and set in motion, interrelationships between other elements. Although those interrelationships are affected by influences of socio-cultural theory and the context of the ELC, the Active Role of the Educator, as presented in Figure 3.1 is a compelling one.

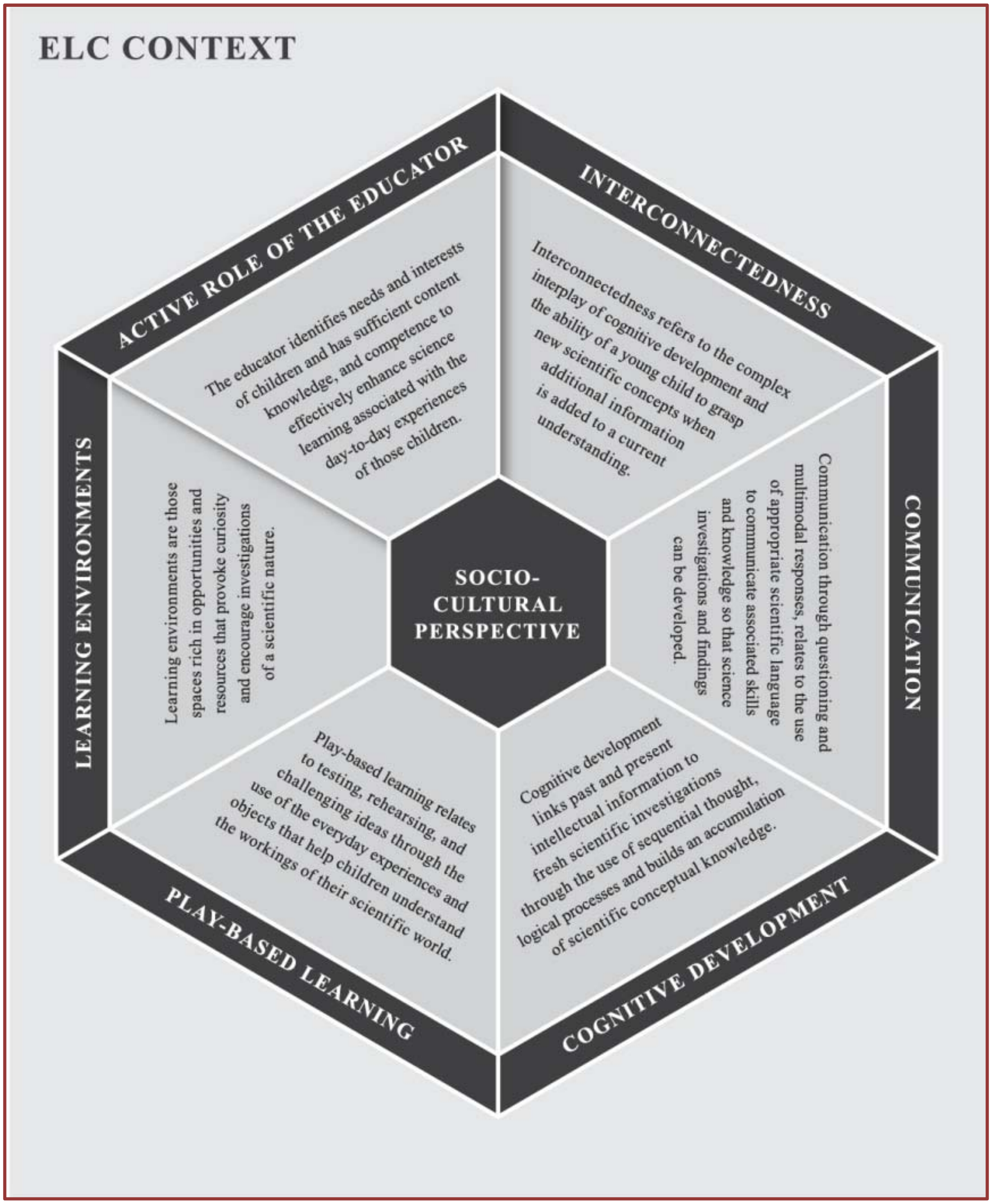

Figure 3.1 The SCALTELC-S framework: Positioning science learning and teaching in an ELC context.

3.3 Dilemmas found to affect the implementation of science learning and teaching in ELCs

Some of the research reviewed for this study focussed on what actually occurs in ELCs in relation to science learning and teaching. The analysis of the literature suggested that several dilemmas exist. These dilemmas are listed below and will now be discussed.

- Science presented as a discrete subject in ELCs
- Limited opportunities for ECE educators to teach science
- Confidence and competence of educators to teach science in ELCs
- Validating science in the ELC curriculum
- Changes and methods of good practice to deliver science in ELCs

Science presented as a discrete subject in ELCs

The first dilemma relates to how science is sometimes presented in the ELC. In spite of research that found science integrated into the every-day experiences of children was both logical and beneficial (Fleer & Ridgeway, 2007), there remained evidence of a tendency for science to be separated and pursued as a discrete subject rather than a part of an interconnected learning program Robbins, 2008; Yelland, 2011). Although not referring specifically to ELCs, the recent research of both Tytler (2007) and Sprod (2011) applies. They echo that there is need for a rethink about how science is presented and to consider the benefits of science being embedded within the daily lives of students. Tytler argued that “traditional science teaching neither conforms to current understanding [of science]…nor represents good practice” (p, 12).

Within the complex and multilayered structure of developing new skills and knowledge by young children, scientific thinking and concept development can be associated with curriculum learning areas, other than science. Connections that occur between areas of learning are unavoidable and occur during the rapid learning processes that young children have been found to employ (see Davis 2010 & Wilson, 2007). This suggests that the notion of single discipline learning and teaching in ECE must be dispelled (Fleer, 2009b; Sprod, 2011). Accentuating science, or any other discipline, within the interdisciplinary nature of learning and teaching in the context of ELCs is an intricate matter and not without its challenges. Szarkowicz (2006) found challenges existed for educators when specific learning skills required for accountability called for the deciphering of the interconnectedness of learning. Foreman and Fyfe (1998) for example, determined that challenges related to assessing the complex nature of children's learning can be lessened through the educator's use of ingenuity and careful planning. Subsequent to the careful planning advocated by Foreman and Fyfe, Szarkowicz established that, with vigilance the reflection and documentation recorded during and after learning will reveal children's capabilities, achievements and interdisciplinary experiences.

Challenges for educators to determine whether or not science is integrated or discrete are compounded when policy and commercial products are permitted on science as a discrete subject. For example, Jones, Kervin and McIntosh (2011) pointed out that curriculum policies, and text books with photocopiable work-sheets that offer the busy educator one-off lessons, tend to reinforce the notion that science should be taught as a discrete subject. In a similar vein, Flemmington, Hewins and Villiers (2011) found multiple methods of learning, under the direction of an educator using an interdisciplinary focus, seemed more suited to the learning style of young children. They added that a reliance on single discipline, pencil and paper exercises, curbed creativity.

Arguably, to ignore the value of interdisciplinary learning experiences for young children would be counterproductive for both educators and young learners because the ideas of children are fluid "and take different pathways to connect learning" (Fleer 2009a, p. 287). Therefore, to entirely understand how science learning and teaching occurs in an ELC, "the provision of time and space in order to capture the meandering of young children's scientific thinking" is a requirement of the effective educator (Fleer 2009a, p. 287). Literature reviewed to explain interdisciplinary learning in ELCs has revealed that valid scientific inquiry can be intentionally shaped when science concepts are woven into the fabric of daily routines, the playful explorations of children, and when nurtured by educators who use specific pedagogical techniques (Arthur et al., 2003; Cutter-Mackenzie & S. Edwards, 2006; Davis 2010; Fleer, 2009a; Johnston, 2005). Skillful confident educators know that children are naturally social, curious and inventive by nature and that they adopt multifaceted learning (Epstein, 2007). These understandings by educators help children to think scientifically in all learning areas

> … in preschool [and] provide all children with the skills necessary to continue learning and thinking critically throughout the school years, ultimately leading to a population of citizens that are scientifically literate and able to innovate.
>
> (Gropen, Clark-Chiarelli, Ehrlich & Thieu, p. 2, 2011)

As an example of integrated learning Sprod (2011) elaborated the findings of Gropen et al. by adding that when children presented their scientific findings for the scrutiny of others, their learning continued to develop in all areas of their personal and academic growth.

Limited opportunities for ECE educators to teach science

The second dilemma came from a perceived lack of opportunity for educators to teach science in ELCs. Subject priority was found to be a dilemma in research by Patrick, Manitzicopoulos and Samarapungavan (2007). Carried out with educators in the USA to find what motivated science learning in Kindergarten, that study was conducted in three schools, included 162 (ages not specified) students and found there was a propensity for educators to follow policy that concentrated efforts on the development of literacy and mathematics. It was found that if science was included in the curriculum, it was presented discretely, such as in a daily weather report. Another finding by Patrick et al. revealed that, when not directed by policy, limited and incidental science was included in the curriculum only when considered appropriate by the educator. Further, no specific time was allocated for educators to include science in the teaching program, and that when science was included, it was taught as a stand-alone lesson. These findings led the researchers to wonder what bearing this would have on the future of science in general, and especially for the learning of the children in their study (Patrick et al., 2010).

Brenneman (2011) argued early childhood education training often let graduate teachers down. Brenneman's study revealed that when an ELC educator was keen, and supported to develop the science, that educator still had to find personal time for preparation and research to fill the knowledge gaps that early childhood education training had not provided. The findings of Swain et al. (2011) revealed that, when educators are competent and keen learners, children tended to engage a deeper understanding about scientific concepts and were presented with more opportunities for engagement. They added that the application of positive impressions about science in ECE by governing bodies was essential as that support strengthened both educators' and children's intuitive practices.

Confidence and competence of educators to teach science in ELCs

Mawson (2011) argued that for early childhood educators to be able to effectively encourage and enhance learning in science, in-depth content knowledge and confidence to impart that knowledge, was required by the educators. Strong evidence in the literature suggests that ELC educators are not confident and competent to teach science. For example, Watters, Diezmann, Grieshaber and Davis (2001, p.1) pointed out that "Early childhood teachers are often hesitant about teaching science because they lack confidence in their conceptual knowledge and understandings". K. Edwards and Loveridge (2011) conducted a study in New Zealand to investigate how early childhood educators supported young children's science learning. These authors asserted that "[A] strong understanding about the Nature of Science (NOS) was required by educators if they were to effectively support children's scientific learning in an holistic manner" (p.32). The NOS that K. Edwards and Loveridge referred to in their study included accepting that

- Science is interrelated with other subject areas
- Science is in a constant state of change and
- Scientific patterns cause and effect, and systems affect the daily lives of people.

They established that when educators developed an understanding about NOS their confidence and ability to support scientific learning would affect their pedagogy and thus, their competence to support science learning. Although NOS was considered an important tenet in the local, Te Whāriki curriculum, little emphasis had been placed on helping educators understand NOS in ECE training in New Zealand (K. Edwards & Loveridge, 2011). That finding would not surprise Brenneman (2011) who argued that the lack of basic yet crucial understanding of science in the training programs of academic institutions generally do a disservice to early childhood educators because those programs limit the emphasis on science through classroom and practicum training.

The dilemma of ECE teacher training has undergone considerable scrutiny through an abundance of research with wide-ranging debate relating to early childhood educators who do not have the confidence and/or content knowledge to teach science well (see for example, Appleton, 1992; Brenneman & Louro, 2008; K. Edwards & Loveridge, 2011; Fleer, 2008; Goodrum et al., 2001; Howitt, 2007; Katz, 2010; Mulholland & Wallace, 2003; Pearson, 2002; Tytler, 2007; Watters et al., 2001). In recognition of a need to develop increased pre-service training in the field of science a research project designed and implemented by Howitt (2010) was conducted to address the dilemma of the low confidence and competence found in pre-service ECE students to develop science in ELCs. Albeit with a small sample of educators, the project addressed the aforementioned needs in both practicum training and university course presentation. As a result of concentrated assistance, the knowledge, confidence and competence of the pre-service educators engaged in the project was found to have improved (Howitt, Blake, Calais, Carnellor, Frid, Lewis, et al., 2012). A tangible product from that research was developed in the form of a teacher resource book that outlined suitable pedagogical skills that supported effective science learning and teaching for 3-8 year old children resulted as an enduring outcome for the research (Howitt & Blake, 2010).

Brenneman summarised the situation thus: "The field of early childhood education could better serve young learners and those who teach them by providing more comprehensive and intensive pre-service and in-service professional preparation programs in early science" (2011, p. 4).

Validating science in the ELC curriculum

The validation of learning and teaching science in an ELC also highlights a dilemma. Following the 1999 report for the American Association for the Advancement of Science (AAAS), the aptness of whether or not to teach science to young children was investigated by Johnson (1999). She concluded that while the learning and teaching of science for young learners was considered valid, confusion arose because of a mismatch regarding how best to develop that science. A debate about pedagogical strategies associated with good practice exists between the traditional didactic method of teaching and that of child-centered inquiry to develop science learning, continues (Johnson, 1999). The debate that calls into focus the validity of teacher training, in situ pedagogy and policy about the implementation of science for the youngest in schools has continued for more than a decade and is evidenced, among others, in the works of Johnson (1999), Mulholland and Wallace, (2003), Brenneman (2011) and K. Edwards and Loveridge (2011).

Edwards and Loveridge (2011) found that the way early childhood educators perceived their own ability to validate children's scientific learning was a concern that reflected the educators' own confidence to present science in ELCs. This however, does not always appear to be the case. Research in the USA by Brenneman and Louro (2008) which reviewed attitudes about cognitive competencies of preschoolers (no specific age of the children included), and science teaching expectations by the educators, found different results. Educators, questioned about their attitude toward teaching science, and whether or not they thought it reasonable and valid to include science in the pre-school classroom responded confidently that science was a genuine part of their day-to-day teaching. After data were analysed, Brenneman and Louro found that, "changes in attitudes about the capabilities of preschoolers and about the most appropriate way to teach and learn science, make pre-school science education not only reasonable and appropriate, but optimal" (p. 114). However, like Fleer and Ridgeway (2007) before them, Brenneman and Luro (2008) later found that, after much research, in reality little had changed to affect the methods and good practice of learning and teaching science for the youngest members of educational systems.

From evidence found in the review of literature, the crucial issues relating to validity of science for young learners appears to remain on three planes. The first relates to the dichotomous views about how best to teach science with young learners (through the use of a play-based framework or from a more didactic approach). The second focuses on the capabilities and confidence of ECE teachers to satisfactorily teach science ELCs, and third, is centred on educational policy and belief.

Changes and methods of good practice to deliver science in ELCs

The final dilemma in this discussion reflects change related to society, resources and teaching strategies. The 21st century has brought new technologies along with rapid and complex changes to scientific knowledge (Venville et al., 2003), all of which challenge good practice in the context of science learning and teaching for young children. Shaping the science of contemporary classrooms includes "[t]he resources and playthings that children have prior to coming to school and in their after school activities [that] are becoming increasingly influential in shaping what they can do" (Yelland, 2011, p. 11). Included in the findings of Johnston (2007) was the view that, in good practice, ECE educators would actively address three qualities that acknowledged and reflected change in their profession. Educators would

- keep abreast of relevant professional development in their field
- recognise that the dynamic nature of science should be acted upon in response to new research and resources
- be at hand during new scientific learning so neither complex connections nor incorrect perceptions hampered intellectual growth.

Recent research by Sprod (2011) supported Johnston's views from 2007 by arguing that without explicit up-to-date attention from educators to guide scientific inquiry, misinformation could occur. He also pointed out that if the topics of investigation are not relevant to the children's current ways of gathering knowledge, a disinterest in science may result. Changes in societal beliefs, attitudes and values, teaching strategies, technology and other resources are connected to all learning and are ignored at the peril of sound learning and teaching (see Fleer, 2011; Yelland, 2011). Swain et al. (2011) reminded readers that, as early as 1980s English translations of Vygotsky's work from the 1920s and 1930s, had acknowledged the dynamics of learning and advocated for "well-designed instructional activities and practices mediating interactive and transformative dialogic relationships between science and every-day concepts" that were situational, empirical and practical so that divisions relating to diversity and learning would not occur (p. 52).

Yelland (2011) considered that variations affecting change in ELCs also relate to a growing trend for accountability of learning outcomes, which she saw as a growing requirement for ECE educators. Accountability in measurable outcomes was seen as problematic by some (see Brenneman, 2011; Greenfield, Jirout, Dominguez, Mair & Fuccillo, 2009; Mawson, 2011). These researchers agree that, when asked to assess the outcomes of science learning and teaching, the educators who lack confidence and knowledge about how to teach science would be struggling to fulfill that requirement.

In summary, the dilemmas and challenges that cause good pedagogical practice to falter in the learning and teaching of science in ELCs are not insurmountable, but do require attention from many directions if effective changes are to occur. In the meantime, research by Pacini-Ketchabaw and Pence (2011) invites educators to "rethink the institution and educational practices which are always subject to revision, evaluation and readjustments… for the production of new realities for themselves and the children they work with" (p.8).

3.4 Examples of curriculum integration and science in the day-to-day learning and teaching of ELCs

Despite barriers and dilemmas in some ELCs, effective learning and teaching of science does occur. The nature of an integrated curriculum, however, is not always helpful in illuminating the quality and quantity of science experiences that are occurring in light of socio-cultural theory. S. Edwards (2009) argued that socio-cultural theory in early education was more covert than overt in action and that a complete shift to socio-cultural activity currently remains questionable because of maintained and strong influences of Piaget's (1896-1980) developmental theory. This section of Chapter 3 presents two examples of the integrated process of science learning and teaching: the first explicit, the other implicit.

An explicit example

An example of science being integrated explicitly into the learning and teaching program of a WA Pre-school classroom for 4 year old children comes from a study by Howitt, Lewis & Upson (2011). Originating from a Collaborative Science Project (see Howitt, 2010) the study investigated how a pre-service teacher, supported by a cooperating classroom educator, a teacher-educator and an analytical chemist who specialised in forensic science, implemented forensic science into the ECE curriculum.

Using an inquiry based approach to learning the children in the Pre-school classroom were encouraged to be involved actively in finding answers to their own questions, investigating possibilities and manipulating materials. They were also expected to explain their experiences. One module from the book *Planting the Seeds of Science: We're going on a (forensic) bear hunt!* (Howitt & Blake, 2010) was implemented to introduce the children to forensic science during six half-day lessons over the three week period of the pre-service teacher's practicum. To introduce the children to forensic science, different types of evidence was presented from which the children collected clues. The children were then guided by the educator to conduct a footprint and fingerprint investigation, go on a 'bear hunt', and engage in a 'teddy bear's picnic'. To analyse the lessons, Howitt et al. (2011) determined children's ability in terms of scientific inquiry.

During participation Howitt et al. (2011) found the children were enthusiastic and appeared to engage their prior knowledge to help them develop theories about the mystery they were investigating. Each discussion seemed to increase the children's curiosity and their opinions about the investigations. Evidence submitted by the children was placed on an 'evidence wall', along with written or drawn explanations, thus enabling the integration of literacy skills associated with discussion, reading and writing. Physical evidence was collected into snap-lock see-through bags and added to the evidence wall, with continuing speculation and conversation. The integration of mathematics was demonstrated when the children counted, compared and measured pieces of evidence, and art was included when children made models and drew pictures of their experiences and theories. Physically the children engaged in a trek to hunt for a bear, and socially they gathered and played through a teddy bear's picnic.

The collection of activities described in this report reflected socio-cultural activity when relationships between people and resources involved cognitive thought to transform information gathered from the implied and obvious clues. Those relationships, described by Rogoff (2003) as the 'three foci' (see Chapter 2) assisted new learning through social collaboration, and shared thinking that reflected cultural know-how. Howitt et al. found the explicit and integrated science lessons had presented relevant and interesting science for children as they improved their scientific inquiry processes. Those processes included:

> "…generating questions and predictions, observing and recording data, using equipment, using observations as evidence, and representing and communicating findings [for] knowledge building." (p. 55, 2011)

An implicit example

Implicit examples of science development influenced by socio-cultural theory, for children under the age of 5 years, are taken from the northern Italian, Reggio Emilia approach to pre-school education, and Millikan's (2003) comparative study of cultural learning and teaching between operational ELCs in Australia and those in Reggio Emilia. To support this section information about the Reggio Emilia (RE) approach comes from the works of C. Edwards et al. (1998), Foreman and Fyfe (1998), Millikan (2003), Malaguzzi (1998), Rinaldi (2006), Reggio Children S.r.i (2012), and University of Queensland (n.d.). Personal reflections taken from a 2003 study tour of RE ELCs are included to corroborate the holistic approach and integrated learning discussed by those authors. The author acknowledges that the RE model of early education is reflective of, but different in intent to, socio-cultural theory as local culture can influence its translation. However, S. Edwards (2009) held that the RE model was strongly influenced by socio-cultural theory.

Undertaken to develop the notion of integrated and constructed learning by educators and young children, Millikan's (2003) study reported how Australian educators reflected the use of connected learning and teaching through the use of RE principles and philosophy, in relation to their own work. Consistent with socio-cultural theory, and how young children learn, comparisons were made with the RE approach that advocated the use of practical, social experiences; a celebration of cultural identity; learning within the local community; time to wonder and explore; and adult facilitation to develop skills that are reflected within the every-day experiences of children (Millikan, 2003). Although not always explicit, as these children, less than 5 years of age, went about their day to day learning in RE, relationships that enable the seamless inclusion of scientific investigation were found.

To stimulate thinking by the children in RE, provocation and cognitive conflict are used (C. Edwards et al. 1998). To illustrate, Rinaldi (in Millikan 2003, p. 89) explained that children were encouraged to think about, and discuss, their 'wonder'. They would then plan and implement an investigation to find a solution through the use of designed and spontaneous playful methods of collaborative prediction and testing of ideas. C. Edwards et al. (1998) pointed out that the ELCs in RE are designed as communal places where questioning, exploration and investigation are encouraged. Like other disciplines of learning, in the RE centres, science is not taught as a discrete subject but rather as an element of the whole learning experience. "Young children are involved in extended, in-depth investigations" where graphic representations are used to record their memories, ideas, predictions, hypotheses and observations to demonstrate the connection of action and thought (Katz, 1998, p. 27). From the later studies of Mackenzie (2011) it was found that a young learner's use of graphic representations provided a powerful demonstration of knowledge. For young children, Mackenzie added, graphic representations helped them make meaning of their experiences and demonstrate an ability to communicate understanding, often before they had developed the more sophisticated skills of writing and associated vocabulary skills.

In recognition of the long and sometimes harsh winters experienced in RE, investigating natural phenomena is inspired by the design of buildings that house ELCs. For example, structures are designed to catch natural light, produce rainbows, cast shadows and have windows especially placed for children to observe the operations outside of an ELC. The outdoor learning environment emphasises the seasons, has natural places to explore; water features and often, views of the working village. Inside, the centres reflect the reality of home, community and school life in rooms that are used in conjunction with a garden. More science is developed through the use of a garden atrium, placed in the middle of the open learning area. In even the bleakest of weather conditions, plants can be grown and small animals such as frogs are accommodated for investigation in the atrium (personal observation, 2003).

The perception of science learning and teaching in RE, however, is challenged. For example, researchers K. Edwards and Loveridge (2011) argue that the crucial ingredient for the development and interpretation of scientific attitudes in young children relates directly to the educator's scientific content knowledge and understanding of the discipline, whether or not science is taught as an interdisciplinary experience or as a discrete subject. While this challenge has merit, and there are no direct references to science being explicitly taught in the ELCs of RE, its inclusion is implicit when children are helped to describe systems, compare and contrast items, classify process and discuss cause and effect (personal observation, 2003). The emergent skills of scientific investigation and concept development in these centres are in keeping with Johnston's (2009) notion that young children learn evolving science skills through active engagement, specifically through the use of the five senses and observation in contexts that are of meaningful to them. Scientific investigation and concept development is explicit to the onlooker when questions, discussion, wonder, and relationships that underpin the absorbing explorations and investigations of these children, are analysed (Gardner, 2004). Gandini, a leader in the development of the RE schools reported that, through scientific investigation, children found meaning and connections about the significance and implications of their place within the 'real world' (Gandini, cited in Fleer et al, 2006). With a sense of anticipation Gandini explained that children find they can discover something new, rediscover a point of interest, create theories, test ideas and reveal clues about any phenomena they considered worthy of observation and examination (Gandini, 1998).

Educators (called pedagogisti) work in collaboration with families and communities so that culture is celebrated and experiences are intentionally shaped to help children recognise their place in the world. To do this the children are engaged in a ZPD, and, when necessary, scaffolding using holistic opportunities and multiple techniques that help the children find how their immediate world works. This integrated approach to learning helps children transform their knowledge and establish the foundation for future science learning (C. Edwards et al., 1998; Millikan, 2003).

Actions that reflect scientific investigation take place within a collaborative socio-cultural environment, under guidance of pedagogisti who argue they "prefer not to leave children always working on their own, but try instead to cooperate with the children's goals" (C. Edwards, 1998, p.187). New (1998) argued that a purpose of the RE pedagogisti is to provoke thought and inspire children to notice the logical process of an event rather than look for direct answers. New also found that children were encouraged to think about cause and effect relationships and investigate how everything "co-exists in a social world full of cultural meaning and significance" (p. 265). C. Edwards (1998) expanded that notion by adding that children are coached in the discovery of the "why" and "how" in relation to their inquisitive demands (p.184). She reasoned the importance of pedagogical coaching is to avert misinformation. Misinterpreting science concepts is a concern also held by Johnston (2005) and Fleer and Ridgeway (2007) when children do not have knowledgeable adults to help guide their findings.

To advance current knowledge and skills pedagogisti in RE work as a team to collaboratively plan, reflect and document the accomplishments of children. The teams, observed by the author, seemed to focus on specific needs and curiosities of individual children and these were accommodated in the curriculum. With a focus on investigation children were guided in their learning then encouraged to construct and present verbal and graphic representations of their thoughts and discoveries. Many of the products, (i.e. maps, diagrams, sculptures) made within the multidimensional investigations, were added to an accumulation of evidence of learning (New, 1998). Exhibitions of graphic representations, made by children during and after their research project, are often displayed in the piazza to provoke the scrutiny of community experts in fields related to the investigation undertaken. This action assists knowledge building, develops critical awareness and indicates the cultural interconnectedness of learning (C. Edwards, 1998; Millikan, 2003). Described as imaginative, dynamic, social and actively interconnected, the learning experiences of the young children in RE reflect the interrelationship of the elements of the SCALTELC-S framework of this study: *Interconnectedness, Communication, Cognitive Development, Play-based Learning, Learning Environments* and the *Active role of the educator*.

An assumption has been made that science is an integral part of the integrated and connected learning for the young learners in RE. The fundamental elements reflected in the preceding discussion supports what K. Edwards and Loveridge (2011), Fleer (2007; 2009a), Johnston (2005a; 2007; 2011), Robbins (2003; 2005a), Swain et al. (2010), and others, have proposed as good scientific practice for young children. Nonetheless, it is noted that these authors have not acknowledged the Reggio Emilia philosophy in their research as an example of science learning and teaching for young children.

3.5 Conclusion

This review of literature, grounded in the Vygotskian socio-cultural theory, has essentially applied the theoretical framework advanced in Chapter 2 and used implicit and explicit references that influence the focus on science. Throughout the review, the SCALTELC-S framework, foregrounded by a socio-cultural perspective, represented the complexities of an ELC context and detailed the six major elements of that framework: *Interconnectedness, Communication, Cognitive Development, Play-based Learning,* the *Learning Environment* and the *Active Role of the Educator* to determine science learning and teaching for young children.

Contemporary issues including technology, popular culture and play-based learning within the context of ELCs have been discussed in association with the development of scientific concepts. While positive images and pedagogy best suited to develop scientific understanding, and its significance in ECE, were found, the review also revealed a continuing and consistent call for more skilled and confident educators to deliver science. Alternative views for desirable and efficient methods of the learning and teaching of science for young children have also been highlighted in this chapter. Integrated and interdisciplinary approaches were considered optimal practices for science learning by some. However, others have argued that the insufficient scientific knowledge of educators could not adequately serve the interconnected development of science. Fleer (2009b) noted that before quality learning and teaching can occur, "more needs to be understood about the diversity of teacher beliefs and pedagogical practices in play-based contexts to support scientific concept formation” (p.1086). Where some researchers have found that play-based strategies provided rich dimensions of learning, still others caution that play should not be automatically linked to learning because "reciprocal relationships are too simplistic and indeed, not supported by empirical evidence that contemporary research agendas require” (Yelland, 2011, p. 11).

It is concluded that the new lenses, through which every-day science concepts are currently being viewed to enlarge the benefit of ECE science, still require refinement. Brenneman (2011) illuminated that point of view by arguing that ECE "…awaits strong research for high-quality science learning experiences in preschool [that can] lead to long term benefits for school achievement, scientific literacy and professional achievements" (p. 3). The next three chapters of this dissertation describe research pertinent to Brenneman's argument.

Chapter 4

Methodology

4.1 Introduction

The purpose of this research was to build on limited knowledge about how 3- and 4-year-old children in Early Learning Centres (ELCs) move their scientific curiosity from wonder to knowing. As indicated in Chapter 1, this study sought to answer four Research Questions, two of which needed data from an empirical investigation. These were Research Question 2 (*To what extent are the science learning opportunities provided in ELCs for 3- and 4- year old children informed by socio-cultural theory?*) and Research Question 3 (*How can the learning and teaching of science by 3- and 4- year old children be advanced by the use of pedagogical strategies derived from a socio-cultural approach?*). To this end, information that reflected what motivated children's active engagement in scientific inquiry, and how that motivation was responded to from a socio-cultural perspective, was required.

At the outset, it was noted that to gain evidence of learning, a flexible and patient method of inquiry was required to accommodate the unpredictable nature of children in the target age group (Einarsdóttir, 2007). As a consequence, an interpretive research methodology was chosen to generate information about emerging science skills and how these were represented. It was intended that, as shown in the work of Fleer and Robbins (2003), the interpretive approach would reveal the social and cultural interactions and interrelationships that help young children learn within those contexts.

As described in detail later in this chapter, three ELCs were identified as sites for this research and a total of seven case studies were conducted in those ELCs.

Refinements of Research Questions 2 and 3 provided specific guidance in relation to the case studies, namely

Research sub-question 2.1

In the seven case studies, to what extent does the effective learning and teaching of science take place and under what circumstances?

Research sub-question 2.2

In the seven case studies, to what extent does the learning and teaching of science appear to be informed by socio-cultural theory?

Research sub-question 3.1

What can be learned from the seven case studies to inform the enhancement of learning and teaching of science for 3- and 4- year old children in ELCs?

This chapter provides an overview of the methodology and methods applied to this research. In line with Strauss and Corbin (1998) 'methodology' is seen as a way of thinking about studying social reality, and 'methods' refer to the set of procedures and techniques used to gather data in that reality. An outline of the research approach is presented in Table 4.1, followed by an explanation of the interpretative research program. Next, the theoretical orientation highlights the ethnographic and grounded theory approach with multiple case study research design. The chapter goes on to depict the multiple methods of data collection, including observations, conversations and interviews, children's drawings, photographs, and the use of a research field journal. The analysis of data (including cross-case analysis), quality standards and ethical issues are then discussed before the chapter concludes.

Table 4.1
Outline of the research approach that informed this study

Position of research process	Approach employed
Research paradigm	Interpretive
Theoretical orientation	Grounded theory and ethnography
Theoretical framework	Socio-cultural framework
Research design	Multiple case study
Methods of data collection	Observations Casual conversations Semi-structured interviews Artefact collection Field research journal
Data analysis	Construction of case studies Interpretation of case studies Cross case analysis
Quality Criteria	Trustworthiness Credibility Dependability Confirmability Transferability Verisimilitude
Ethical issues	Informed consent Confidentiality Anonymity Research participant relationship

4.2 Interpretive Research Paradigm

Interpretative qualitative procedures are systematically used "to generate a theory that explains at a broad conceptual level, a process, an action, or interaction about a substantive topic" (Creswell, 2005, p. 396) that can interpret human behaviour and gain access to the meanings behind that behaviour (Hammersley & Atkinson, 2007). Metaphorically speaking, Merriam (1998) likened an interpretative research paradigm within a qualitative study to an umbrella that can cover several forms of inquiry in a natural setting. In addition, Merriam emphasised that social phenomena can be observed and interpreted while creating minimal disruption within the environment being researched. Fleer and Robbins (2003) acknowledged those points and argued that the paradigm of interpretative research is appropriate for studies conducted with young children because the socio-cultural context of an ELC echoes combinations of active social interaction and cultural awareness. Overall, "…different realities are created by different individuals as they [qualitative researchers] interact in a social environment" (Gall, Borg & Gall, 1996, p. 19) to create the multiple views of a context under study.

Merriam (1998) described the main characteristics of qualitative research as:

- being initiated by the researcher's interest
- designating the researcher as the primary instrument for data collection and analysis
- involving field work
- using inductive research strategies
- being richly descriptive

When these characteristics are applied to research, the researcher's own interests can inform the study with elements of personal beliefs, previous experience and cultural value, therefore a level of subjectivity may be inherent in results (Merriam, 1998). Merriam continued that, even with the intent of impartiality, the researcher's human characteristics could inadvertently influence data through responsiveness to the context and adaptation of techniques to suit that context (also discussed in Quality Criteria, later in this chapter). In recognition of the value of the researcher's presence Merriam (1998) argued that the benefits of being the primary researcher outweigh the alternative because that presence affords access to a greater understanding of interconnected activity, and opportunities to be responsive to the uniqueness of a setting. From Merriam's view (1998, p.6) the research paradigm within this research enabled "situations in their uniqueness" to bring a direct link between the researcher and the participants to gain a substantial understanding of the development of science in ELCs, and its relevance to socio-cultural theory (as reviewed in Chapters 2 and 3).

When the researcher is grounded in the study, richly descriptive data are gained. This is achieved by making contextual meaning of a situation, and of verbal and non-verbal communication, that are naturally presented during daily activities and routines. It also facilitates theory being tested through "observations and intuitive understandings gleaned from being in the field" (Merriam, 2002, p.5). Venville et al. (2003) and Fleer and Robbins (2003) reinforced that researchers who are empathetic to the meaning children construct as they demonstrate individual qualities to make sense of their experiences, often in complex settings, take a qualitative approach to their research. The intensity and depth of this particular empirical study was magnified by the use of focus children as they went about their daily activities. Further information about the focus children, and the researcher as an influence on this study, is presented later in this chapter.

4.3 Theoretical orientation

This study, interpretive in nature and designed to find what science looks like in operational ELCs, incorporated ethnography with grounded research theory to create a qualitative design that "unfolds as fieldwork unfolds" (Patton, 1990, p. 61). It is anticipated that the combination of these practical research theories will provide the necessary support to develop new theory associated with the learning and teaching of science for 3- and 4- year old children in ELCs. The role that Grounded Theory and Ethnography can play in assisting the development of new theory is explained in the following paragraphs.

4.3.1 Grounded theory

Data for this research were grounded within the reality of fully operational ELCs. Creswell defined grounded theory design as "a systematic, qualitative procedure used to generate a theory that explains, at a broad conceptual level, a process, an action, or interaction about a substantive topic" (2005, p. 396). In line with this study the theory was later expanded by Creswell (2008) as being a method used to explain events and interactions associated with educational processes. Further, this enabled systematic data collection that led to theory forming, the explanation of processes, and the comparison of new information with identified and emerging categories or themes (Creswell, 2008). The grounded theory method offered two important opportunities for this research: first, to discover new theory that could advantage the learning and teaching of science in ELCs, and second, to redesign current theory from collected data to augment the development of science concepts and skills for 3- and 4- year old children.

4.3.2 Ethnography

Ethnography is defined by Patton (1990) as an area of scientific research that is achieved through intensive field work. The interpretation and application of data collected during that field work, Patton maintained, is what sets ethnographic research apart from other methods of data collection because it focuses on, and reflects upon, elements associated with the culture of a group of people, and influences that generate culture. Patton (1990) also explained that ethnography is used to study and interpret culture within empirical settings. He described the role of an ethnographer as being twofold: first, as participant in the everyday function of an environment being studied, and second, as observer of the actions that combine to illustrate influences and factors within a setting.

Hoey (2009) added that ethnographic information gleaned from participation and observation by the researcher is then recorded, from an unbiased position, as field notes. Echoing the earlier work of Merriam (1998), Hoey went on to explain there was a possibility of data becoming transformative if researchers, familiar with the context, see themself as part of the culture. In recognition of the probability that personal experience, motivation and history could influence judgements made by researchers, integrity of results would include validation through multiple reviews and collection of accurate information from all participants (Hoey, 2009).

Combining grounded theory and ethnography

In this study, grounded theory and ethnographical inquiry were integrated and brought together in an effort "to understand situations in their uniqueness as part of a particular context and the interactions" (Patton cited in Merriam, 1998, p. 6). Patton (1990) wrote that the purpose of data collected by ethnographers, usually by means of a participant observer, is to describe the real life and everyday practice of a selected context and suggested that it therefore sits comfortably with grounded research theory. As argued by Creswell (2005), when ethnography is combined with grounded theory in interpretive research, a useful framework can be developed to position a study constructed by individuals interacting within social worlds. That proposal is fundamental to this study.

4.4 Multiple case study research design

A multiple case study research design was selected to support this study. Punch (2009, p. 8) defined case study as the analysis of "a phenomenon of some sort, acting in a bounded context" that results in an intensive, holistic description usually occurring in a social unit. The value of empirical case studies was argued by Merriam to be the in-situ information that invariably helps to understand in-depth the complexities and interrelationships within researched contexts. Merriam explained further that the interrelationships within case studies offered "thick, rich descriptions” that support qualitative research (1998, p. 18).

Multiple case studies "are the preferred strategy when 'how' and 'why' questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context" (Yin, 2003, p. 1). In view of other possible anomalies such as physical elements, historical, economic and social influences that shed light on interpretations and conclusions of research, Leedy and Ormond (2005) also supported the use of multiple case studies. They argued that multiple case study design offers rich opportunities for comparisons, theory building and making purposeful generalisations about a little known or poorly understood situation.

Einarsdóttir (2007) explained that for the purpose of gaining useful information from the interactive and complex settings, in which young children learn, multiple views were desirable to demonstrate an action or understanding. To add value to research undertaken, Yin (2003) argued that, for an expansive view of the participants and their actions, prolonged engagement in the field seemed ideal to gather data for case studies.

To guide this study and provide that expansive view of the data collected, a number of case studies were considered highly desirable, and chosen, to support rigour in analysis. Within this research the ‘case’ is a child, or children engaged in a science activity within an ELC that may or may not involve an educator. Following a pilot study, seven case studies from three diverse locations were carried out, over three school terms that spanned two successive calendar years (2008-9), to find how learning and teaching in ELCs informed the development of science.

4.5 Overview of the context and participants

4.5.1 Context

ELCs taking part in this research consisted of two pre-kindergartens, named for the purposes of this study, ELC1 and ELC3, and one playgroup, ELC2. As indicated in Chapter 1, the ELC classes, known as pre-kindergarten in Western Australia (WA), have non-compulsory attendance and cater for 3- to 4- year old children. The two pre-kindergartens participating in this research were each part of a larger established independent faith school under the auspices of different religious sectors. Typically, the ELC section of a school is overseen by a Junior School Principal and managed at the classroom level by an early childhood educator with support from an education assistant (EA). The playgroup (ELC2) was situated in a different context and not part of the WA education system. ELC2 is a parent run unit governed by *Playgroup Australia* and children, aged from birth to 4- years old, attend under the guidance of their parents or carers. Leading into the case studies in Chapter 5, a more detailed description of each ELC is presented.

4.5.2 Participants

Fundamental to this study were the participants, and especially the children who were the focus of specific case studies. Methodological considerations before children could be engaged in this research are discussed later in this chapter (see Quality Criteria and Ethical Issues). Discussions in those sections include the intense deliberations that are essential to selection criteria, consent, and acknowledgement by the researcher of the unequal power relationship between adults and children.

Contributing to this study were 11 focus children (seven boys and five girls) from the total population of 56 children. In the context of ELC1 and ELC3 these children were initially selected by their teacher. In ELC2, parents both supported and selected children to participate. As is explained later in the chapter, these children only participated if they wished to.

Where the general role of the educator is emphasised in this study, the qualified educators who specifically participated are not the focus of investigation. However, to provide a more prominent picture of participants, some background information about the qualified educators, attached to ELC1 and ELC3, is included. Both educators had been teaching for some years since their initial training: T1 for 15 years and T3 for 12 years. T1 and T3 indicated, to the researcher, they were familiar with socio-cultural theory from university lectures but neither sought to specifically apply the theory in their respective classrooms. These educators were both qualified Primary School Teachers, before a contemporary four-year-tertiary-qualification for ECE training became specific for educators attached to these ELCs. Although neither T1 nor T3 had acquired specific ECE training they each had had considerable experience in the teaching of ECE: T1 for 15 years and T3 for 4 years.

All adult participants in the study, including the researcher, were female. Adults and children who participated are also discussed in Chapter 5. The researcher, as the “primary instrument for data collection and analysis” (Merriam, 1998, p.6) was a key participant in this study. The position of the researcher (hereafter referred to as E) has been described briefly in Chapter 1 and therefore is not repeated here, although later in this chapter, in ethical issues concerning the researcher-participant relationship, that position is again clarified. A discussion related to 'positions of power' of adults working with children, is included in 2.3.6, the role of the educator, Chapter 2.

An overview of both contexts and participants contributing to this research follows in Table 4.2. Contained within that table are details that introduce the physical setting, population, gender, attendance times, staff profiles, opportunities for children to participate in science activities, and level of parent involvement in the learning and teaching program.

Table 4.2
An overview of the three participating ELCs

Description	ELC1	ELC2	ELC3
Institution	Independent School PK-Yr12	Local Government Community	Catholic Primary School PK-Yr6
Group and age range	Pre-kindergarten 3yrs-4yrs	Play-group 0-4yrs	Pre-kindergarten 3yrs-4yrs
Attendance	x 4 days per week 8.30am - 1.30pm	x 1day per week 9.00am - 11am	x 4 days per week 8.45am - 1.00pm
Population	22	~ 19	15
Gender	Girls and boys	Girls and boys	Girls and boys
Educators	Teacher + one education assistant	Parents	Teacher + one education assistant
Training and experience of teacher and Education Assistant (EA)	Teacher: Primary trained with ECE units - 15 years ECE experience EA: qualified	Parent assisted program Specific training or experience not sought	Teacher: Primary trained with ECE units. Limited ECE experience EA: qualified
Science opportunities	Daily	None specific	Incidental
Parent involvement in class	Minimal – rostered help parent choice. Fathers and mothers involved.	Total involvement by parents, mothers only observed	Mothers and/or grandmothers invited to start day to help settle child.
Focus Children	Whole class*	2 x boys	1 x girl, 1 x boy
Data collected	Term 3, 2008	Term 4, 2008	Term 1, 2009
Visits and duration	2 x 1 hour 4 x 2 hours 1 x 3 hours 1 x 4 hours	4 x 1 hour 3 x 2 hours	2 x 1 hour 5 x 2 hours

* 1 x boy and 1 x girl arranged to be the focus children in ELC1 withdrew their support early in the study. Incidental conversations thereafter provided specific examples of child involvement.

4.6 Stages of data collection

Data were collected across 22 field work sessions consisting of 39 hours of contact, over three school terms that spanned two successive calendar years (2008-9). A five stage approach was used to collect data: pre-research, initial visit, pilot study, intense study visits and a post data collection visit. Table 4.3 provides a summary of collection dates, duration, and purpose that illustrate these five stages. A description of each of these five stages follows Table 4.3. Throughout the rest of this chapter, the letter E is used to refer to the researcher. T1 is used to indicate the educator in ELC1, T3 as the educator in ELC3 and P1 or P2 to name parents in ELC2.

Table 4.3
Diary of visits to ELCs for data collection

Centre	School term	Dates	Purpose	Duration
ELC1	Term 3 2008	07.05.08	Pre -research	1 hour
		30.07.08	Initial visit	2 hours
		06.08.08	Pilot study	3 hours
		11.08.08	Intense study visits	2 hours
		13.08.08		2 hours
		20.08.08		4 hours
		25.08.08		2 hours
		27.08.08	Post data collection	1 hour
ELC2	Term 4 2008	23.10.08	Pre -research	1 hour
		30.10.08	Initial visit	1 hour
		06.11.08	Intense study visits	2 hours
		20.11.08		2 hours
		27.11.08		2 hours
		04.12.08	Post data collection	1 hour
		14.11.08	Phone interview with a parent	1 hour
ELC3	Term 1 2009	16.02.09	Pre-research	1 hour
		20.02.09	Initial visit	2 hours
		27.02.09	Intense study visits	2 hours
		06.03.09		2 hours
		13.03.09		2 hours
		20.03.09		2 hours
		27.03.09	Post data collection	1 hour

4.6.1 Stage 1: Pre-research

In the pre-research stage and in recognition of ethical issues involved when research includes young children, an ethics clearance was initially sought and approved from Curtin University (Approval Number HR69/2008) (see Ethical Issues, page 143). Also, to meet a national government requirement, a 'Working with Children' certificate (Number 879808) was obtained from government authorities to register the researcher eligible to work with young children. With both approvals in place, initial contact was made with three potential ELCs to determine a willingness to engage in this research. These ELCs were selected to offer diverse institutions from different socio-economic backgrounds and to enable access to children of the focus age group required for this study. A representative from each ELC, known to E, was contacted in the first instance to seek an opportunity to carry out research in the centre. Once an in-principle agreement was established, an exchange of detailed background information about the centre and the research took place.

As a formality, in the case of ELC1 and ELC3, the Heads of Junior School (principal) of which these ELCs were part, were contacted by E. After this initial contact, the principal had no further role as a participant in this study. Discussions between E and the principal of each ELC1 and ELC3, and the contact parent at ELC2, included implications related to ethical consciousness, expected duration of the study, number of focus children preferred for observation, legal requirements, and mutual benefits for involvement in the research. Anonymity of participants and institution was offered to the principal at the onset of the discussions indicating that any published results from the research would not include real names of participants or the school/playgroup.

In this pre-research phase Information Booklets were delivered to each centre that contained ethical considerations, facts about the research, and consent forms to be signed by the principal, participating teacher and parents of children to be observed (see Appendices A and B for detail pp. 303-310). Background information about the participating ELCs was informed by each centre's enrolment forms, information books and conversations that offered, for the research, knowledge about the establishment's social and cultural history, ethos, protocols and governing policy.

This knowledge embellished important groundwork for the research prior to engaging with children, their carers and educators.

To assist in the collection of data the teachers from ELC1 and ELC3, and a parent from the playgroup, ELC2, contributed the following support:

- Identification of children for focussed observation as outlined earlier in this chapter.
- Obtaining permission from parents for focus children to be engaged in possible audio recorded interviews, observations, conversations and photographs.
- Nomination of an appropriate school term that best catered for requirements of data collection and would serve the centre's operations.

4.6.2 Stage 2: Initial visit

As shown in Table 4.3, an initial visit was made to each ELC. The initial visit provided an opportunity to document the 'big-picture' detail of the centre that included the socio-cultural fabric of the setting, governing policies and general information about the centre's physical attributes. Discussions between the teacher, E and a small number of parents who had sought further clarification were included in the initial visit. The discussions reiterated the content of the Information Booklet (Appendix A) to reassure parents of the integrity of the study. Also, during this initial visit, all children in the centre were introduced to E. A more specific introduction and discussion was arranged with the focus children who had agreed, as far as possible, to have a role in the research. During that discussion focus children learned about their role in the study and verbally agreed to participate. It was known to both the focus children and E that respective parents had already discussed the research with the children, as had their teacher in the case of ELC1 and ELC3. This was confirmed when a boy stated he was going to be cooperative because "Mum said I am helping other children learn" (Boy1, ELC1, 30.07.08). The focus children were also informed they could withdraw if they decided that they no longer wished to participate.

At an appropriate time a brief and general discussion about the learning and teaching of science for young children was held with the teacher and her cooperation sought to conduct a more detailed audio-recorded interview at a later date. Participants were also advised that field notes would be taken during each visit, to record observations and conversation points, and that these would be used in ongoing discussion of visits to the ELCs.

4.6.3 Stage 3: Pilot study

Before the larger scale research began, a pilot study was conducted in ELC1. This small scale trial was arranged the address the following points:

- For E to refresh and consolidate her understanding of the routines and procedures of a pre-kindergarten setting.
- To trial data collection strategies planned for use during children's active engagement. These included using an audio-recorder, and recording observations and conversation while in the presence of those children.

The pilot study was conducted during a 3 hour visit to ELC1 on 06.08.08 and after the initial visit had been made (see Table 4.3).

Pilot study setting

During the centre's 30 minute play-break, one of the children disclosed to E his views on the workings of the hand operated water pump situated in the playground. The purpose of having pumped water in the playground was twofold: so the children could include water in their free-play time, and to assist their learning about water conservation (T1, casual conversation, 06.08.08).

Pilot study vignette

Children were observed carrying water from the pump to the sand-pit, during free-play, for the purpose of collaboratively mixing what they called 'cement'. The product was then spread onto a paved area. In a conversation with the teacher it was revealed this activity was devised by children and enacted each day. The children ran a 'competition' to find whose sand mix 'cement' would dry the most by home-time. During the sand-mixing activity, a boy (3-years-and 5-months-old) with the pseudonym of Marty discussed with E the finer points of pumping water according to his understanding. He explained the difficulty of pumping water and catching it before it went into the ground and said it was best to have someone help you. Marty knew it was 'effort' that made the water pour from the spout, but when questioned he was not sure what ‘effort’ actually meant. Marty was sure, however, that if you "put effort in, you'd get results" (Marty, ELC1, casual conversation, 06.08.08). In response to a question about water conservation, Marty said he wasn’t sure about that. At the end of the visit, children showed to E the 'dried cement', and a child was declared the 'winner' for that day by her peers.

Pilot study discussion

Although no specific science lesson had been planned, the children found science projects for themselves through play and from their current personal understanding of concepts. While no questions about evaporation, energy, or the effects of combining water and sand were asked, the children displayed a rudimentary understanding of cause and effect with each of these concepts. It was also noted that the children’s experiences and understanding of concepts could have been extended had adults been on hand to listen to explanations, ask questions (for example about the bearing of the weather on drying their cement), pose problems and inspire further investigation. Further, sustainability and the economic use of water were neither visible nor discussed during the play session. Observations of the free-play operation revealed to E children who appeared confident in their natural ability to construct, investigate and explore their environment.

After observing the children at play an attempt to make an audio recording of the ‘cement activity’ proved futile. The futility was brought about by an overt display of curiosity and a seemingly limited concentration span of the children. The ineffectiveness of trying to record conversations was probably brought about by E’s inexperience in recording the voices of young children in interview, and the children’s preference to be socially interactive and manually engaged manipulating or testing things. For example, the children were highly motivated by the audio-recorder yet had difficulty in answering direct questions, preferring instead to ask their own questions. This action reminded E that children required a familiarisation period with new resources before gains could be made. Nevertheless, as a result of this pilot study, it was concluded that the process of audio-recorded interviews with young children would produce limited results. Thus, future data collection when working with the children was modified to emphasise observation and casual conversations, which were recorded in field notes. Salient points of the casual conversations were later substantiated during reflective conversation with T1.

4.6.4 Stage 4: Intensive study visits

The bulk of data gathering was conducted during the intensive study visits. A total of four visits were made to each of ELC1 and ELC3, and three visits to ELC2 (see Table 4.3). It was revealed during the first of the visits to ELC1 (11.08.08) that a previous agreement to have photographs taken of children and the physical set-up of the centre had been reconsidered and rescinded by parents and the school's principal. Additionally, the children who were to participate at ELC1 changed their mind during the second visit and withdrew their support. These changes were accepted. Without independent participants, specific encounters within the whole class were then observed in ELC1.

E's role was dual in nature and fluctuated between passive and active participation. Passive participation involved becoming familiar within the context of the ELC. Active participation involved more refined interactions within the community. A detailed description of these roles is presented in the 'Methods of data collection' section of this chapter.

Becoming a familiar part of the ELC routine enabled E to gather data easily because adequate time was available to engage in activities, record detailed observations and connect with contributors throughout the experiences of each visit. Observations made about the setting and interrelationships between and amongst children, adults and the environments were recorded during these intensive study visits and reflected upon after each visit. Recorded as field notes, entries were added into the field research journal. If permitted, photographs were taken and children's drawings collected during these visits. A recorded interview with each centre's teacher or in the case of the playgroup, a parent spokesperson, was made when children had left the ELC for the day. In the case of the parent spokesperson from the playgroup (ELC2), an informal telephone conversation was undertaken during an evening (14.11.08) because this was more convenient in her role as mother of two small children. Detailed descriptions of these forms of data collection are presented in the 'Methods of data collection' section of this chapter.

4.6.5 Stage 5: Post data collection

The post data collection stage consisted of a single visit to each ELC (see Table 4.3). Morning tea and copies of photographs taken in the ELC (as arranged) were provided to the centre to thank participants for their cooperation. This visit also included a verbal sharing of preliminary findings with the pre-kindergarten educators and the school's principal (or parents, in the case of ELC2). A written report was later submitted to both ELC1 and ELC3 after preliminary data were collated and analysed. A formal report was not a requirement of ELC2, but photographic records were collated and presented to the children and parents, in the form of a story book, as a memento of their participation in the research.

4.7 Methods of data collection

While remaining mindful of what science might look like in ELCs, interactions and relationships that influence behaviour between children, children and adults, adults and other adults, children and the environment, and children with the natural or provided resources, called for a variety of data collection methods to be used. As indicated earlier these methods included passive and active observation, conversations and interviews, and artefact collection. The field journal was used to record data, taken as field notes, and for reflection of that data collected.

The purpose of using multiple methods was to enhance validity of the research findings by providing rigour, breadth and depth (Denzen & Lincoln, 1994). Multiple methods of data collection also allowed for triangulation, in the classic sense of seeking convergence of results (Creswell, 2008). Additionally, multiple methods allowed for overlapping and different aspects of a phenomenon to emerge: one method sequentially informed another, contradictions and fresh perspectives emerged bringing additional breadth and scope to a study (Creswell, 2008).

Triangulation to reinforce the study design and contribute to methodological rigor was gained through combining multiple sites, multiple participants and multiple methods of data collection at individual sites. Multiple sites allowed for the diversity of the ELC settings. Multiple participants encapsulated different perspectives of experiences. Multiple methods of data collection acknowledged that groups of children can behave differently in different settings and again, differently on different days. For example, during some visits to the ELCs the children wanted to be fully involved in this study: have their photographs taken, demonstrate actions and discuss engagement. Yet, on a subsequent visit to the same centre, the same children were just as likely to be reluctant to participate in any way. This was further illustrated by the children who had originally agreed to be an active part of the research yet withdrew their permission during a follow-up visit. As a consequence of involving multiple participants, using multiple sites and multiple methods of data collection, the uniqueness and complexities of each of the three ELCs were captured. A summary of the range of data collection methods for each ELC can be found in Table 4.4. Each method of data collected is described below.

Table 4.4
Summary of methods of data collection at each ELC

Method of data collection	ELC1	ELC2	ELC3
Observations	✓	✓	✓
Conversations with children	✓	✓	✓
Conversations with parents		✓	✓
Conversations with teachers	✓		✓
Teacher/parent semi-structured interview	✓	✓	✓
Children's drawings	✓	✓	
Photographs		✓	✓
Field notes	✓	✓	✓

4.7.1 Observations

Observation, as a tool for research, is defined by Creswell (2005, p. 211) as the "process of gathering open-ended, first-hand information by observing people and places" within a setting where individuals and their actions can be studied first hand. Additionally, Creswell described an observer as one who may take both an active and/or a passive role. A passive observational role occurred when, without interrupting proceedings within the observed context, details of routines, interrelationships and characteristics are made from a distance as a spectator (Creswell, 2005). As an active participant, Creswell continued, the researcher vigorously engages in the actions, routines and events of the setting.

Both passive and active observational participation were employed in each centre. An example of passive observation occurred when, without interrupting their actions, notes were made by E to reflect the interrelationships and actions observed during play. In contrast, active observation occurred when E became involved, for example, providing practical assistance to guide children in their learning. Persistent observation, of children's activities, was the key that allowed E to become entrenched in the culture, routines and experiences of each learning centre. Through routinely visiting the centres and using persistent observation, empathy with teachers and children resulted in ease of communication and responsiveness. Persistent observation also enabled 'normal behaviour' as opposed to behaviour that could have been interpreted as the 'halo effect' where those being observed 'perform' for the researcher (Patton, 1990).

Observations made to present an overview of what science looked like in ELCs provided essential glimpses of the interactions and interrelationships associated with science activities. Field notes describing interpretations of those observations were added into the field research journal during and after observations were recorded. These field notes then contributed to the data collection and were reconsidered during visits to the centres and, time and again, away from the centre to corroborate and collate the ideas that informed the research.

4.7.2 Casual conversations and semi-structured interviews

To take advantage of time constraints within the demanding nature of an operational ELC, casual conversation and semi-structured interviews were conducted to provide maximum flexibility for participants and enable responsive, uninterrupted dialogue to occur. Active listening was essential to facilitate correct interpretation. Direct discussions with children, conversations between children and conversations (or interviews, or both) with adults, served to enrich descriptions and observations of the interrelationships and interactions of a socio-cultural environment operating within the context of each ELC. Field notes recording salient points of verbal interactions were made during experiences or debriefing sessions and, as such, could not be recorded verbatim due to the nature of constraints under which the discussions took place. Conversations noted, however, were verbally cross referenced with adults for accuracy. It was found that children could not always recall details (such as verbal interactions) of occurrences that took place a week previously. For example, where the children could remember the previous week's activity, they could not always recall finer details about an activity. Children were however, always given the opportunity to acknowledge their participation of a previous encounter.

The purpose of semi-structured interviews is to have a focus through set questions but allow for digression in responses (Creswell, 2008). Semi-structured interviews were used to gather information from centre leaders about their perceptions related to the learning and teaching of science for children in ELCs. Audio-recorded interviews were made with the classroom teachers in ELC1 and ELC3 and later transcribed as data. An extended telephone conversation with the parent spokesperson at ELC2 was recorded by way of note taking during the interview and immediately following that conversation, while the information was fresh in the mind of E. At times the planned questions became redundant as divergence and unsolicited stories about the learning and teaching of science richly informed data from these interviews and expanded the adult perspective about what science looks like in ELCs. The transcribed interviews were verified with participants prior to them being accepted as a record of data.

For ELC1 and ELC3 classroom teachers, the following questions were prepared:

1 How long have you taught children under the age of five?
2 Do you think it important to teach science concepts to young children? Why?
3 How is science a part of your curriculum?
4 Where would you rank the teaching of science to children under 5 years of age and why rank it there?
5 How do you teach science to children under 5 years of age?
6 Where do ideas for science investigations and experiences come from?
7 How do you assess children's knowledge after a science concept has been taught?
8 What if anything, makes you feel uncomfortable about teaching science?
9 Any other comments?

Due to the different context within ELC2, a different set of questions was used in the telephone interview. The ten questions below were used to guide the semi-structured interview with the parent spokesperson:

1 Do you see playgroup as a teaching/learning opportunity? Explain your answer.
2 What is the most challenging thing about guiding the learning of multi-aged in the playgroup?
3 Do you think it important to teach science concepts to young children? If so, why?
4 If science is a part of the playgroup activity planning, how is that done?
5 When your child attends school, where would you rank the importance of teaching science and why would you rank it there?
6 If children are engaged in science from a young age, do you have an opinion about how they ought to be taught science? Explain the reason for that opinion.
7 How are the ideas for activities and experiences created for the multi-aged group of children in the playgroup?
8 Do you assess what a child may have learnt during playgroup activities? Explain your response.
9 From a parent's perspective, is it important to point out scientific concepts, when they occur, to children?
10 Any other comments?

4.7.3 Artefact collection

In light of unpredictable engagement and the variances in communication capabilities of children, photographs and children's drawings were sought as supporting evidence of participation in science activities to add a depth of rich description to the complexity of some experiences. During attempts to collect artefacts relevant to the study it became apparent some children were reluctant to part with examples of their work, such as drawings. Thus, few artefacts were collected and none photographed. Examples collected for this research are presented to illustrate appropriate case studies (see Chapter 5). Other pieces of work that would have embellished an activity, but not collected, were discussed with the owner for details about its construction and content (for example Crayon Boy's letter to his Nana, as described in Case Study 7, Chapter 5). Field notes were made about discussion points and children's interpretations of their work.

Photographs of children engaged in activities taken in ELC2 and ELC3 came with the understanding that copies would be provided to the centres, for distribution, at the end of the research. That request was met during the Post Data Collection visit to relevant centres. Photographic evidence of participation in science activities in ELC2 included a sequence of action snapshots of a boy constructing a skateboard from building blocks, whereas photographs taken in ELC3 illustrated children classifying seed pods. Any images used in the publication of this research have parental consent.

4.7.4 Field notes

The majority of primary data for this study were captured as field notes. Patton (1990) argued that the commitment by the researcher to make notes at the time of observations lessened a chance of inaccurate recall. First hand and anecdotal in nature, descriptive and reflective field notes taken from grounded situations by E were recorded as notes and stored in a field research journal. These field notes provided an ongoing record of data collecting from observations, discussions, insights and perceptions and contributed to the overall data collected. Although taken with “disciplined intention” to avoid preconceptions, field notes are invariably subjected to the observer’s reactions and interpretations (Patton, 1990, p. 242). Silverman, (2001) argued that, no matter how disciplined the intention, while making field notes the writer is not simply recording data but analysing them at the same time. Personal reactions to observations are inadvertently “impregnated with assumptions” therefore immediate interpretations are contained within the writer’s field notes (Silverman, 2001, p. 2).

Recollections of the in-field experience, triggered by the predominantly short notes made at the time of observation, were expanded as soon as possible after a field visit. Annotations reflecting ideas and questions were added when these recollections came to mind and contributed to the initial notes. The cumulative grounded information that contained descriptions and snippets of conversations to enhance the field notes also revealed details of context, interrelationships and culture. Reflective discussions born of experiences recorded in the notes were made with the people associated with the experiences, and with research supervisors to clarify thoughts and confirm deductions made.

4.8 Data analysis

A description of the process used to construct and interpret the case studies is presented below. This is followed by information relating to the process of performing the cross case analysis.

4.8.1 The construction and interpretation of case studies

Following the same format used by Howitt and Venville (2009), each case studied was written in three parts: introduction, vignette and discussion. The introduction was to provide the setting and context that positioned the vignette of each individual case study. The purpose of the vignette was to recreate the experiences as close as possible to reality. To achieve this, the vignette incorporated enough local detail to provide authenticity and structure to identify the experience of how science was being developed within a specific ELC, and the discussion delivered an interpretation of the experience (Howitt & Venville, 2009). Constructed as a narrative, each vignette is an account based on actual events that captured the actions and interactions of the experience, in a vivid and life like manner (Wildy, 1999).

To enhance authenticity within the case studies, direct quotations from conversations with children, teachers and parents are included along with photographs of children interacting with objects of investigation, and children's drawings. The transcription of interviews and reflection of field notes and artefacts assisted in the reconstruction of the experiences captured for the vignettes. This broad approach ensured the narrative emerged from a multiple collection of associated information that could provide the finer details for the vignette's discussion. A total of seven case studies were constructed: three from ELC1, and two each from ELC2 and ELC3.

With the ultimate goal of interpreting the science learning and teaching opportunities provided in ELCs, how they were informed by socio-cultural theory and how this analysis contributed to building new theory (e.g. SCALTELC-S), each vignette followed a process of five phases of development as described by Moustakas (1994).

- First, data collected during field work that was immersed in the day-to-day life of the ELCs, were collated.

- Second, a period of revisiting the initial collation and writing up cumulative notes enabled clarification of the data collected. This phase included periods of discussion with ELC participants and the study's supervisor.
- Third, and after the initial vignette was assembled, a time of contemplation enabled increased awareness and brought new clarity to the meaning of the vignette.
- Fourth, the vignette was left for a period of incubation before being revisited for fresh insights and understanding to its meaning. This phase also illuminated any connections with vignettes of the study and reshaped deep discussions about the content of each vignette.
- The final phase brought understanding to the construction and interpretation of all vignettes through discussions and synthesis to find emerging themes and interpretation of data collected.

The five phases undertaken to write and check a vignette and discussions, took between six and 18 months each and involved up to six cycles of reflection. The cycles of reflections involved revisiting and rechecking every detail of the construction of the case studies to ensure that no relevant data were omitted, and that information added was appropriate and relevant. Also, the narratives were rechecked against field notes and thoroughly discussed with participants, colleagues and supervisors, for authenticity. This time frame also allowed the researcher to think about the experience and what it meant after the fact. The approach also permitted a deeper understanding of the nature of the experience and greater opportunity to uncover the meaning (see for example, Anderson, 1998; Janesick, 2000, and Moustakas, 1994).

4.8.2 Cross-case analysis

A cross-case analysis is a considered process to "build abstractions across cases" (Merriam, 1998, p. 195). To achieve a cross-case analysis qualitative studies are synthesised to provide explanations and patterns for analytic insight and interpretation (Patton, 1990). Before more predictable patterns are yielded and conclusions drawn from a synchronisation of qualitative studies, however, Miles and Huberman (1994) argued that putting a cross-case analysis into theory is a complicated process that begins by finding aspects from individual cases relating to themes and the dimensions. From the view of Yin (2003), cross-case analysis comes from the practice of multiple case study design and is used to gain theoretical knowledge that is grounded in different contexts and content within a study. Thus, a cross-case analysis , in relation to this study's research questions, will form a chain of evidence based on information found in individual case studies for the purpose of forming a theoretical position within an interpretative research paradigm.

The cross-case analysis in this research was conducted on two levels. First, comparative interpretations from the seven individual case studies resulted in the construction of consistent themes and unique occurrences. Second, these results were then synthesised within the framework of the study to seek a deeper understanding of the similarities and differences that contributed to the main findings of this research. The process was complex and time consuming yet revealed commonalities, underlying themes and interrelationships between the cases studied, as described in Chapter 6.

4.9 Quality criteria

4.9.1 Acknowledging researcher background and perspective

"All research is concerned with producing valid and reliable knowledge in an ethical manner" (Merriam, 1998, p.163) and, when the primary instrument for qualitative data collection and mediation is the researcher, "perhaps the most common concern about qualitative methods is subjectivity" (Patton, 1990, p.480). Merriam (1998) also argued that a prominent concern of the researcher being the primary instrument is the possible, but unavoidable, bias that can enter the data gathering and analysis periods of research. Bearing that in mind, Patton (1990) explained that when personal connections and professional information that may affect data collection, analysis and interpretation are acknowledged, possible distortions can be reduced. Denzin (1997) therefore considered it an important measure of validity for the researcher to identify their position and point of view in relation to the study, thus ensuring "rigour, balance and fairness" had been considered (Silverman, 2001, p.2).

As indicated in Chapter 1, the researcher in this study (E) has a background in science education for young children, and considerable experience as a teacher of ECE. This brought to the research both strength and weakness. Strength came from the researcher's credibility and authenticity within the field of ECE, and in particular science learning and teaching with young children. A weakness was that, without intention, the inevitable subjectivity in fieldwork could sway credibility and trustworthiness (Merriam, 1998; Patton, 1990). Acknowledging that it would have been easy for E to oversimplify observations or misconstrue the intentions of the participants throughout the study, measures were taken to bring as balanced an interpretation as humanly possible. With awareness that findings would be mixed with "hunches, insights and intuition" (Creswell, 2005, p. 251), measures were taken by E to prevent distortion. These included:

- maintaining a philosophical belief in the value of qualitative studies, its dependence of accurate reporting and the need to gather data from real situations
- regular, weekly visits to each ELC over the period of one school term
- carefully documenting detailed observations
- reviewing methods used and observations made, with participants and research supervisors
- being aware of predispositions such as the 'halo effect' where participants can perform for the benefit of the research. This was guarded against through multiple visits to each centre
- through long term engagement in the process of reflection that caused revisiting, time and again, the perceptions made about the data gathered.

Cognisant of Patton's belief that researchers should "strive neither to overestimate nor underestimate their effect, but take seriously their responsibility to describe and study what those effects are" (Patton, 1990, p. 474), E endeavoured to bring credibility and validity to this study.

Irrespective of the precautions outlined above it is acknowledged that a power/knowledge differential was highly likely to exist between E and the other participants in this study. Mentions of positions of power are found in Chapter 2, section 2.3.6, in section 4.10.3 of this present Chapter and in the key findings of Case Study 3, Chapter 5. While little can be done to mitigate such power

differentials, nevertheless a keen awareness of them is necessary when findings of the study are interpreted.

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4.9.2 Trustworthiness

Patton (1990) explained that trustworthiness, associated with interpretive research methods, originates from ethical acts within the context of a study. A requirement of trustworthiness, Patton continued, is that truthful information is presented for all participants about the purpose of the investigation, the implications associated with being observed, and the resultant findings. The amiable acceptance of the study by representatives from each of the three settings contributing implied a sense of trustworthiness in the information received, the researcher's moral direction, and the university's moral obligations. Credibility, dependability, confirmability and transferability will now be discussed to further illustrate the components of trustworthiness addressed in this research. Verisimilitude is also presented as a form of quality control relevant to this research.

Credibility

A component of trustworthiness is credibility that justifies the behaviours of the researcher and an honest account of the findings (Bryman, 2008). Bryman explained that credibility relates to internal validity in that "prolonged participation in the social life of a group…allows the researcher to ensure a high level of congruence between concepts and observations" (2008, p. 376). Merriam (1998) added that internal validity refers to how well research findings match reality. In Merriam's terms, reality in qualitative research is seen as holistic, multidimensional and ever changing. Credibility in this research thus confirms the grounded nature of the study and is evidenced by extensive field work in the reality of a working ELC environment. As indicated earlier, to improve credibility, this research used multiple methods of data collection, multiple data sources, and multiple perspectives of interactions (including the voices and actions of children and educators from each ELC), cycles of reflection (by E) in developing and analysing the case studies, and member checking. Authenticity of information collected was checked by participants as early as possible after data were collected, and rechecked before those data became explicit in the case studies. As a consequence, the case studies provided thick, rich descriptions (Merriam, 1998) to reflect the reality of the particular context.

Dependability

Dependability used for qualitative study communicates whether or not findings are consistent and dependable with data collected (Merriam, 1998). Although Bryman (2008) noted that dependability within research parallels reliability, and therefore replication, Merriam (1998) had earlier argued that replication does not fit with qualitative research because the multifaceted, highly contextual and emergent nature of qualitative research makes precise replication "impossible" (Merriam, p. 206, 1998). For research to be proven dependable, Guba and Lincoln (1997, p. 242) consider that the inquiry process would need to be open to public inspection so it could be "tracked and trackable." They emphasised the necessity for decisions, actions and interpretations made by the researcher in the context of the research, to be judged and understood by a reader of the study. To increase dependability and credibility within this research the methodological section is described in detail, including timelines of data collection, selection of participants and contexts, and construction and interpretation of case studies. This detail offers the reader understanding of the processes that lead to the findings, and provide a basis for replication of the study.

C*onfirmability*

Confirmability parallels the objectivity of a study and recognises that complete objectivity by a researcher in responding to data collections is impossible (Byman, 2008). Therefore, Bryman argued that to demonstrate confirmability the researcher would employ best efforts to show their study was undertaken in good faith, knowing that personal qualities or orientations could create bias. When the researcher is the primary instrument for data collection, and even with the intent of impartiality, it is recognised that human characteristics could influence data through responsiveness to the context, and adaption of techniques to suit that context (Merriam, 1998). As the primary researcher in this study, it is acknowledged that E's history and knowledge of science activities in early childhood educational settings could have had bearing on expectations and outcomes aligned with the context of the study. Being aware of expected and essential objectivity and to guard against this overt possibility, in depth discussions with the study's supervisors and member checking with ELC participants were employed.

Every effort was made by E to ensure data collection and analysis could be confirmed as a true and accurate record of events and actions accumulated throughout the research. For example, cycles of reflection were introduced as a strategy to minimise the potential of bias. These cycles ensured that more than one opportunity was provided for participants to check information used to construct the case studies. Member checking enabled participants to audit notes, vignettes and transcribed interviews to confirm that they were accurately represented in the study. This strategy also permitted data generated in the research to be removed if any information was found to be unacceptable or inaccurate. Where children's voices could not be member checked, adults in relation to the child's engagement were asked for confirmation. Other strategies used to guard against bias came from multiple methods of data collection and the use of multiple perspectives of interaction through the inclusion of children, teachers and parents.

Transferability

Transferability of a study to other situations to gain external validity depends on the degree of similarity between the original situation of a study and the circumstances of another study (Lincoln & Guba, 1985). Transferability is, according to these researchers, the ability to generalise across different circumstances. Although the thought of transferring one study to another situation was "appealing", Lincoln and Guba pointed out that it would be impossible to do so (1985, p. 110). These researchers also found that transferability related to the 'thick descriptions' of a study that required the researcher to provide sufficient detailed information that could be used in further studies. Holloway (1997) pointed out that those thick descriptions referred to by Lincoln and Guba would also provide explicit patterns of cultural and social relationships before the study could be replicated elsewhere. From the extensive and detailed descriptions of the methodology and methods of data collected and presented for this study, the reader could make generalisations to be applied to new research; however, individual contexts, situations, and the people who have contributed to this study would make precise replication impossible.

4.9.3 Verisimilitude

Denzin and Lincoln (1994) consider verisimilitude to mean having a representation of research that is as consistent with what actually happened as possible and that representations of actions are accurately presented. The three different strategies used in this study to improve verisimilitude came from: enabling participants, through their voices and practical involvement, to help construct the vignettes; member checking through the cycles of reflection that afforded adult participants opportunities to check and recheck the vignettes for accuracy and act upon any inaccuracies; and, through thick rich descriptions that illuminated details of the actions that made up the vignettes (Merriam, 1998).

Although every effort was made to ensure verisimilitude within the reality of the study, there remain possibilities of omission due to complexities associated with either the spontaneity of the actions of young children or finer details related to a context's cultural and social uniqueness. However, sufficient information has been presented within this chapter so that the framework used to construct this study can be replicated.

4.10 Ethical Issues

One of the basic tenets of educational research is that ethical consideration is required for any research that explores the experiences of individuals and that the researcher has ethical and legal responsibilities towards all participants, in all phases of research. To illustrate how this research met ethical requirements, informed consent, confidentiality and anonymity, and research participant relationship are discussed below. As indicated earlier and preceding the research, an ethics clearance, as per National Health and Medical Research Council (NHMRC) requirements, (NHMRC, 2007) was sought and granted through the Curtin University Human Research Ethics Committee (Approval Number HR69/2008).

4.10.1 Informed consent

Following a phone call by E requesting a meeting to discuss the research, a representative of each ELC (either the principal or a spokesperson elected by the institution) was visited and an initial discussion about the study took place. At that visit verbal information about expectations of involvement was provided. The discussion was supported by Information Booklets and consent forms. Copies of those documents can be found in Appendices A and B. In conjunction with the documents, teachers in ELC1 and ELC3 (or other parents in ELC2) were informed of the outline and implications of the research, and invited to participate by the ELC representative. Extra documents were left with the representative for this purpose to enable considered consent by participants. It was agreed that E would contact the institution in one week to confirm arrangements.

Teachers in ELC1 and ELC3 who agreed to be involved (and parents in the case of ELC2) were then presented with extra copies of the Information Booklets to hand to prospective parents. Because of the precise age of the children required for the study, parents needed to give consent on behalf of their child if they were agreeable to having their children join this research. Specific parents were chosen by the teacher to join the study in light of their willingness to be involved in other ELC activities and having children who were considered, in the professional judgement of the teacher, to be suitable for and capable of, focused participation. Parents who agreed to allow their children to participate were informed by the teacher that the research was voluntary and they could withdraw their child from the study at any time. Once parental verbal agreement was made with the teacher (or parent spokesperson in ELC2) that a child may participate, parents of the focus children were invited to meet with E for an impromptu question and answer time. This offer, made by the teacher (or parent spokesperson in ELC2), was scheduled to occur during the initial visit to the centre by E for the purpose of addressing any further information parents may have required. Parents of participating children were asked to discuss the research with their child to confirm the children were happy to be involved. Parents (and centre representatives) were also offered time, at the completion of the research, to discuss the study if required.

For ethical reasons, each child's parents had to give formal consent before their child could participate. Parents of other children in the ELC were to be informed by their representative that a study was being conducted and given an opportunity to comment before the study began. For example, one parent wanted assurance that neither her child's nor her own photograph would be included in any data gathered. To meet that request, two actions were taken. First the child was pointed out to E for identification, and second, all photographs were screened by that centre's representative to ensure the images were not inadvertently captured. Once agreement and consent were established with all adult parties, the whole class of children in each centre were then informed by the teacher that E would be working with some children and that others may be asked to help. After the representative in each centre had checked (by direct inquiry) that focus children had been informed by their parents their role in the study was elaborated by the representative. That role was reconfirmed, by E, after it was established the children had been informed by both parents and the centre's representative. To assist in their understanding, and using non-condescending language considered appropriate for children of this age, the following information was explained to the children:

- there would always be an adult with them that they already knew
- if they so wished, they could work with a friend
- they had a right to withdraw from the research at any time, and
- they did not have to submit any work they chose to keep.

As the representative had done previously, E also asked if the focus children had any questions to ask about their participation. Rather than questions, the children made comments or statements such as Boy1 at ELC1 who stated he was he was going to be cooperative because "Mum said I am helping other children learn" (30.07.08).

4.10.2 Confidentiality and anonymity

An essential part of the ethical issues associated with this research is related to confidentiality and anonymity. Assurance was given to all parties, in each ELC, of confidentiality and anonymity and that their participation would not lead to embarrassment or betrayal as a result of their contributions. Further, identifying names of participants, including names of the ELC and geographic location, would not be made public. To meet these assurances pseudonyms, rather than identifiable names, were used to identify those who contributed to the study and, where necessary, data changed to ensure identity was protected. As an example, the centres were designated ELC1, ELC2 or ELC3 as a method of protecting their identity. Children who contributed to the vignettes were given pseudonyms; for example, names such as Nature Girl and Skater Boy have been used in the case studies. Likewise, the identity of teachers and education assistants have been assigned a number in relation to the centre in which they teach; for instance, T1 and EA1 for ELC1.

4.10.3 Research participant relationship

When conducting research with young children, as in this research, there is an unequal power relationship automatically established due to the subordinate position of the children (National Statement on Ethical Conduct in Human Research, NHMRC, 2007). This unequal power relationship may impair children's consent to participate as well as inhibit their involvement in the research (NHMRC, 2007). To address this issue, all contributors to the research were informed that participation was voluntary and that they could withdraw at any time. This assurance was provided through the parent consent form and information pages found within the information booklet, as discussed above. This was also told to the children.

Various methods were used to reduce the power relation between E and the children. Children were introduced to E and aware of her presence in the centre during each visit (see Table 4.3). A minimum of three visits to each centre involved E working directly with the children. When not actively engaged with the children E's role was that of passive observer. During these observational times the children seemed to become comfortable and familiar with the company of E when they initiated conversations or asked for assistance. An example of participant relationship came when the children, who had earlier agreed to be focus children in ELC1, approached E during an observation time and withdrew their agreement. Their entitlement to change their mind about being involved in the study had been clearly given during the preparation stages and their decision was honoured. In another example, a focus child in ELC2 wished to contribute to the study. He demonstrated this when he insisted his photograph be taken to help E with her work.

4.11 Summary

Chapter 4 has presented the methodology and methods used in this qualitative research for the preparation and procedures of this study. To frame the reality of the study, methodology emphasised an interpretive research paradigm where ethnography and grounded theory combined with multiple case study design. Contextual information introduced the reader to participants and ELC's contributing to the study. The five phases associated with the interpretation of the cases studied were then outlined before the multiple methods of data collection, that included observations, semi-structured interviews and the gathering of artefacts were described. Stages of data collection and how that data were interpreted and analysed through case study design and cross-case analysis were then presented. Quality criteria of the research were discussed through the concept of trustworthiness (credibility, dependability, confirmability, transferability and verisimilitude). The chapter concluded with a discussion of the ethical issues used when dealing specifically with young children in qualitative research.

The following chapter presents seven case studies that emerged from the data that informed this study.

Chapter 5

Findings of Case Studies

5.1 Introduction

Chapter 5 presents the seven case studies that resulted from data collected in three Early Learning Centres (ELCs). As narratives, each case study contains four parts: an introduction to the specific context and experience, a vignette that describes interaction and the scientific concepts explored, a discussion, and a brief summary of the key findings in response to the sub-questions of Research Questions 2 and 3. These sub-questions are presented below.

Research sub-question 2.1

To what extent does effective learning and teaching of science take place and under what circumstances?

Research sub-question 2.2

To what extent does the learning and teaching of science appear to be informed by socio-cultural theory?

Research sub-question 3.1

What can be learned to inform the enhancement of learning and teaching of science for 3- and 4- year old children in ELCs?

The chapter begins with an overview of the seven case studies. This is followed with detailed descriptions of the contexts of each of the three ELC settings from which those cases were drawn, based on observations and other data collected pertaining to each setting. The seven case studies that report the engagement of 3- and 4- year old children in science learning and teaching experiences are then presented before the chapter concludes with a brief summary that sets the scene for Chapter 6 in which the findings of these case studies are synthesised in a cross-case analysis.

5.2 Overview of case studies

Descriptions of interrelationships between 3- and 4- year old children, other people, the environment and resources used during science learning and teaching form the basis of the case studies constructed. Opportunities presented for those children and how the children constructed (or failed to construct) science concepts are described, with references to artefacts, observations, interviews and conversations that contributed to the experiences recorded.

Individual engagement, small group work and whole-class situations were observed during the field work where play, guided teaching and demonstration lessons were noted. Interactions that highlight pedagogy and the often unpredictable engagement of young children are also captured in specific contexts for each case study. The backgrounds of the teachers and education assistants were summarised in Chapter 4 and are again mentioned in this chapter, in contextual situations, to refresh the readers' memory and to situate them within specific cases studied.

To distinguish educators specific to each case study, participating teachers are assigned a letter and number according to the ELC in which they teach: T1 and T3 (in ELC1 and ELC3 respectively), and education assistants, EA1 or EA3 (in ELC1 or ELC3 respectively). Other contributing educators are parents who are described as P1.1 (from ELC1), P2.1, P2.2, P2.3 (from ELC2) and P3.1, P3.2, P3.3 (from ELC3). The researcher continues to be referred to as E and pseudonyms rather than real names are used to identify the focus children.

The first three case studies relate to the Pre-Kindergarten group, ELC1; the next two were constructed in the Playgroup, ELC2; and the last two obtained from the Pre-Kindergarten group, ELC3. Table 5.1 presents a summary of the seven individual case studies. The information unites the number of each case study with the ELC in which it was constructed, the name of the case study, the children who were the focus of the case study, and the list of contributing educators.

Table 5.1
Summary of case studies

Case Study	Early Learning Centre	Case study name	Focus children	Contributing educators
1	ELC1	"You eat it when you watch TV."	Whole class	T1, EA1, E
2	ELC1	A sound difference	Sound Boy 1 Sound Boy 2 Sound Girl	T1, EA1, E
3	ELC1	"Now can I draw a spider?"	Whole class Spider Girl	T1, E, P1.1
4	ELC3	"They're not toys!"	Nature Girl Nature Boy	T3, EA3, E
5	ELC3	"Uh-Oh, wet shoes."	Water Girl Water Boy	T3, EA3, E
6	ELC2	Skater boy	Skater Boy	P2.1, P2.2, E
7	ELC2	Warm crayons work	Crayon Boy 1 Crayon Boy 2	P2.3, E

Note 1: A Pilot Study was conducted in ELC1 on 06.08.08 prior to construction of the seven case studies presented in Table 5.1
Note 2: Initial descriptions of children's activities in Case Studies 4 and 6 appear in Blake and Howitt (2009, 2011)

5.3 Overview of participating ELCs

As stated earlier, three ELCs were involved in this research. The school to which ELC1 was attached catered for children from Pre-Kindergarten to Year 12, whereas ELC3 was part of a school that catered for children from Pre-Kindergarten to Year 6. The third centre, ELC2, was a non-sectoral community Playgroup registered with the national body *Playgroup Australia*.

Children enrolled in ELC1 and ELC3 were aged from 3-years-and-6 months to 4-years and their immediate needs, while in the ELC, were met by the classroom teacher and the education assistant (e.g. T1 and EA1 in ELC1, or T3 and EA3 in

ELC3). Children in ELC2 could be enrolled from birth to 4- years of age and they attended the centre with their parent or a legal guardian.

All three centres were made of environments for nonspecific, play-based learning with one centre (ELC1) having used converted spaces within their environment for specific science lessons, prior to this research being conducted. Although the three ELCs represented a diversity of social structures, communities, physical environments and learning contexts, some contextual commonalities did exist. Commonalities included non-compulsory enrolment of children, mixed sex groups, and specifically defined physical areas of learning that included indoor and outdoor play spaces. All three centres were purposefully considered by E to reflect learning and teaching experiences for young children, under (Western Australian government) compulsory school age. Parents supported these education centres by assisting in a variety of ways. Assistance included helping with in-class routines (such as morning tea, table-top activities and play-time supervision), and by contributing fees to meet operational costs. The setting for each of the three ELCs is described below, drawing on information and observations gathered prior to and during visits and on observations recorded during visits.

5.3.1 Setting: ELC1

ELC1 was situated in a well-resourced centre. Housed in a 90- year old two storey house that had been renovated to specifically cater for Pre-Kindergarten classes, the location of ELC1 was in the grounds of a large inner city school. The upstairs part of ELC1 accommodated an Out of School Child Care facility when the Pre-Kindergarten group was not operational. Some ELC1 children stayed after their Pre-Kindergarten session to attend this secondary facility on an occasional or daily basis. The school that incorporated ELC1 was found in a high socio-economic area that catered for more than 1000 children, ranging from Pre-Kindergarten to Year12. All children wore the school's uniform. The ELC1 learning and teaching environment was observed near the end of the children’s third school term in Pre-Kindergarten.

A qualified early childhood teacher (T1) with a keen interest in science activities and 15 years’ experience in ECE taught the co-educational class of ELC1. T1 managed ELC1 with the help of a full time, qualified education assistant (EA1) “with many years' experience" (Semi-structured interview T1, 20.08.08). Together, T1 and EA1 provided stimulating semi-structured learning, for 22 children five hours per day, four days a week. Daily planning by T1 and EA1 included the use of a range of inviting learning spaces that offered children opportunities for free-play or guided investigation. EA1 moved around the learning spaces, when the children were using them, and became involved in learning activities only if her assistance was requested by the children. Other contributions by EA1 included preparing and tidying the two outside areas used by ELC1 children, and contributed to this study (Pilot Study, 06.08.08, and Case Study 3). At other times EA1 prepared activity areas and work to be displayed inside the classroom. When presenting didactic and demonstration lessons, T1 conducted either whole-class or small group teaching. Learning outcomes were governed by the school's direction and planned curriculum, and parental expectations.

A time-table scheduled the learning and teaching sessions and these were segmented into teacher-led learning and teacher-guided or free play-time, inside the classroom. One half-hour for free play-time, outside the classroom, was scheduled as a part of the daily routine. Two outdoor areas were available to ELC1, yet shared on a roster basis with other classes. One area housed fixed climbing equipment over a sand-pit, paths for trike riding and larger toy play, and an open lawn space for running and ball games. The other contained a specifically designed garden for children with gravel paths, native plants and a sand-pit. The water feature of this garden contained a child sized, fixed hand-operated water pump. Loose pieces (e.g. tricycles, water trough, buckets, and hard-hats) were added to these areas on a daily basis by EA1.

The learning environment inside ELC1 presented for children flexibility and an abundance of resources in creative and aesthetic learning spaces. Consumable resources were refreshed daily. Examples of learning spaces included a writing table set up for experimental writing, copying letters, and tracing over a template of own name; a place for quiet contemplation alongside a sectioned off reading area; a space with costumes and items to encourage fantasy and role play including a sit-in car, a variety of items related to a garage, a kitchen with child size furniture, and a nursery with cots containing a variety of dolls. A collage table that had soft wire, aluminium foil and examples of sculptures was set up to provoke creative interest, and a construction area called the Block Corner was available for children to create structures from either connectable plastic pieces or wooden building blocks.

Recorded evidence of each child's participation, that interconnected learning and achievement for the current (third) school term, was bountiful. Examples of work produced by the children and/or photographs of engagement were either thoughtfully and artistically displayed around ELC1, taken home on the day of creation, or contained with an accumulation of work samples in each child's portfolio that recorded progressive accomplishments.

With the experience of three school terms, children attending this centre were accustomed to routine. They appeared confident and polite, and were easily engaged in conversation. Most children indicated spontaneously to E that they were keen to move on to more challenging experiences and longer hours at school, for example "I'm ready for big school now" (field notes, 20.08.08). With all children in attendance the population of ELC1 included twenty-two children, T1 and EA1.

Of the eight field visits to ELC1 (see Table 4.3, Chapter 4), three case studies were constructed. Case Studies 1 and 3 represented whole-of-class-demonstration lessons, whereas Case Study 2 described an investigation that spontaneously occurred during scheduled time for free-play. E took the role of passive observer in Case Study 1 (*"You eat it when you watch TV!")* and Case Study 2 (*A sound difference).* In Case Study 3 (*"Now can I draw a spider?")* E acted as both passive observer and active participant. Notes made on the day that evidence was collected for a case study were validated during discussions with educators on follow-up visits.

The two focus children in ELC1, who had agreed to be a part of this research, changed their mind during a visit early in the research (11.08.08). As a result, observation concentrated mainly on whole-of-class engagement. Specific incidents during those whole-of-class activities were recorded to highlight examples of children engaged in scientific inquiry. Although other children were not specifically engaged to become the focus in ELC1, four children with the pseudonyms of Sound Boy 1, Sound Boy 2, Sound Girl and Spider Girl, incidentally assisted with data collection.

5.3.2 Setting: ELC2

ELC2 was housed in a purpose built 30-year-old single storey accommodation that contained five interconnected rooms and an outdoor garden. The building was provided by local government and catered for five individual Community Playgroups, each rostered to attend the centre on a different weekday. These Playgroups catered for a maximum of 20 children aged between birth and 4-years of age. Each child was accompanied by their parent or guardian. To join a Playgroup parents registered with Playgroup Australia (WA) and once dues were paid, attendance was voluntary. There were no 'school terms' to cluster days marked for attendance; however, government school term dates were usually followed. ELC2 represented one of those Playgroups where the parents and children attended for three hours each week, and only on Thursday.

Managed by a committee of parents, ELC2 was situated in a multicultural, inner city area that celebrated a diversity of languages and cultures. Irrespective of cultural heritage, all parents and children engaged in conversations with E spoke English. Numbers of people attending ELC2 fluctuated during the study's six data collection field trips; however, a consistent group of children and their parents participated in the case studies collected. The minimum number of children (many were siblings of others) attending on data collection days was 12, and the maximum was 19. In addition to attending ELC2 most of the children who had attained 3-years-and-6-months-of-age were also enrolled to attend another Playgroup or Pre-Kindergarten (on different premises) during the week.

The overtone of ELC2 was one of child-centeredness and interconnected learning. Resources that reflected high use were available to meet the needs of children of all ages. Indoor equipment included manipulative toys, dress-ups, books, blocks, a play gym and a variety of construction, writing and recycled materials suitable for independent and small group play. These resources were available for the children at all times in defined spaces. For example, a space for dramatic play included a puppet theatre, puppets, dress-ups, a microphone and stage rises. The block construction area contained a variety of shapes and sizes of 3D wooden blocks with a small wheel-barrow, large toy trucks and man-sized hard-hats. The home environment play-space contained equipment and furniture that resembled a kitchen and a nursery. The reading space was sectioned by a colourful rug and contained a collection of well used books and 3D puzzles on child-sized book shelves. For visual arts, a space with a collection of stationery items and recycled boxes were placed on a small table. Paints and brushes were available at the request of a child. The variety of learning experiences, with many adults on hand to assist if required, offered children independent choice and catered for a range of capabilities, learning needs and skills development. Alongside that choice, where time was not governed by a time-table, was an abundance of space, both inside and outside of the building. These flexible areas were adjusted daily, according to the children's requests. However, for the confidence of the younger children the basic layout (i.e. Home Corner and Book Corner) remained in the same rooms (Casual conversation, P2.1, 30.10.08). Low climbing equipment was found in an inside room of the building, and more challenging, higher climbing frames were positioned outside the building along with places to dig, spaces to run and paths for riding wheeled toys.

Sometimes, older children appeared to be protective of younger ones' engagement in some activities. For example, an older child rescued a younger child from walking in the arc of a swing, while another older child retrieved a crayon from a toddler who was attempting to chew it (Field notes, 30.10.08). Parents were never far from the interactive play-spaces. Adults, when busy with other children or talking to one another, always acknowledged a child's presence by placing a hand on a shoulder, presenting a smile, or politely asking children to 'have-a-go' or 'wait their turn' (Field notes, 30.10.08). The nature of learning in ELC2 appeared to be guided by parents, but generally learning occurred as a result of spontaneous and self-directed play at opportune moments, rather than as prescribed by a time-table or program of work. Curiosity and decision making, discovery, problem solving and investigation by children were nurtured by parent-educators. These actions have been recorded in Case Study 6 and Case Study 7. No formal records of learning were kept in ELC2, apart from an occasional, informal, family photograph. These were not displayed as groups other than ELC2 used the facility (Casual conversation, P2.1, 30.10.09).
Generally, parents held an expectation that their children would learn through discovery and social interaction during this early period of their lives. Further, parents only intervened in social interactions (called 'incidents') of sibling rivalry and petty squabbling when social skills needed clarifying or to support emotional

needs. The children were attired in play-clothes and, as explained by the parents, it was expected the children would get dirty during their investigations. Older children were encouraged to assist in caring for younger children but sometimes, the older ones became oblivious to others when engrossed in a point of interest (Casual conversations, P2.1, P2.2, P2.3, 30.10.08).

Each of the two case studies constructed in the learning environment of ELC2 explored incidental scientific investigations. In each case study, one young boy was the focus. The boys, given the pseudonyms of Skater Boy (Case Study 6) and Crayon Boy1 (Case Study 7) were, coincidentally, of the same age (3-years-and-8-month-old) and each had been attending ELC2 for more than two years. Further, each had a younger sibling who also attended this Playgroup, and each was accompanied by his mother. Skater Boy attended this playgroup one day a week with his mother and sister, and for two other days of the week he attended Pre-Kindergarten at a local school, without his sister or mother. Crayon Boy1 also attended a Pre-Kindergarten class without other family members for three other mornings of the week. These focus children reported they looked forward to starting 'real' school next year (Skater Boy, 20.11.08; Crayon Boy, 27.11.08). The seven field visits to ELC2 each lasted between one and two hours and occurred during October, November and early December of 2008 (see Table 4.3, in Chapter 4).

5.3.3 Setting ELC3

ELC3 was a co-educational Pre-Kindergarten class consisting of 15 children, aged between 3- and 4- years of age. It was part of a school for approximately 250, 3- to 11-year-old children, set in a relatively low socio-economic area. All children wore the school uniform of this faith based school. Children attended ELC3 for four hours per day, for up to four days a week. With a separate school entry and ready access to a spacious garden, ELC3 was accommodated in one room. This spacious room was once a regular primary school classroom in the original 40-year-old primary school. Time spent in ELC3 was governed by a whole of school time-table that also regulated shared spaces and resources.

This class was the first Pre-Kindergarten experience offered at the school and, when data collection commenced the 15 children enrolled in ELC3 had only been attending school, part-time, over 6 weeks (a total of 18 half-days). From a casual conversation with T3 it was found that the first part of the day in ELC3 included parents (or grandparents) staying to play with their children in a bid to help settle them (Casual conversation, T3, 13.03.09).

A qualified primary school teacher, T3 had been teaching for 12 years, four of which were in Early Childhood Education (ECE). This class was the first Pre-Kindergarten group T3 had experienced. She was assisted by a skilled EA (EA3) with two years of ECE experience. T3 had previously worked as a primary school specialist science teacher with children in Years 5, 6 and 7, and had enjoyed teaching science with those older children. However, T3 felt Term One was too early in the year to introduce science to these younger children. Further, T3 considered literacy and mathematics rather than science, were the high priority subjects in ECE (Semi-structured interview, T3, 20.03.09).

The teaching time-table that governed the indoor sessions consisted of 20-minute periods that enabled the children to participate in free-play. These play times were interspersed with whole-class mat-sessions, guided one-on-one instruction, or small-group teaching. The daily work schedule that led ELC3's learning and teaching structure was influenced by a school curriculum, parental and school expectations within the existing school's culture. Demands by other classes on shared areas and equipment restricted out-of-doors free-play-time, for ELC3 children, to half an hour on each day they attended.

The learning spaces and equipment for children to use within the classroom were purposefully kept to a minimum. This teaching strategy was implemented for two reasons. First so that children would not be overwhelmed and therefore help them settle into a routine new to them. Second, to assist children learn to play together, as they currently tended to choose isolated play (Casual conversation, 20.02.09). The children's limited concentration span was further highlighted in the following teacher quote:

> Their [the children's] concentration span is very limited and they seem to flit from one thing to another without too much engagement.

> Some things they seem to get 'hooked' on and can stay there for quite a while but mostly they are settling, finding out what's here and watching what others do."
>
> (Semi-structured interview, T3, 13.03.09)

T3 was mindful that because of the children's limited experiences in a school environment, the social and cultural nature of the ELC was still forming. As much as all children were encouraged to engage in activities by T3 and EA3, the seemingly more insecure of them appeared unsure about what to do and did not spend time engaged, in depth, in any activity. Although equipment in the room was sparsely displayed, there were enough resources to engage the children. The home-corner, for example, housed a collection of child-sized furniture (a table, chairs and a kitchen cupboard), kitchen utensils, dishes, cups and a tea-pot. Alongside the kitchen area was an appropriately sized wardrobe with dress-ups that included adult clothes, super-hero/heroine costumes and a box of hats to encourage role-play. This area also contained four cots with dolls and a basket of small blankets and clothes for the dolls. Table-top activities included wooden puzzles, bead-threading, jig-saw, crayons and paper for drawing and colouring-in. A bookcase containing picture books was also in the room. On the carpet in the middle of the room was a train set with adjustable tracks and carriages that were connected with fitted magnets. Manual energy was required to make the train travel on the tracks. Playing with the train set was limited to two children at any one time. The outdoor area for ELC3 was a large playground made up of open space, fixed climbing equipment and a sand-pit. Random loose pieces were added to this area prior to outdoor-play-time by EA3 and collected immediately afterwards, as the area was scheduled for use by other classes in the school.

Casual conversations with parents revealed that the process of settling the children into school and the unaccustomed routines (especially those without older siblings) required emotional adjustment for both parents and children. Parents were confident any unsettled behaviour at the beginning of the day was a temporary phase that would pass when the routines became familiar to the children. Parents also confided that, within this community, it was common for grandparents and friends to be home carers while parents worked. Being left in unfamiliar environments such as commercial child-care was rare (Casual conversations, P.3.1, P3.2, P3.3, 06.03.09). Taking into account the apparently limited school experiences of these children, and their shallow engagement in activities, the displays of separation anxiety were not unusual (Talay-Ongan & Ap, 2005). The educator's purpose in a Pre-Kindergarten, according to T3, was to evoke conversation and to scaffold new learning experiences for these very young children. T3 continued that "in a way, we are teaching them to play" so they can learn (Casual conversations, T3, 13.03.09).

During free-play-times, when children could select an area of interest to investigate, the more confident appeared to flit from table to table while those who seemed less confident tended to stand by and watch others play. T3 advised E that she chose to introduce resources into a new learning space only when she thought the children were ready for new experiences and able to cope with minimal assistance from adults. An example, called the Nature Table, that contained a variety of natural objects such as leaves and seed pods, was set up to stimulate interest. This addition was the catalyst for Case Study 4.

Of the two case studies constructed from ELC3, data for Case Study 4 (*"They're not toys!")* were collected during the second visit to the centre and highlighted a guided teaching investigation conducted to develop the emergent science skills of observation for the purpose of classification. Case Study 5 (*"Uh-oh, wet shoes!"),* records the focus children engaged in an unplanned experience that involved water and a range of resources. Like those in Case Study 4, these resources were also new to the children. Observations made and anecdotal notes recorded during data collection phases, for both of the ELC3 case studies, were discussed with T3 on follow-up visits.

The focus children in Case Studies 4 and 5 were a girl and a boy. The girl was 3-years-and-8-months old; the boy 3-years-and-7-months old. These children appeared to be exceptions to the majority of shy and reticent children in ELC3. The parents of the focus children explained their two families knew each other from outside of the ELC and their involvement in this study had been discussed, at length, at home (Casual conversation, P3.2 and P3.3, 20.02.09). For the purpose of the research, the focus children were given pseudonyms. In Case Study 4 they are known as Nature

Girl and Nature Boy. Although the same children participated in Case Study 5, their pseudonyms were changed to Water Girl and Water Boy, in line with the theme of Case Study 5. The seven field visits to ELC3 lasted for between one and two hours and were summarised in Table 4.3, in Chapter 4.

5.4 Case Study 1: "You eat it when you watch TV"

Introduction and context

The first case study, taken on 11.08.08, is derived from the observation of a whole-of-class lesson in ELC1 and occurred after the early morning, introductory mat-session. In the role of passive observer E remained out of direct sight of children and during the session made notes of the activity in the Field Journal. These notes included jottings of overheard questions and answers between children and an educator and children. Some of these notes are used to illustrate interrelationships throughout Case Study 1. To begin, eighteen 3-and 4- year old children were seated on the floor in a semi-circle. Inside the semi-circle was an area covered with paper and a warming, electric fry pan. T1 and EA1 were seated on small size chairs at the open end of the semi-circle. The session was introduced by T1 as a special occasion where the children were going to cook corn seeds and afterwards, take popcorn home to eat. T1 asked the children about their experiences with popcorn. Questions included: "Who has eaten popcorn?", "How was it cooked?", and "When did you eat it?" Responses from the children did not always relate directly to the question but included: "It cooks in a bag in the microwave."; "It stinks."; "You put butter on to make it taste nice."; "No, you put salt on it."; "You eat it when you watch TV."; "It's white."; "If you just buy it, it's got colours." and, "It's in a bucket at the movies." It was concluded from these responses that these children had considerable prior knowledge about popcorn.

Vignette

Each child was given a piece of corn in its seed state and asked to use their five senses to observe it. They were asked not to eat the seed, and to talk about their findings with the person sitting beside them. After a short time of conversation, selected children reported to the whole group their review of the look, smell, sound, feel and taste of the corn seed. T1 then told the children to keep the corn seed and that later they would compare it with some popped corn to see how it had changed.

T1 placed other corn seeds into heated oil in the pan and, to the excitement of the children, the corn started popping. Shrieks of joy and exclamations included: “It’s flying.”, “It’s shooting.”, “It’s gone really high.”, “Catch it!” and, “Look! It’s over there, near the door.” Laughter, continuous excited chatter, and wide eyed amazement accompanied the children's responses as corn popped in the pan or landed in various places around the room. It was observed by E that through engagement, utterances and happy dispositions, the children appeared to be thoroughly enjoying the experience.

When the corn was cooked each child retrieved a piece of popped corn. Again the children were asked to use their five senses to observe the product and discuss their findings with another child. Next, they were asked to compare the popped corn with the seed they had kept, and once more, discuss any changes noticed with the person sitting next to them. Children were again directed not to eat the corn they were investigating but encouraged to taste it by placing it lightly on their tongue. To compensate for not eating the example, children were promised a take-home bag of popped corn. As the children smelled, felt and chatted about their piece of popped corn, EA1 removed the cooking implements and placed popped corn into small containers which were then put in each child’s home-locker.

T1 asked selected children to report to the group comparisons that had been found between the two pieces of corn (cooked and uncooked). Responses included: hard to soft, no smell to good smell, hard to squishy, brown to white, and small to big. T1 insisted these responses be elaborated and thoughtful questioning from her prompted expansive oral language. For instance, if a child said it smells different, that child was asked what it smelt like before it popped and how was it different now. The elaboration was, “It didn't have a smell before it was cooked. Now it smells nice.” One child claimed, “They’re all the same.” Clarification by that child indicated all seeds were small and brown and now they were bigger and white.

In response to the comment, “They're all the same”, T1 challenged the children to use their observational skills and find some proof that they were not all the same. Many “What else?” prompts from T1 encouraged children to make closer observations, yet this appeared to have a negative effect as the children's interest began to wane. Eventually a child pointed out that his popped corn had a sharp piece on it and the un-popped corn didn’t. With renewed interest the children agreed that, although initially smooth, some popped corn had ended with sharp points.

After this observational science session, children dispersed to play in a learning space of their own choice. Follow-up about the corn popping experience did not occur until just before ‘home time’. Children, in a sharing circle, were asked to recall the popping corn along with other occurrences that had filled their time at school. Information offered about the popping corn related to smell, that the pieces “flew up in the air" and that they had some to take home to eat while they watched TV.

Discussion

Coupled with an opportunity to observe the scientific concept of changing matter, this experience was also used by T1 to develop the skill of ‘compare and contrast’. Initially the children were very keen to be a part of the activity and appeared to be interested in and enjoy the experience. Given the health and safety issues related to investigations involving heat and hot oil, and the unpredictable nature of young children, a certain amount of regulation was required (and observed) during the process of this structured investigation. The ability of the children to describe the popcorn in detail indicated that prior teaching had included elementary scientific skills associated with observation and compare and contrast.

Integrated with science communication, skills relating to oral language and reporting were developed during this investigation through brainstorm, open ended questioning by the teacher and discussion that involved children providing and sharing information. Building the skill of oral language to enhance science literacy was demonstrated when T1 insisted that children provide "full sentence answers" to describe changes and report their finds. For example, rather than T1 accepting “it’s different” for an answer, children were invited to extend their responses, pay closer attention to detail and recall differences before and after change. This led the children to making detailed oral comparisons, such as "It didn't have a smell [before it was cooked] and now it smells nice." For some children this interaction presented opportunities to rehearse observational and reporting skills. However, in the large group situation not all children were able to participate in the teacher-led discussions. The concept of heat causing change was overlooked in the discussion that focussed on differences noticed before and after the corn was cooked.

The children in Case Study 1 were encouraged to participate through peer discussion, making careful observations of the corn, and responding to open ended questions posed by their teacher. At no time were they invited to ask their own questions about the corn in either its popped and un-popped state, yet questions asked by children reveal what interests and puzzles them (Fleer & Ridgeway, 2007). Therefore, the prospect for children to satisfy any individual curiosities, or redeveloping their thoughts to modify their current understanding of the scientific processes, appeared to be lost. It was also observed that while some children demonstrated self-regulation and remained on task, others lost interest early in the experience. Others still, seemingly had difficulty engaging in directed tasks. When children's interest is stimulated and content knowledge is known (and ready to be built on), discussion with a more knowledgeable other has the potential to enhance learning through the use of the zone of proximal development (ZPD) (Vygotsky, 1978). However, as each child has a learning need, and therefore an independent ZPD, meeting the range of needs can be a challenging task for the educator.

Although an every-day experience was provided, evidence from this 'one-off' lesson suggested that an opportunity to construct a scientific concept associated with cause and effect, or that heat was used as a change agent, was absent. By lesson's end, only some children had either presented their prior knowledge or reported observed changes. Also, when children, selected from the whole group were asked to orally recall the experience, later in the day, they appeared disinterested and, even with prompting by T1, were still unable to elaborate a recollection. It appeared that while selected children were able to orally report their findings during the experience, they found it difficult to recall details of the action later in the day. As a form of explanation about the lack of recall, T1 revealed that children became so busy during the morning that they often forgot many of the things they had done. T1 also indicated that it was not possible for everyone to contribute their findings, and that the dangers of the hot pan and immediacy of the action of corn popping did not provide opportunities for all children to be interactive (Casual conversation, T1, 11.08.08).

When asked about the nature of what appeared to be a one-off lesson, T1 clarified that the group had, over three weeks, experienced three lessons to investigate change. These were: making jelly, adding warm water to flax seeds, and popping corn (Casual conversation, T1, 11.08.08). Although the corn experience was a part of a sequence of intentional experiences to witness change, there appeared to be no connection for the children between the sequences of lessons to create a pathway to develop the concept of change. The lesson related to corn, for example, occurred some weeks after the other experiences and was presented in isolation without a precursor or follow-up session to develop the scientific concept of change. The impression was taken by E that it would have been difficult for some children to have made connections between the experiences, gain deeper understanding of the components of the investigations, or advance conceptual knowledge.

Although T1 acknowledged that teaching science "is vitally important", when asked about concept development she revealed a lack of confidence due to not having a background in how to formally teach science. T1 explained,

> "I am not trying to get to something like 'heat leads to a change in state'. I don't care if they know that just now, I really just want them to see that we can act on things and it brings about a change, and that's [the activity] what's interesting."
>
> (Semi-structured interview, T1, 13/08/08)

T1 reasoned that if she were to give the children the answers then they simply learn to repeat information, "but that doesn't mean they understand what's happening." The goal from T1's point of view was to get children to wonder about things, ask why things happen, and other related questions that would lead to new learning.

> "I just like to get excited with them [the children] rather than being seen as the deliverer of knowledge and information, so I think I'd get uncomfortable if I have to manipulate the situation too much, to get what I am looking for" (Semi-structured interview, T1, 13/08/08).

Fleer and Robbins (2003) argued that when children are able to direct some of their own scientific investigations and discuss findings, learning becomes meaningful. This situation did not occur in Case Study 1 because the learning experience was controlled by the teacher. For example, questions were not invited from the children. Also, without follow-up activities associated with this experience, the different capabilities of children and variances in their learning styles were not catered for. Had an independent learning centre, with magnifying glasses, fine pens and paper, measuring implements, and containers (some filled with corn seeds and some with popped corn) been provided for children, they could have extended learning with further investigation through play.

With free investigation and an opportunity for self-directed learning, observations could have been enhanced with still pictures (or provided via DVD) of farmers and fields of growing corn, having real ears of corn and corn seeds for planting. Other activities could have included small groups of children cooking corn (to attend to individual curiosity), the use of magnifying glasses to gain detail of corn seeds and popped corn for fine line drawings, plunging hands in and out of containers of seeds to produce sensory experiences, and spooning and pouring the seeds to observe fluidity and movement. Seeds could also be measured and counted, drawn or glued in patterns in either cooked or raw state. A sequence of drawings produced that retold the story of cooking corn would have helped embed scientific concepts being developed. Had those drawings included the electric fry pan, heat could have been discussed. Also, photographs of the investigation, used with captions offered by children, would help them to recall the event. Contained within small take-home-reading-books, photographs of the experience would then be integrated with other areas of learning and shared with people outside of the classroom, thus developing a deeper understanding of the process and result of the investigation.

Key findings in relation to the research questions

In relation to the learning and teaching of science, Case Study 1 revealed that, although an opportunity to develop a science concept about using heat to change matter was presented to the children, their learning appeared to be limited. This conclusion is drawn because later in the day, when the children were asked to recall popping corn, they were unable to convincingly recollect the experience. It is therefore interpreted that because engagement for the children was restricted to directed observational moments and controlled responses, they were not more fully engaged.

The one-off controlled learning and teaching experience presented in Case Study 1 was inconsistent with a socio-cultural approach, mainly because of the limited engagement children had in their own learning. Their participation with others, and the lesson's adherence to a structured time-table, appeared contrived to suit this teacher-led science lesson, rather than to engage the children in an interactive social learning experience consistent with a socio-cultural approach.

For the future enhancement of a science investigations, such as the example in Case Study 1, a link between what the children already know and new information is an essential part of pedagogy (Epstein, 2007). Although children's prior knowledge about pop-corn was gained through questioning, the children's responses were not developed and opportunities for them to ask their own questions, to extend current knowledge, were limited. In conjunction with a point made by Papic and Mulligan (2005, p. 215) that "…science learning does not occur as an isolated process", opportunities prior to, and after the popping corn experience would have enabled children to connect the new experience with what they already knew. Lead-up and follow-up strategies could also have been employed to acknowledge the various learning styles and capabilities of children with different background information and experiences. These additional experiences can add meaning and connection to new learning.

5.5 Case Study 2: A sound difference

Introduction and context

'*A sound difference'*, is the second of three case studies derived from ELC1. Three focus children, given pseudonyms of Sound Boy1, Sound Boy2 and Sound Girl, construct their own learning apart from other children in ELC1. T1 and EA1 were both in attendance at the time this case study was assembled: T1 was conducting a guided teaching session with four children while EA1 supervised the other 12 children, engaged in self-directed learning. Data were collected from passive observations and casual conversations between E and the focus children. Notes added to the field research journal were discussed and validated in a follow-up visit with T1.

Children in this class had recently been engaged in a series of music lessons. These included the testing of sound made by using rubber and wooden mallets to create rhythm, and learn that the pitch of sound can be changed. The three focus children were playing in a learning space defined as the Block Corner. Observations of this investigation, taken during self-directed play time, are coupled with a later session called the sharing circle. The sharing circle is a strategy used in ELC1 that offers children a time to report to class-mates their news, actions and achievements of the day. These reports are recorded by the teacher and shared with parents, by means of a notice board, at the end of each school day.

Vignette

Playing in the Block Corner the focus children were observed using rubber mallets to strike a range of sizes and shapes of wooden construction blocks. This self-directed activity saw the children occasionally singing songs and making up nonsense rhyming words to accompany the beat they created. Mostly, however, they were comparing the sounds made when striking different blocks. Conversation was loud and dotted with laughter as comparisons about the sounds were being discussed. Every now and again, the three children stopped talking and laughing to listen carefully for differences in the sounds they made. In turn the children compared these differences, each trying to prove or disprove another's opinion about the sound produced. Sound Boy2 discovered that by striking the hollow wooden blocks (as opposed to solid blocks) a "better" sound was produced. He demonstrated and the others agreed. They also conferred that different shaped blocks produced different sounds. Sound Boy1 then told his friends he was making different sounds with two blocks that were the same. The blocks appeared to be the same shape, size and texture (observation by E).

When T1 announced "pack away time," Sound Boy1 remained with the two blocks he considered to be identical in shape and size yet each producing a different sound. He seemed engrossed in his work and continued to strike the blocks one at a time and, with his ear close to the blocks, would listen for results. He was oblivious of the hub-bub as the rest of the class noisily packed away resources they had been using. Finally T1 reminded Sound Boy1 to put the blocks away and to join the class in the sharing circle.

At the sharing circle the teacher asked the assembled children, "What did you learn this morning that we can put on our notice board to tell our parents?" The following conversation took place:

Sound Boy1	When I hit two of them with the gong they made different sounds.
Teacher	What did you hit with the gong?
Sound Boy1	The blocks.
Teacher	That was one big block and one small block was it?
Sound Boy1	No. They are the same. The small ones.
Sound Girl	They are both small but different.
Teacher	What do you mean they are small but different? Do you mean the size is different?
Sound Boy2	Yes. They are small but different.
Teacher	How are they different?
Sound Boy2	At the top.
Sound Girl	No. At the side. They are different at the side.
Sound Boy2	If you hold them like this, it's the top (demonstrates without the block)

Teacher	Let's test Sound Boy1's learning. Go and get the blocks and the gong [mallet]

While the focus children retrieved the blocks and a rubber mallet, other children in the group displayed curiosity and discussed possibilities. They also offered advice to help solve the conundrum. Once the blocks and mallet were assembled the report continued:

Teacher	Those blocks look the same to me. How are they different?
Sound Boy2	See? The top.
Sound Girl	No. The side. It's different on the side. See?
Teacher	Let's all have a look. What do you think? (To children who had gathered around for closer scrutiny)
Chorus	Same! Different! Hit it!

Children with the blocks then demonstrated a very slight difference in sound to their class-mates. They also pointed out that although the blocks appeared to be the same size they were in fact marginally different, and this they concluded made the sound different.

Discussion

This vignette offered an example of a scientific concept being developed through play and self-directed learning. During a cooperative group investigation three children applied their own structure to test and gain information. Through the use of prior experience, observation associated with aural and visual senses, planned physical application, prediction and verbal interaction the children clarified ideas and explained their discovery. Astute preparation of a play space by T1, and appropriate resources, enabled these children to develop an interest, transfer earlier learning and create scientific insight, albeit through an unplanned investigation.

Transference of learning was demonstrated as the children, who had been studying changing pitch for the previous two weeks, continued their music lessons according to their own agenda. By chance and meticulous testing, they discovered that even the smallest change in the construction of like objects could alter the pitch of a sound when tapped with a rubber mallet. Through a shared interest, Sound Boy1, Sound Boy2 and Sound Girl extended their own learning by coaching each other. When T1 asked the children to explain their findings more fully, she engaged their ZPD to help them become better informed about their discovery.

Without hindrance, self-directed play enabled Sound Boy1, Sound Boy2 and Sound Girl to work collaboratively and effectively learn with familiar resources in a context that made sense to them. Using prior knowledge, they tested and defined ideas connected to previous lessons, rehearsed communication skills, composed their own tunes and accidently expanded their intellectual understanding about music through discussion and investigation. T1 then provided further opportunity to instil and share new knowledge with class-mates. Skills augmented by the focus children during the verbal reporting of their findings included peer tutoring, sequential thinking and effective communication. Working like scientists Sound Boy1, Sound Boy2 and Sound Girl concentrated on the task at hand, persevered with their investigation, processed their ideas during the testing phase of the investigation, made predictions and consolidated their findings before reporting the outcome.

This vignette provided evidence of young, self-motivated children who moved their scientific curiosity through inquisitiveness and testing, then corroborated their findings through reporting to others. Observed communication and observational skills demonstrated how play offered for these children a medium to consolidate their learning.

Key findings in relation to the research questions

Case Study 2 exemplifies small group, play-based and self-directed learning to develop a scientific concept. The effective placement of loose objects in an unexpected location stimulated the curiosity of children in Case Study 2 and led them into a self-directed investigation. The children collaboratively worked ‘like scientists’ as they investigated, deliberated, tested and retested their ideas to find a resolution and advance their own learning (Foreman, 2010). The circumstances in which this investigation took place suited the playful, social and interactive methods that children use as they respond to their learning environment (Greenman, 2007). Also, the effective use of time and support offered by the educator in the sharing circle enabled the children to bring their investigation to a conclusion. This action represented effective pedagogy.

The provision of meaningful resources and supportive interaction legitimised this investigation by the focus children, and reflected socio-cultural theory. The interactions of the children and the educator exemplified participation within a community of learners who share information and acknowledge the importance of collaboration. Science learning was enhanced when guided learning and sufficient time to investigate was provided for the children to satisfy their hypothetical conundrum.

5.6 Case Study 3: "Now can I draw a spider?"

Introduction and context

"*Now can I draw a spider?"* is the third case study taken from ELC1. It involves nineteen, 3- and 4- year old children and T1, a parent (P1) and E as educators. The case study describes a science learning and teaching experience (called Magic Milk) that is constructed in two parts. The first part, in which E took a passive observational role, describes a one-off, teacher directed experience for the children in ELC1. The second part, sees E as an active participant during the recall and reporting of the first part of the lesson. Data were collected and recorded from observational notes and supported by a semi-structured interview between E and T1; casual conversations with T1, the children and P1.1; and artefacts created by a four-year-old girl with the pseudonym, Spider Girl. After the lesson described below and during a one-on-one guided teaching session, the conversation presented in this case study was recorded by E in point form and elaborated immediately following the incident. This particular case was discussed at length with T1 during the field visit, with the study supervisor, and again with T1 on a follow-up visit to validate the observations made.

Children in ELC1 had been following a theme of 'colour', a part of which included mixing prime colours to create new hues and shades. After reading in a children's science book about an investigation called 'Magic Milk' that highlighted mixing colours, T1 chose to include this investigation in her learning and teaching program. The investigation called for food colours to be added to a small dish of milk and, using detergent as the active agent, disperse and mix the food colours thus making different colours. It was predicted by T1 that this investigation would be messy therefore it was to be conducted in an outdoor learning environment. A table, covered with a plastic sheet, was placed on a grassed area adjacent to the climbing equipment that reached above a sand-pit. Beside the table was a chair for the teacher and four smaller chairs for the children. On the table was a tray with implements and ingredients for the experiment. Implements included saucers, eye-droppers and cotton buds; ingredients were milk, food colouring and dish-washing detergent.

The procedure for Magic Milk had five steps: pour a small amount of milk into a saucer; use an eye dropper to add one drop of each of three different food colours onto the milk; dunk one end of a cotton bud into detergent; place the cotton bud with detergent into the milk; and observe the immediate change when the surface tension of the milk was broken. Prior to commencement, T1 explained to E and P1.1 (who were observing the activity) that, due to the underdeveloped fine motor skills of children in ELC1, each step required adult assistance.

Seated at the table, four children were told to wait their turn and, one at a time, each was guided through the process of the activity by T1. The fine motor skill required for using the eye dropper was a challenge beyond the capability of most children. As a result colour was squirted onto the milk rather than being applied, one drop of colour at a time, as instructed. With each new group of children the excitement was observed as palpable as they waited to be involved. However, by the time the last child of each group of four had their turn, interest had waned. This was indicated when the fourth child of a group tended to rush through the steps without waiting for guidance. One child, who had observed the experience over the shoulder of another, refused to come to the table and join in. When T1 asked why he did not want to participate, the child replied, “I want to play.”

While four children participated in the Magic Milk investigation, another group of four children was brought to the table by EA1 to wait their turn ‘to be scientists’.

Meanwhile, the other 11 children in this class of 19 were playing freely in the playground. The playing children were using climbing equipment, a slide, tricycles or digging with small spades in the sandpit. Water play was also being used to practise pouring and measuring, or to transfer water from the trough to a bucket by means of absorption through the use of a sponge.

During a casual conversation while setting up the investigation, T1 acknowledged that reporting this activity, due to a diversity of capabilities, would prove to be difficult for many children in the class. Ideally, T1 said, she had wanted to provide a challenge for the more capable children and collect evidence of learning for the children's portfolios. Each child in the class owned a portfolio that contained annotated work samples and photographs that evidenced learning and products. These portfolios were used to report learning to children's parents (casual conversation, T1, 20.08.08).

Vignette

After the investigation and back in the classroom, E initiated a conversation with Spider Girl. The conversation was designed to find what had been learned from the Magic Milk investigation. At first, Spider Girl was unable to explain the process or an outcome. However, under guidance (and perseverance) Spider Girl agreed to draw the sequence of events that described the Magic Milk investigation in four steps, but only if she could draw a spider. The following conversation between Spider Girl and E elaborates:

E	What did you do with the milk and food colours?
Spider Girl	I don't know.
E	Think about the bowl of milk and the colours you put in with the eye-droppers – what happened?
Spider Girl	They got mixed.
E	What mixed?
Spider Girl	(Rolls eyes to ceiling) – You saw it, they mixed.
E	So I did. I can't remember which colours you put onto the milk. Can you?
Spider Girl	Yes. Red and yellow.
E	Any other colour?

Spider Girl	And blue.
E	What made the colours mix?
Spider Girl	The milk was magic
E	Really? What makes it magic?
Spider Girl	I don't know. It was just magic milk.
E	Did you do anything to make the colours mix.
Spider Girl	I dropped the colour on with the things. I already said that.
E	What did you drop the colour on?
Spider Girl	The milk! I said that too.
E	Is that all you did to make the colours mix?
Spider Girl	No.
E	What else did you do?
Spider Girl	I mixed it with a stick. The white stick.
E	A white stick? Was there anything special about the white stick?
Spider Girl	No. My mum cleans my ears with that.
E	Did you put anything on the stick before you put it into the milk?
Spider Girl	Yes. It was yellow.
E	What was yellow?
Spider Girl	The stuff. In the jar
E	What was that stuff called?
Spider Girl	I don't know.
E	Why did you put yellow stuff on the white stick?
Spider Girl	[My teacher] told me.
E	What happened then?
Spider Girl	The milk colours. All them swirls. And yukky colours.
E	Tell me about the swirls.
Spider Girl	The colours kept moving around and around and then got all mixed.
E	What colours could you see?
Spider Girl	Green, I think. And pink. And was there purple? No grey.
E	But they are not the colours you put into the milk. You told me you put yellow, blue and red colours in the milk.
Spider Girl	That's the magic. They change.
E	Would you like to draw what happened for me now?
Spider Girl	Alright. Can I draw a spider too?

E — I have four sections on this paper. Can you draw what happened first, in this square? (Points to section (a) Figure 5.1)

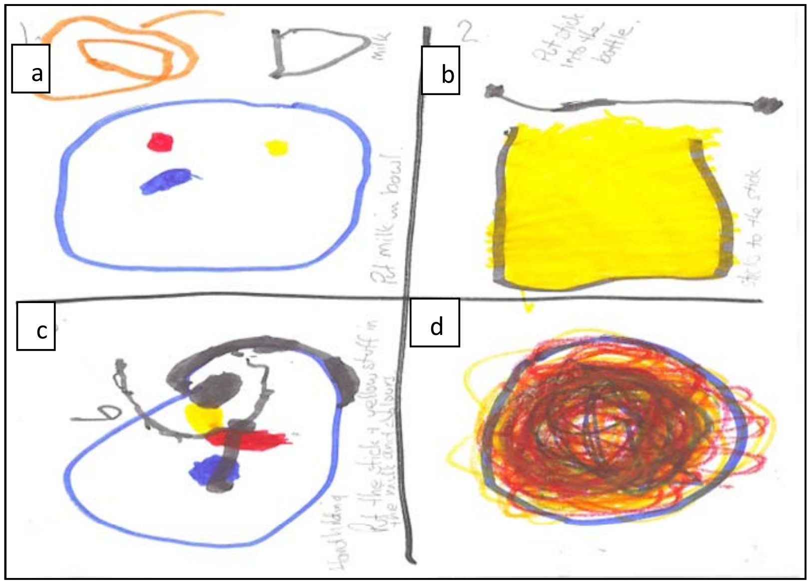

Figure 5.1 Spider-Girl's representation of the Magic Milk sequence

a Put milk in the bowl
b Put stick into the jar
c Put the stick with yellow stuff in the milk to mix the colours
d Finished!

Spider Girl — And can I draw an elephant on there too? I can draw spiders.

E — I think you must be a clever artist. I wonder if you could draw the bowl that your teacher put the milk in?

Spider Girl — I haven't got white to draw milk. You need white. I'll use grey.

E — Good idea. Can you put the colours in too? Well done. What happened after you dropped the colours onto the milk?

Spider Girl — Where will I put the stick?

E — Let's put that in this square. (Points to section (b) Figure 5.1)

Spider Girl — Look this is the yellow stuff. It's in a jar. That's a jar, j-ar, jar. (Using the strategy, onset and rime, Spider-Girl spelt the word)

E — I wonder what the yellow stuff is called.

Spider Girl — I told you I can't remember.

E — I think it is called detergent.

Spider Girl	I don’t think so. Maybe. Was it?
E	I remember your teacher said it was what mummy used to wash the dishes.
Spider Girl	Mummy doesn’t wash dishes. She's got a dish washer.
E	OK. Now let’s draw where you put the stick in the milk and the colours. (Points to section (c) Figure 5.1)
E	What happened after you put the stick into the yellow stuff?
Spider Girl	The colours swirled and swirled and mixed all up. When I finish can I draw a spider? (Three coloured crayons at one time and in a hurried, careless fashion, were applied in a concentric motion in section (d) Figure 5.1)
E	Wow! Look at all those swirling colours. You’ve done very well. May I keep this diagram that tells me how you made the colours mix?
Spider Girl	Yes. Now can I draw you a story with a spider? A spider's got eight legs y'know?
E	I would love to see that.

The story Spider Girl then told was about a spider that found a pear and wanted to eat it. The pear did not want to be eaten. So the spider gave the pear eight legs to be like him, then they could both run fast. See Figure 5.2 for her drawing.

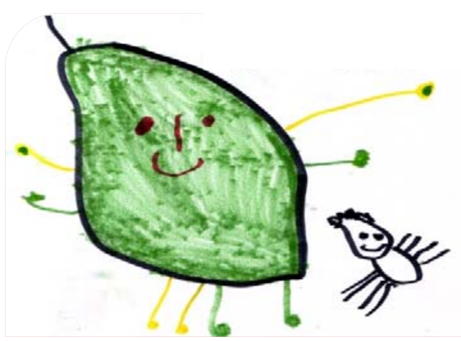

Figure 5.2: Spider Girl's drawing of the spider story

Discussion

Without an introductory discussion about the Magic Milk investigation, prior experiences, interest and enthusiasm of the children did not appear to be taken into account. During the experience, children were neither asked to predict an outcome of the investigation nor invited to ask questions. No scientific explanation was provided for the children regarding surface tension, properties of milk, nor the possible action of detergent on milk. Questions asked of T1 were generally ignored; for example, when one child asked, "What's this yellow stuff?" T1 replied, "That's the magic ingredient." Children were not told that the “yellow stuff” was detergent. To those children wondering what was being prepared, they were told (by T1) they would be using eye droppers, "just like scientists."

Although using eye-droppers, working like scientists and the concept of magic was used as a form of motivation, the novelty factor was short lived. The children seemed to enjoy the idea of Magic Milk, yet seemed perplexed about the activity and became disengaged early in the experience. Indeed they seemed to focus on activities at the sand pit and water trough, rather than engaging in the science investigation.

Arguably, due to distraction, and the controlled nature of the experience, the perceived excited curiosity that children brought to the investigation quickly evaporated. Contrary to the recommended action of Fleer and Ridgeway (2007), these children had not been given the opportunity to relate to the nature of an investigation, build on their present knowledge and engage in a social, interactive way. Therefore, possibly due to a lack of understanding, the curiosity that was engaged at the beginning of the experience was not sustained throughout the session. When asked their thoughts about Magic Milk, the responses from a small group of children included shoulder shrugging and bewildered replies such as, “dunno” “magic” or unrelated information such as, "I poured water in the bucket". Disengagement from the activity continued to be displayed later in the day by Spider Girl who appeared to be hampered in making meaningful connections with the Magic Milk investigation.

During a discussion between E and T1 about the novelty of the Magic Milk investigation and E’s perception of loss of interest by children, T1 explained that she was more interested in children just observing how things happen so they could enjoy the ‘wow’ moments of an experience and exercise wonder. Also, T1 felt the children had enjoyed the ‘wow’ factor about this experience, and that was what they would remember (Casual conversation, T1, 20.08.08). During a semi-structured interview prior to this investigation, T1 reflected:

> "They [the children] are too young to be troubling them with scientific facts that are beyond their comprehension. I mean, although I am very interested in science, I don’t know a lot about science facts. And there is a part of me that doesn’t really care why it's [the result] 'wow'. To me it is important for kids to know that something's just happened. They can't be expected to worry about how and why just now. Kids at this age particularly I don’t know that I feel I need to teach them concepts or explain things to them. There's time enough for them to get that."
>
> (Semi-structured interview, T1, 13.08.08)

T1 explained how the Magic Milk experience benefited the children as it exposed differences in language development and fine motor skills that could now be addressed.

> "Everything we do provides opportunities to improve language and fine-motor skills. I think at [in] Pre-Kindy particularly, there is such a huge range of difference in developmental levels... you have some kids who ... are very limited in verbal skills and some have had limited exposure to ... exploring things."
>
> (Semi-structured interview, T1, 13.08.08)

From this explanation, it appears that although a scientific investigation was provided, opportunities to develop skills related to fine motor and language rather than science concepts were perhaps the underlying aims of the science lesson. It could be argued however, that these skills would have been more easily and enjoyably acquired by the children during the unstructured play that was happening at the same time as the investigation, especially if eye-droppers had been included in the water play. While the colours mixed by the children were mostly given their correct names and recorded observations provided details of the process, as shown in Spider Girl's sequential drawing (Figure 5.1), the process of the investigation was teacher directed with minimal engagement by the children.

Where some eager-to-please and capable children easily drew the sequence and gave succinct verbal accounts of the process, others struggled to provide an intelligible response to requests. This outcome did not surprise T1 because she was aware of the diverse capabilities relating to physical development and attention span, of children in the class. However, all were expected to try to produce a recount of the event, as evidence of their learning and ability (Casual conversation, T1, 20.08.08).

During the second part of this case study, a conversation with Spider Girl relating to the sequence of investigating Magic Milk indicated that her recall of the investigation was not easy, although she appeared to be a bright girl with a solid knowledge of vocabulary and emerging literacy skills. Notwithstanding the fantasy attached to her story about a pear and spider, it included the biological facts that a spider has eight legs and that a pear did not have legs. Further, her theory was that in order to run fast, more legs and feet were required. She therefore allotted both characters in her story the same amount of legs "to make it fair". Even if she did not recognise her knowledge as scientific, spiders (and pears) were relevant in her life and provided an opportunity for scientific knowledge to be extended.

Although Spider Girl was more interested in drawing a picture to tell her own story than addressing the task at hand, she did notice that changes had occurred in the set activity, and with prompting, achieved the report required by T1. Overall, Spider Girl was not sure why the colours mixed but guessed it was the detergent and, to make her explanation of the process more meaningful, she recalled prior experiences of cotton buds and dish washing. Prior experiences and current knowledge did seem to be useful in that it helped her expand her knowledge about the uses of every-day objects (cotton buds and detergent) and thus new understandings about varying their use.

Taken from a book written for primary-school-aged students and to inspire science investigations at home, it appeared doubtful whether the Magic Milk investigation helped the children in ELC1 acquire solid scientific information. The purpose of the lesson was explained by T1 as another opportunity for the children to see how colours mixed. When asked about the appropriateness of the investigation for these young children, T1 explained thus:

> "To me it's very much an immersion thing. Giving them the answer isn't necessarily going to help them out. And, I am not trying to address concepts. I just want to give them as much as I can and you know if it's interesting them, then we'll go with that. Let's explore, I say. Let's take a risk. Let's enjoy it... If there is just a right or wrong answer it is going to stifle their ability to think and apply what they are learning. That's why I think it's vitally important at this age...to just do it." (Semi-structured interview, T1, 13.08.08)

As a case study, "*Now can I draw a spider*?" illustrated the structured process of a 'one-off' lesson that appeared to meet the requirements of the teacher rather than the interests of the children. The misleading reference to 'magic' offered when a deliberate question was asked about an ingredient, potentially contributed to fantasy rather than scientific information and raised a concern for those children who did not understand the process. Accordingly, this could have developed a misunderstanding about chemical reactions being 'magical' and impede further knowledge acquisition or construction by the children. Arguably this experience could just have easily left a bigger conundrum for children to deal with later in their schooling.

Key findings in relation to the research questions

The extent to which effective science learning and teaching occurred in Case Study 3 appeared negligible, due mainly to the circumstances under which the activity took place. The children did appear to benefit from observational skills exercised as they watched the food colours change when mixed with detergent and milk, smelled the ingredients, and manipulated the eye droppers and a cotton-bud. However, the pedagogical strategies used during this demonstration science lesson appeared to leave the development of scientific concepts to be incidentally attained. Along with the ‘wow’ factor, the lesson appeared to be undertaken for the purpose of producing a work example for each child’s portfolio. The investigation was conducted without knowledge of the children’s capabilities or their understanding about the resources being used. Further, the area in which the investigation took place caused the children to be distracted, as other children were playing around them. It is reasonable then to assume that the children contributed limited attention to the process.

In Case Study 3, the learning and teaching of science did not appear to be informed by socio-cultural theory. It must be reiterated that educators are not being judged in this study. For example, the children’s cultural knowledge about the resources had not been taken into account. As previously discussed, children are social, active learners with cultural knowledge, and gaining meaningful understanding of the process and outcome of this lesson would have been difficult for them due to their superficial involvement.

This case study highlighted that children’s prior capabilities and knowledge need to be identified and taken into account by the educator, before an intentional investigation takes place. It also highlighted the acknowledged 'position of power' between children and their educators. The teaching and learning in this science investigation would have been enhanced had sufficient time been given for the children to ask questions and familiarise themselves with the resources before the process of the Magic Milk investigation started, and that Spider Girl (and other children) have greater input into science investigations aligned with their interests. Also, guided follow-up activities designed to expand the investigation could have provided opportunities for children to further understand the instruments used, the science processes and concepts associated with this activity.

5.7 Case Study 4: "They're not toys!"

Introduction and context

On the morning that data were collected for Case Study 4, a new learning space called the Nature Table had been added to the ELC3 classroom. This learning space, set up in an area removed from the main part of the room, contained a collection of natural objects including a variety of seed pods, leaves and bark. T3 advised that the space included child sized chairs to encourage children to sit and play with the collection. When parents brought their children to ELC3, they took them to the new exhibit, modelled curiosity and pointed out features of the objects to their children. No objects, however, were touched. Later in the morning, while 13 children from the class joined T3 for story time, E was asked by T3 to guide the focus children, Nature Girl and Nature Boy in an investigation at the Nature Table with a view of developing the scientific skills of observation and classification.

Photographs were included in the data collection for Case Study 4 ("*They're not toys!")* to provide a durable reminder of the experience and enable a considered response to the activity. Along with Field Notes made during the construction of the case study, these photographs were discussed with other educators.

Vignette

Although slightly curious, Nature Girl and Nature Boy did not appear keen to touch or play with the natural objects they described as "dirty" and "not toys." During an initial discussion, the children revealed to E that although some objects were familiar, they had had minimal experience with items that had been incorrectly assumed (by both E and T3) to be 'every-day' objects.

A discussion, initiated by the children, revealed to E they were troubled about safety and hygiene. Specifically, the children were concerned about dirt on the seed pods and biting insects that might be living inside the objects. To address this unexpected concern, E introduced the children to the objects by using, as puppets, two gum-nuts (seed pods). The gum-nuts told a story about the purpose of the activity, pointed out some obvious features of seed pods, and convinced the children the activity was safe.

When the children were comfortable to be involved they were invited to each select a seed pod and challenged to find two features of their chosen example. The responses of Nature Girl and Nature Boy related only to colour and a hole in one of the pods. Next, the focus children were directed to use observation skills associated with the senses of sight, smell, touch and sound to find differences between two examples (e.g. a gum nut and a pine cone). Their reticence to handle the objects continued for two reasons. First because they retained the belief that biting spiders lived inside the pods and second, they wanted to learn to read. To elaborate, they asked “Why are we doing this when the others [children] are learning to read” (Casual Conversation, focus children and researcher, 06.03.09)

To boost their confidence and encourage participation, E gave the children an explanation about the uses of classification and more time to become accustomed to the collection. Also, labels were written that named the objects so the children could ‘read’ them. Once the children were comfortable to handle and give closer scrutiny to the objects, they were asked to sort the seed pods into two groups: big seed pods and small seed pods (Figure 5.3). When the collection of big seed pods were separated from small seed pods, according to their own definition of 'small' and 'big', the children were asked to reclassify one of these groups using the same criteria: big and small (Figure 5.4).

Figure 5.3

Nature Boy compares size of pods

Figure 5.4

Nature Girl reclassifies pods

Next the children were asked to make their own classifications. Nature Boy decided to put all the pods with 'sharp' edges into a group (Figure 5.5) while Nature Girl sorted pine cones from the rest of the collection (Figure 5.6).

Figure 5.5

Nature Boy sorts pods with sharp edges

Figure 5.6

Nature Girl sorts pine cones from other seed pods

The objects that had earlier been rejected by the focus children now appeared to be handled with interest and confidence.

Rather than re-joining the rest of the class for the next session with T3, Nature Boy and Nature Girl remained with E and continued, in a playful manner, to sort the collection of natural objects according to their own rules. With freedom to play, they manipulated objects and serendipitously extended their classification skills. Nature Boy put long leaves end to end to represent the outline of a track for his 'bark train' to travel on, while Nature Girl imagined palm bark to be a boat and sailed it on her sea created of leaves and a table cloth.

Discussion

The initial reluctance by Nature Girl and Nature Boy to become engaged in the study of natural objects appeared to be caused by their cultural perception that the objects were dirty and not to be played with. Had the children been involved in the collection of those objects, from their natural location, their prior knowledge may well have provided a better starting place to establish new information. However, once initial fears abated and the experience progressed, these children became uninhibited, relaxed and interested in the science of classification. As a passive observer, E noted that Nature Girl and Nature Boy discussed possibilities and exhibited sustained shared thinking. Also, an intellectual relationship seemed to grow between them and they each playfully helped the other in their ZPD. Developing confidence through collaborative, playful learning the children asked questions of each other and of E, solved problems, made critical choices and acknowledged the other's opinions. These actions rehearsed and expanded cognitive development. Designed to enhance the scientific concept of classification, the focus children appeared to achieve the objectives of this session by means of a guided teaching, practical experience, playful interaction and trial and error.

During discussions about the benefits of investigative science activities for young children T3 explained, “I don’t feel confident teaching science to young children… and I don’t ever remember learning science in primary school” (Semi-structured interview, T3, 13.03.09). Yet in a conversation immediately after this activity, T3 acknowledged that guided play and intentional teaching had helped the focus children build their knowledge and successfully develop the basic science skills of observation and classification, and reading the names of the objects. T3 added that she felt the children’s language base had also expanded as a result of their engagement with the natural objects (Casual conversation, T3, 06.03.09).

The aims of the lesson were extended by the children as they went on to consolidate new knowledge and playfully create patterns, alternative classifications and new names for the objects. While engaged in their learning, Nature Girl and Nature Boy displayed persistence, humour, curiosity and skills of communication. The interconnectedness of learning was evident, from the children’s point of view, when they informed E of their prior experiences and knowledge related to trains and boats. Additionally the interconnectedness of learning and teaching was elaborated by the educator T3, when she conducted a follow-up lesson to develop language through the use of classification, using found materials.

Interwoven with intentional teaching and guided play, the social skills of self-regulation, conversation and being mindful of the rights of others were noted as the original classification experience progressed. Arguably these skills supported social-emotional development and enabled the children to make predictions, and explain their actions, as they exchanged information about patterns, labels and descriptions of pieces chosen. It was also helpful during a language lesson that indicated transference of skills from the nature table to another lesson.

Key findings in relation to the research questions

Interpretation of data gathered in Case Study 4 indicated that effective learning and teaching occurred, mainly because the learning environment appeared to be attuned to the needs and experiences of the children involved. The opportunity provided for children to address their fears prior to the investigation acknowledged the children's prior knowledge, attitudes and capabilities, and supported their learning.

The caring context within the classroom of ELC3 reflected an environment that showed signs of being informed by socio-cultural theory. "I guess I don't know enough about learning for these littlies yet, but we are learning together and it is important that I help them settle into school and socialise before I expect too much. It's slow but it's a big move from home to here" (Semi-structured interview, T3, 13.03.09). As such, children's developing needs were addressed and enough time was provided for the children to successfully gain new knowledge. T3 recognised that nurturing and confidence building were the essential starting point for these younger children before quality learning could occur.

Learning could have been enhanced had additional resources been added to the Nature Table. For example, the addition of magnifying glasses to observe detail and paper with fine-line drawing pens to record images the children saw. Also, had the Nature Table been left in the classroom for a longer period, learning would have been extended. It was revealed to E on a follow-up visit that, under pressure from parents who were concerned about cleanliness and the unsuitability of the natural objects (because some children had renamed and used the pine cones as imaginary hand grenades), that EA3 had discarded the objects and dismantled the learning space.

5.8 Case Study 5: "Uh-oh, wet shoes!"

Introduction and context

"*Uh-oh, wet shoes*" is the second of the two case studies drawn from ELC3. This particular experience occurred in the outdoor play-ground area of ELC3. As instructed by T3, EA3 placed on a concrete area a water trough half-filled with water. Resources placed alongside the trough included toy boats, shell moulds and two child sized buckets (one smaller than the other) for the purpose of a science activity related to pouring and measuring water. T3 advised E that as the equipment was new extra time was required by EA3 to prepare it for the activity. All new items were plastic and had to be removed from their wrappers before this session began. Resources included long-sleeved plastic aprons for the children to wear.

The instructions from T3 (to both EA3 and E) were that the children could "mess about pouring water, filling small containers and counting the amount of times it took to fill a larger one [bucket], and they could also find what floated and what sank" (Casual conversation, T3, 27.03.09). The children were not party to T3's instructions but were told they were going outside to play with the water. The focus children appeared to be exceptionally excited about being involved in this activity. EA3 dressed them in their aprons and told them to put the toys into the water. EA3 had also asked them to be careful and not pour the water out of the trough. Observational data and short conversations between the children, and the children and EA3, were recorded and a photograph taken during the activity to add to the evidence of engagement.

Vignette

Dressed in their aprons, Water Girl and Water Boy appeared oblivious of anything that EA3 said to them. Instead, they tossed all of the toys into the water and developed a splashing game with a good deal of mirth and excitement. With very little direction or knowledge about the purpose of the experience they readily engaged in spontaneous and free play. When she could, EA3 asked the children to pour water from one container into another and to count the pours until the big bucket was full. Simultaneously, EA3 asked the children to also find which toys floated and which ones sank. The novelty of the experience made it difficult for the children to follow instructions. When this was realised by EA3, her initial instructions were abandoned and she left the children to freely explore the water and equipment (Casual conversation, EA3, 27.03.09).

After a short time the exuberance dissipated and Water Girl and Water Boy began to use the equipment more thoughtfully. Firstly they talked to each other about the experience, as opposed to shouting at each other. Next, they began pouring water from one container to another. It was then that EA3 asked them to remove some of the other toys from the water and try to fill the bigger container using a small container. Water Girl chose a plastic boat as the device to pour water into the bucket that Water Boy was holding. This, however, was unsuccessful.

Although Water Girl painstakingly filled a smaller container with water, emptying it into the larger container was a challenge for her. Although she aimed the smaller container of water at the larger container, the result was disappointing because of the awkward method of pouring being used. Without success, the children soon chose to abandon this activity. They displayed a lack of patience, skill and reason to accomplish the task. Water Boy was overheard asking Water Girl why they were doing this (pouring water). Without further instruction the children tested some ideas for themselves. For example, Water Boy found that by using the larger container to scoop water, it filled more satisfactorily, even if not to the top. It appeared that they could not see the purpose of pouring small amounts of water into the larger container so decided to fill the larger container directly. This seemed a more sensible course of action to Water Boy, as he said, "This is quicker." His idea was adopted and is demonstrated in Figure 5.7.

Figure 5.7 Water boy directly fills the larger container

However, each time Water Boy tried to lift the bucket to see if it was full, the contents sloshed back into the trough, and he was unable to conserve the initial volume of water. After many unsuccessful attempts to fill the bucket to the top, Water Boy scooped water closer to the edge of the trough as if to get the trough's wall to push the liquid into the bucket. His method eventually caused the water to rise over the rim and spilt down the front of his apron, into his shoes. "Uh-oh, wet shoes!" he told EA3. Water Boy did not have the skills to completely fill the bucket nor the strength to securely hold it, when it became heavier due to its load of water. It was also noted that both children tended to pour the water towards themselves rather than away from their body, as they emptied a container.

The floating and sinking activity was not attempted as the allotted time for the activity had expired. The children were each helped to take off their apron and shoes before they returned to the classroom. EA3 and the researcher then quickly tidied up before the next class, scheduled to use the area, arrived.

Discussion

This case study demonstrated five things. First, the curiosity of the children was evident. Second, time to explore newly introduced equipment without interruption or expectation, before the experience, was not provided. Third, prior knowledge or skill capacity did not appear to have been taken into account before the lesson. Fourth, the sharing of the area, that caused the need to vacate it to make room for another group, imposed an insufficient time frame to develop the experience. Fifth, more could have been gained for the study had the researcher questioned EA3 about her expectations and discussions with T3, prior to the activity.

The children demonstrated curiosity when they spontaneously rushed to engage with the equipment in their learning environment. They did not ask for directions or make rules between themselves as they established the useability of the resources at their disposal. The children confirmed, after the experience and in conversation with E, they had played with water at home in the bath and in a paddle-pool. Water Girl and Water Boy also acknowledged there was a difference between playing with water inside and playing with water outside: "You're not allowed to make a mess inside" (Water Girl), "But you can make a mess outside" (Water Boy) (Casual conversation between the children and E, 20.03.09).

For the children to have benefited from this experience an introduction to the resources, knowledge of the children's pouring capabilities, and specific instruction or guidance were required. Without a suitable introduction the focus children were unclear about what they were to do, and their minimal experience could not guide them. These results indicated the importance of the educator gaining the prior knowledge of children, and the value of guided instruction. Time to become acquainted with the resources, the requirements of the investigation, and safety rules were all missing from this isolated lesson.

The experience illustrated the spontaneity of young children and their ability to create their own learning as they developed their own method of filling the container. In later discussions, the children told E about their experience and said it was called "messing in the water with new toys." However, they could not agree on why they were allowed to mess about with the water. From observations taken it was identified that Water Girl and Water Boy did not have the necessary skills to carry out requirements of the lesson. Also, the method used by Water Boy to get the water to stay in the bucket suggested he was still developing the concept of fluidity. It is therefore concluded that these children needed teacher guidance to develop meaningful learning and teaching about the science of this experience.

An area of frustration identified by T3 and EA3 in this study related to the scheduled use of the outdoor-play-area that prohibited prolonged engagement in an activity. Had the children been able to come back to the task at a later time they may have approached it differently. By the same token, however, had more time been spent in preparation for the experience, expectations could have been explained to the children and goals more likely achieved. As argued by Rinaldi (2006), children are interested, attentive listeners when their curiosity has been aroused.

In Case Study 5, it was found that the children changed the teacher's intention of the lesson as they made the most of an unexpected opportunity. The results of the session were not surprising given the children's limited experience with the equipment and the immature pouring skills demonstrated. Along with underdeveloped physical skills, limited social skills, including self-regulation and school rules were exhibited by the children as they ignored the requests by EA3, until their egocentric and immediate needs were met.

Key findings in relation to the research questions

Interpretation of data from Case Study 5 indicates that the effective learning and teaching of science was limited for all participants due mainly to insufficient planning. The circumstances under which the experience was conducted revealed inadequate preparation and engagement by both the children and the educator. First, the learning space selected for Water Girl and Water Boy to develop their science lesson was only available for a limited time, and second, the teacher did not appear to be engaged in this investigation, other than to briefly instruct EA3. The children's immaturity and the superficial role of the educators indicated this experience was a lost opportunity to develop the learning and teaching of science.

In the spirit of how young children engage with the environment and its resources when developing an understanding of their world, Water Girl and Water Boy capitalised on their situation and constructed their own knowledge through social play. A part of a socio-cultural approach was illustrated when the children collaborated to find a meaning in their predicament. However, without the guidance of a more knowledgeable other person, the learning and teaching of science was not informed by socio-cultural theory.

Science learning and teaching outcomes for Case Study 5 could have been enhanced had the pedagogy of effective planning and effective engagement been employed by the teacher. Effective planning would have included detailed information for the EA, adequate time for preparation of resources and learning environment, and gaining an awareness of the children's present capabilities and prior experiences. Effective engagement required an introduction to the purpose of the activity, a time to playfully investigate the usefulness of a limited number of resources, plus a more purposeful exchange of communication between the educator and the children. It is fair to assume that, had these enhancements been considered, the experience could have had more rewarding outcomes for both the educators and the children.

5.9 Case Study 6: Skater Boy

Introduction and context

Skater Boy was the result of a spontaneous construction activity that took place in a transition area in ELC2. As parents moved in and out of the area and other young children were engaged in a variety of activities, the focus child with the pseudonym of Skater Boy set about collecting resources and arranging his own learning space. When other children came too close to his work area he shielded his resources and made it clear he had a job to do. He was aware E was observing his actions, but this did not appear to bother him in any way. Instead, he presented as a confident self-directed learner. Skater Boy informed E he was going "to start school real soon," and then boldly announced to no-one in particular that he was going to build a skateboard.

The mother of Skater Boy told E that her son had been attending this Playgroup for more than two years and was therefore confident in this environment. He knew all the parents and other children who attended Playgroup on the same day as he did and was familiar with the centre's routines and resources (Casual conversation, P2.1, 27.11.08). From a discussion with another adult in the same room, it was learned that Skater Boy had wanted a skateboard of his own after watching older boys ride skateboards in a shopping centre car park. His request to parents to buy a skateboard was denied; however, his father had taken Skater Boy to a shop to show him how a skateboard worked (Casual conversation P2.2, 27.11.08). As a consequence, Skater Boy decided to make his own. To do this, Skater Boy collected resources from another area of ELC2, worked in isolation, engaged in ‘self-talk’ and made his skateboard.

Vignette

3D wooden building blocks, two cylindrical and one rectangular, were retrieved from a play-space that contained construction equipment. Skater Boy then placed the two cylinders, which he called "rollers" under the rectangle that he called the "standing board" and tested his design by trying to stand on top of the construction. He found his prototype unsatisfactory because the cylinders rolled out from under the rectangle and his skateboard collapsed. Not to be deterred, he went back to the box of construction blocks and retrieved more cylinders. Although it was clear that Skater Boy wanted no interruptions, he constantly checked that he had an audience and sometimes offered a short report.

Skater Boy	That one didn't work. I got more rollers.
E	Why didn't it work?
Skater Boy	It needs three rollers, not two. (See Figure 5.8)

Figure 5.8 Skater Boy tests his skateboard with three rollers

The trial using three rollers was as unsuccessful as the first, when two rollers were used. He looked at his skateboard and appeared to consider his next move before he returned to the block box and brought more cylinders to his construction site. The cylinders, carefully spaced out, were placed one at a time under the rectangle, adding to those already placed (as seen in Figure 5.9).

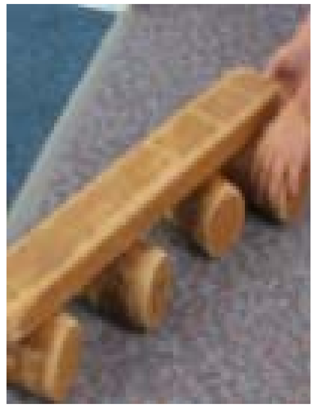

Figure 5.9 Adding and spacing new rollers to the construction

Skater Boy continued to modify his construction. Each time a cylinder was added he counted them all, one at a time, and would announce the new number thus: "I had three now I got four." He was congratulated by E for his clever counting but chose to ignore the compliment and, single-mindedly, continued to construct and test his skateboard. While the skateboard no longer collapsed when tested, Skater Boy recognised a need for something stable to hold onto during the trialling phase. With each new test, he held onto a cupboard for stability and tried to balance on the board. Figure 5.10 demonstrates this action.

Figure 5.10 Stabilising the test

Continuing not to acknowledge his audience, Skater Boy announced, "Look. I've got five now. There's no room for any more. It'd better work now." He carefully stood on the standing board while hanging onto the bookshelf and discovered this time the board did not move too far. He let go of the shelf and raised his hands above his head to prove he had achieved his goal. As Figure 5.11 demonstrates, Skater Boy momentarily balanced on his engineered skateboard.

Skater Boy	Look! Look, it works.
E	Well done!

Figure 5.11 Skater Boy balances on his skateboard.

His smile indicated self-satisfaction but as he bent his knees and pushed down like a real skateboard rider, he felt the skateboard begin to move, so jumped off. Excitedly he asked, "Did you see? Did you see? It worked. Good!" Then, as if it didn't matter, he collected all the building blocks and tossed them back into the block box before moving on to another activity.

Discussion

This case study describes how self-directed play in a well-resourced play space can successfully accommodate the personal learning agenda of children like Skater Boy. With a mix of curiosity and determination plus the use of 'self-talk' he demonstrated sequential thinking as he mentally and physically planned, tested and modified his construction until his goal was accomplished. Self-motivation in an environment where an uninterrupted train of thought and playful learning was encouraged, this boy was able to follow an activity through to its conclusion in harmony with his own needs. During construction of the skateboard, Skater Boy exhibited transference of prior knowledge when he based his design on vicarious information and intrinsic knowledge. Further, he demonstrated a known skill of one-to-one number correspondence by accurately counting the rollers.

It appeared that the curiosity and determination of this young boy was of paramount importance to him as he single-mindedly went through the paces of constructing a skateboard based on personal interest and information he had vicariously and practically collected. In a casual conversation between E and Skater Boy, he revealed, “I can start big-school now because I am big.” And further that, “Big boys ride skateboards” (Casual conversation, 27.11.08). In his sense of being grownup, it was perceived that Skater Boy saw the riding of skateboards was a rite of passage to prove his readiness to go the big-school.

Confident and familiar with the available play spaces and resources Skater Boy was able to test his theory and, armed with adequate resolve, planned and made his own skateboard. Because self-interest was being served, motivation, concentration, determination and self-regulation seemed to come naturally. These attributes were demonstrated throughout this self-directed engineering project. Skater Boy worked alone, collected his own components, planned and articulated through self-talk his thoughtful sequence of action during construction demonstrating cognitive development. Aware of an audience, Skater Boy shared his thoughts albeit without making eye contact or acknowledging others in the room.

Although the words ‘balance’ or 'gravity' were not used by Skater Boy in his self-talk, it was clear he understood what the concept of balance meant. Also evident through observations and conversations was the integration of other learning and clear thinking skills to inform this study. For example, the mathematical concept of ‘adding on’ was both demonstrated and articulated during the process. Thinking was evident when he thought out loud about his sequence of construction, and the evolving trial and error process. Unwittingly, Skater Boy used the “elements of a technology process” as he planned, made and tested, then evaluated and adjusted his model skateboard each time he found fault with an original idea (Curriculum Framework, Western Australia, p. 294, 1998). This formula suggested that Skater Boy was advancing his current understanding and improving knowledge as new skills were attained.

Later in the morning, and in another play-space, Skater Boy was building a ramp. When asked, he said his ramp had to be the right size because he was going to ride his skateboard down the ramp "real fast." His experience in this self-directed construction activity was now being transferred to accommodate further learning.

Key findings in relation to the research questions

The circumstances under which science learning and teaching occurred in Case Study 6 are different in that the educators in ELC2 are parents rather than fully qualified teachers of ECE as in ELC1 and ELC3. Therefore, science learning and teaching occurs as a playful and incidental experience, as opposed to one that is purposefully planned. However, Case Study 6 has revealed much about rudimentary engineering skills of Skater Boy and his knowledge about skateboards. This disclosure is invaluable for his future schooling and demonstrates the importance of transition from one learning unit to another.

Even if the educators in ELC2 were unaware of socio-cultural theory, it appeared to indirectly inform the learning environment for this case study. As children freely interacted with other children and adults, they tested their own ideas, investigated resources, and worked in an environment that acknowledged culture, capabilities and various learning styles. Where the inclusion of conversation with other children was not a feature of Case Study 6, socio-cultural connections were clearly being made between the internal and external thinking processes of Skater Boy as he used self-talk, body language and thoughtfully appraised his own work to demonstrate learning and connect science to everyday experiences.

Skater Boy showed clear signs of intelligence and problem solving skills in his quest to independently achieve his goal. However, it can be argued that the learning and teaching of science in this case study could have been enhanced had Skater Boy been less insular in his learning. Strategic planning by an educator and effective teaching within this scenario could have led to an extension of current knowledge that enhanced an understanding about scientific concepts related to forces, balance and machinery.

5.10 Case Study 7: Warm crayons work

Introduction and context

This is the second of two case studies taken from the Playgroup, ELC2. On this particular day a total of 17 children and 11 adults were in attendance. Case Study 7 (*Warm crayons work)*, relates to Crayon Boy1 who presented as a quiet lad that appeared to want to stay away from the cacophony and exuberance of the rest of the Playgroup. The play space that Crayon Boy1 chose in ELC2 was called the Writing Table and was situated near the centre's kitchen, where his mother was preparing the morning snack for the children. While this activity was observed, smaller children came into the area, either looking for their parents (in the kitchen) or wanting to use the writing table and instruments.

The table at which Crayon Boy1 sat with his younger brother was child-sized with appropriately sized chairs. On that table was a collection of different coloured paper and two boxes: one was containing pencils, the other large wax crayons, most of which had a paper sleeve. These writing implements were available for children of all ages and abilities and, while some items were relatively new many had the appearance of being well used, dull and old.

Two brothers, one aged 2-years-and-3-months and the other 3-years-and-8-months, were being unobtrusively observed by E as they engaged in a conversation with each other about crayons and how to use them. The boys were left to work together and freely engage in a writing activity. In a later conversation with the mother of Crayon Boy1 and Crayon Boy2, she described her eldest son as being a patient and quiet instructor, always keen to help his little brother and explain things to him. And, by contrast, her younger son, "…was by nature a handful who couldn't sit still for long" (Casual conversation, P2.2, 23.10.08). This comment was evident when Crayon Boy2 lost interest in the writing activity after completing only a few crayon strokes on paper. When the mother introduced E to the boys she told them that E was a scientist researcher and they may be able to help. Crayon Boy2 was not interested with this information and moved on to another activity. After the younger boy had left, E moved from being a passive observer to being an active participant and commented to Crayon Boy1 that he was a great teacher for his little brother and seemed to know a lot about crayons. At the invitation of Crayon Boy1, E sat at the table with him and was quietly told he wanted to be a "scientist teacher" when he grew up (Casual conversation, Crayon Boy2, 23.10.08).

Vignette

Once both E and Crayon Boy1 were settled at the table, this young boy said he was going to make a drawing for his Nanna because she liked his drawings. He selected some computer paper and pulled the boxes of wax crayons and pencils closer for the task. As his picture took shape, he seemed determined to use every pencil and every crayon available to make a drawing for his Nanna. The work consisted of many small scribbles, and on one side, an intricate pattern of small parallel lines began to emerge. Along with the story about Nanna, and information about her dog, Crayon Boy1 told how some pencils and crayons didn't work because, "When they get old there's no colour left." He demonstrated this fact with blunt pencils and crayons that had been worn down to their paper case. To display his knowledge he went on to explain, without encouragement, that the white crayon didn't work because "…it kept its colour only for brown paper." He then dashed off to get some brown paper to prove his knowledge was correct.

To extend his teaching and continue to impress his audience, next he tested the white crayon on white paper (see Figure 5.12) and announced confidently, "It’s invisible!"

Figure 5.12 Crayon Boy1 demonstrates white crayon is invisible on white paper

When asked what else he knew about crayons and pencils he remained silent and thoughtfully went on with his picture, but this time the strokes were getting bolder. It was noted by E that he chose the newer crayons as opposed to the worn ones for his work. When he next began a conversation he relayed his knowledge about dogs, what they could do, and that he was going to get a dog one day. While he was talking about dogs he was absentmindedly rubbing the palm of his hand with a thick orange crayon (as seen in Figure 5.13) He was asked what the crayon felt like.

Figure 5.13 Crayon Boy1 absentmindedly warms the crayon in his hand

Crayon Boy1	Soft.
Crayon Boy1	And it's not cold now.
E	What was it like before it was soft?
Crayon Boy1	It's hard. And cold.
E	Why isn't it cold now?
Crayon Boy1	Ah, when you draw it gets warmed up. See? In the box are cold. Touch 'em (pointing for E to test).

Crayon Boy1 handed E several chosen crayons from the box to test his idea.

E	So, when you draw with a crayon it warms up, is that right?
Crayon Boy1	Yes, this one [a blue crayon] was writing and it's not so cold.
E	I don't think I can tell the difference.
Crayon Boy1	No. Blue's not good. I don't draw dogs with blue.
E	What do you draw dogs with?
Crayon Boy1	This one [an orange crayon]. It's like Nanna's dog I reckon this one is good one. See?

Crayon Boy1 began scribbling using the orange crayon he had been holding.

Crayon Boy1	Try this one. This one works better now it's been drawing. See? It's not cold.
E	How do you know it works better than the other orange crayon in the box?
Crayon Boy1	Because I haven't used that one yet.

To prove his point Crayon Boy1 demonstrated two orange crayons. The first crayon was 'cold' and had not been used before in this session. The second crayon that he had been using was 'warm' and made bolder colours.

Crayon Boy1	This one [cold crayon] is hard to draw [with] and this one [warm crayon] was better colour. Look! You can do it. (Hands the warm crayon to E)
E	Thank you. Let me see if you are right.

Discussion

Interpersonal and contextual influences appeared to play a role in the development of Case Study 7 where the scientific concept of change caused by transference of heat was unknowingly tested and articulated by Crayon Boy1. The provision of appropriate resources in ELC2, the unstructured nature of his investigation, a personal agenda (to write to Nanna), and having an interested adult with whom he could share his information, all seemed to contribute to his discovery of improving the colour of a wax crayon.

The transference of heat was not discussed by Crayon Boy1, although the study suggested he was aware that a change had occurred in the crayon as he attributed that change to drawing. Given that heat was transferred from his hand to the crayon during both drawing and rubbing the crayon on his hand, Crayon Boy1's explanation was remarkably accurate for someone without knowledge of the scientific principles related to friction or mentioning that heat causes change. The difference between a cold crayon and a warm one was proved in his drawings because the warmer ones produced a bolder colour and he was contented with that knowledge. He substantiated his information when he explained and demonstrated his theory. He was also able to compare and contrast the differences between 'hard' and 'soft', 'cold' and 'warm', and demonstrated that the white wax crayon was ineffective when used on white paper.

Crayon Boy1 had incidentally discovered new knowledge, and then embedded his findings by testing them. He added to this learning by explaining and demonstrating his ideas to a supportive adult. Although this story did not begin with a firm scientific curiosity and his findings were unintended, the result was meaningful to him as he improved his understanding about crayons. Crayon Boy1's knowledge base, confidence, oral language, and fine motor skills all appeared to increase as a result of this casual, undirected investigation. Working like a scientist he processed his ideas, tested them using the method of 'compare and contrast' then reported his findings.

Key findings in relation to the research questions

In Case Study 7, opportunities for Crayon Boy1 to extend his science learning were developed according to his own agenda and with the assistance of an educator to guide his thinking. The circumstances under which he achieved his learning suggested that the environment suited his thoughtful and quiet learning style. It must be noted, however, that as in the previous case study, Case Study 7 was undertaken in a Playgroup that operates with parents as educators rather than under the direction of a qualified Early Childhood Educator.

As discussed in the key findings of Case Study 6 (see pages 196 and 197), the operation of ELC2 appeared to be well informed by socio-cultural theory because children learned in a social and interactive environment that met their immediate learning needs. Crayon Boy1, and other children in ELC2, are guided in their learning by parents who had the best possible account of their child's prior knowledge and this was incidentally used to develop new learning. Also consistent with a socio-cultural approach is that when an adult listens intentionally to a child's interpretation of how things work, it gives that child's idea currency that can lead them to greater confidence and understanding of their thought processes (Rinaldi, 2006). In the ELC2 learning environment the children were heard and encouraged to work collaboratively. They were provided with appropriate space, time and resources, and engaged in driving their own learning. Interactions with adults that support and encourage personal interest demonstrate the use of the ZPD to extend learning. All of these features are consistent with the socio-cultural theory.

The learning and teaching of science was enhanced for Crayon Boy1 by an educator who helped him extend current scientific knowledge about prediction, changing matter and reporting findings. The ZPD teaching strategy was also employed. Although this was not a planned experience for Crayon Boy1, it demonstrated the value of conversation and guided learning and teaching. It also provided a window of opportunity for future planning for educators. With new information about the boy's skills and his interest in dogs, more thoughtful challenges that assist cognitive development can be set for him. The information also provides an essential platform for new learning and becomes a part of the conversation between parent and educators in Kindergarten during Crayon Boy1's transition into a new learning situation, in the New Year.

5.11 Summary

The vignettes presented in these case studies have provided seven individual snap-shots of what the learning and teaching of science looked like for the 3- and 4- year old children in three different ELCs. The pragmatic circumstances of those snapshots involved one whole-of-class activity, four small-group-work investigations and two case studies in which the young learners chose to work apart from other children. The construction of each case study critiqued those learning circumstances, pedagogical strategies and children's interaction, from a socio-cultural perspective.

Through the insights revealed, and in association with the SCALTELC-S theoretical framework devised to guide this research, the next chapter presents a cross-case analysis of these seven case studies. Common factors and uniqueness across the cases were synthesised and analysed, to reveal evidence of engagement by the children, and pedagogical strategies used by the educator, for the future of learning and teaching of science in ELCs.

Chapter 6

Cross-case analysis and interpretation

6.1 Introduction

The purpose of this chapter is to present a synthesis of the findings through a cross-case analysis, or in the words of Merriam, “build[ing] abstractions across cases” (1998, p.195). To attain that purpose, findings from the individual case studies (presented in Chapter 5) and the reviews of literature (presented in Chapters 2 and 3) were synthesised and taken to a new level of analysis. Where the analysis of individual case studies (in Chapter 5) provided provisional answers to Research Questions 2 and 3 and their subset questions, the intention of the cross-case analysis is to provide more erudite answers to these Research Questions.

In the first instance all individual case study profiles were re-examined for inter-case relationships and common factors. Those factors were then connected to information derived from relevant literature explanations associated with socio-cultural theory and the subsequent SCALTELC-S framework, for a more comprehensive understanding of the findings. As such, the iterative process of this cross-case analysis established connections between the pragmatic learning and teaching of science in ELCs and the study’s theoretical frameworks.

This chapter begins with a presentation of the factors which emerged from the synthesis of the case studies. Then, reflected through lenses focussed on a socio-cultural approach, those factors are discussed with specific reference to the practical and theoretical elements of the SCALTELC-S framework. At the chapter’s end, a concentrated look at the role of the ELC educator precedes a concluding summary that highlights how the cross-case analysis answers Research sub-questions 2.1, 2.2 and 3.1.

Research sub-question 2.1

To what extent does the effective learning and teaching of science take place and under what circumstances?

Research sub-question 2.2

To what extent does the learning and teaching of science appear to be informed by socio-cultural theory?

Research sub-question 3.1

What can be learned to inform the enhancement of learning and teaching of science for 3-and 4- year old children in ELCs?

6.2 Factors emerging from the case studies

As indicated in Chapter 5, the initial systematic collection of data pertained to one whole-of-class activity (Case Study 1), four small-group-work investigations (Case Studies 2, 3, 4, and 5), and two children who worked individually (Case Studies 6 and 7). As the analysis unfolded, the interpretation of the seven case studies revealed factors of similarities and differences in pedagogy and practices that permeated the learning and teaching of science.

Factors that were significant in the story of an individual case study were termed 'major factors'. Those that were less significant, yet noteworthy in the interpretation of a case study, were termed 'minor factors'. Still other factors, termed 'underlying factors' relate to governing policies, beliefs held by adults significant to the study, shared learning spaces, and timetabling. Although the underlying factors contributed to each case study, they relate to circumstances that cannot be easily controlled by the participants. These factors are briefly discussed later in this chapter.

Depending on how it was applied, a factor could vary in the extent to which it was helpful in the development of science skills and knowledge. For example, the factor of questioning was found to be pedagogy that was inconsistently applied across the seven cases studied, and hence, different circumstances brought about different outcomes. Related literature (see Chapter 3, 3.2.2) advocated the use of different types of questioning as a useful learning and teaching strategy for the growth of communication and cognitive development, yet its application was not always found to advantage science learning in the case studies analysed.

In some instances it was found that a factor would present as a positive influence in one case study and a negative influence in another. Play was one such factor. In Case Study 2 (*A sound difference*) play was found to present a positive factor as it helped the children establish new knowledge. However, the circumstances surrounding Case Study 3 (*"Now can I draw a spider?"*) were different, and generally, play was found to be a factor that contributed to being distracted from the science activity. The standout factor, with an influence across all case studies, was found to relate to the role of the educator. As indicated in the introduction to this chapter, that role will be addressed later.

From the analysis of other factors across the seven case studies, those that most influenced the learning and teaching of science were documented. A summary of those influencing factors are presented in Table 6.1. The first column of this table identifies the case study by name, number and ELC.

Table 6.1
Major, minor and underlying factors identified from each of seven case studies that influenced the learning and teaching of science in the ELCs

Case Study Identification	Major factors	Minor or *underlying* factors
Case Study 1. *"You eat it when you watch TV"* ELC1	Prior knowledge, questioning, collaborative learning, every-day resources, scaffolding, specific learning space	Lost opportunities, one-off session, structured teaching, *school policy, time-table*, *beliefs*
Case Study 2. *A sound difference* ELC1	Prior knowledge, collaborative learning, free-play, questioning, ZPD, resources, self-regulation, specific play space, self-directed learning	Working like a scientist, reporting findings, guided teaching, transference of learning, time
Case Study 3. *"Now can I draw a spider?"* ELC1	Prior knowledge, questioning, child's personal learning agenda, structured teaching, self-regulation, every-day resources, learning environment	One-off session, personal agenda, lost opportunities, *school policy, reporting and assessment, time-table, beliefs*
Case Study 4. *"They're not toys!"* ELC3	Prior knowledge, guided teaching , free-play, collaborative learning, specific learning space, self-directed learning, every-day resources, self-regulation, ZPD	Modelling, scaffolding, guided-play, *beliefs, time-table*
Case Study 5. *"Uh-oh wet shoes!"* ELC3	Prior knowledge, collaborative learning, free-play, self-regulation, resources, learning environment, time	Lost opportunities, one-off session, child's personal agenda, *school policy, shared space , time-table beliefs*
Case Study 6. *Skater Boy* ELC2	Prior knowledge, play, time, self-directed-learning, ZPD, free-play, unstructured spaces, resources	Working like a scientist, vicarious motivation, personal agenda, transference of learning, *beliefs*
Case Study 7. *Warm crayons work* ELC2	Prior knowledge, questioning, scaffolding, unstructured spaces, resources, collaborative learning, time, ZPD	Guided teaching, child's personal agenda, reporting findings, *beliefs*

6.3 Discussion of the factors

As summarised in Table 6.1, major factors from across the seven case studies were initially examined in light of interrelationships with the SCALTELC-S framework and that of socio-cultural theory. This analysis incorporated a critical look at the role these identified factors played in the development of young children's emergent science skills and knowledge.

Factors raised from the seven case studies, and frequency of the occurrence of those factors across the case studies, are presented in Table 6.2 along with elements of the SCALTELC-S framework. It is noted that elements of the SCALTELC-S framework are interrelated and usually, each factor is associated with more than one element. Identified factors were: recognition of children's prior knowledge (abbreviated as 'prior knowledge'), learning environments, resources and specific learning spaces and time (including the use of time-tables); collaborative learning, ZPD, scaffolding, and self-regulation; play-based learning, questioning, and personal agenda; guided teaching, self-directed learning, lost opportunities and one-off sessions; inflexible teaching strategies, children reporting their findings, children working like a scientist, and explicitly transferring prior learning; guided play, the use of modelled strategies, and vicarious learning. Those factors that occurred across four or more case studies are described in detail, while factors that occur less frequently are discussed collectively. Finally, the underlying factors are discussed briefly.

Table 6.2
Frequency of factors found across the seven case studies and interrelationships with the SCALTELC-S framework

Factors	Occurrence in case studies	SCALTELC-S
Prior knowledge	1-7	Interconnectedness
Learning environments	1-7	Learning Environment
Resources/Space	1-7	Active Role of Educator
Time e.g. time-table	1-7	Interconnectedness
		Active Role of Educator
Collaborative learning	1,2,4,5,7	Interconnectedness
ZPD/Scaffolding	1,2,4,6,7	Play/Communication
Self-regulation	1,2,4,5,7	Learning Environment
		Active Role of Educator
		Interconnectedness
Play	2,4,5,6	Communication
Questioning	1,2,3,7	Cognitive Development
Personal agenda	3,5,6,7	Play-based Learning
		Learning Environment
		Active Role of Educator
		Interconnectedness
Guided teaching	2,4,7	Communication
Self-directed learning	2,4,6	Cognitive Development
		Play-based Learning
		Active Role of Educator
Lost opportunities	1,3,5	Active Role of Educator
One-off sessions	1,3,5	
Inflexible teaching strategies	1,3	Interconnectedness
Reporting findings	2,7	Communication
Working like a scientist	2,6	Cognitive Development
Transferring learning	2,6	Learning environment
Modelling	4,1	Active Role of Educator
		Interconnectedness
Guided play	4	Communication
Vicarious learning	6	Cognitive Development
		Play-based Learning
		Active Role of Educator

6.3.1 Prior knowledge

Children's prior knowledge, which originates from cultural conceptualisations, was highlighted in each of the seven case studies reported in Chapter 5. Hattam, Lucas, Prosser and Stellar (2007) pointed out that meaningful learning for children was more likely to be established from familiar and pivotal starting points from which prior knowledge provides fundamental information for building new information. However, the cross case analysis revealed, that children's prior knowledge was not always called upon to enhance science learning and teaching.

The factor of children's prior knowledge was found to be especially significant for developing science concepts in Case Studies 2, 4, 6, and 7. For instance, the children in ELC1, Case Study 2 (*A sound difference*) built on information they had previously gained in music lessons to expand their understanding about pitch and the scientific concept of sound. Prior knowledge, brought from outside of the classroom assisted new learning for children in ELC3, when it was used in Case Study 4 (*"They're not toys!"*). In this example, before Nature Girl and Nature Boy would sort unwashed, natural objects, they revealed, to the educator, they held a fear about insects that may live in seed pods, and that dirt on the objects could make them ill. This information was used, by the educator, to help the children overcome their fear and guide their learning so the scientific process of classification could be developed by Nature Girl and Nature Boy.

Although Skater Boy in ELC2, Case Study 6 (*Skater Boy*), did not have anyone to assist him with the building of his skateboard, his self-talk and a casual conversation between the researcher and his mother (06/11/08) revealed he brought to his construction prior knowledge about the structure and workings of a skateboard. Skater Boy used his prior knowledge to frame a starting point and commence new learning. Another use of prior knowledge was demonstrated by Crayon Boy1 in ELC2, Case Study 7 (*Warm crayons work*). As Crayon Boy1 absentmindedly played with crayons and tested his ideas, he voluntarily unveiled his knowledge about dogs, the importance of his grandmother and unique scientific knowledge about how warm crayons worked better than cold crayons. With a view of advancing his current bank of knowledge the educator used the information presented by

Crayon Boy1 to develop new learning challenges. Prior knowledge, as illustrated in these case studies, benefited the children's learning because it provided a solid platform onto which new information could be established.

In some of the cases analysed it was found that the children's prior knowledge was not gleaned by the educator, nor were expected outcomes discussed between educator and learners. In these cases opportunities to enhance learning and teaching of science concepts were deemed to be lost. For example, in ELC2 Case Study 5 ("*Uh-oh, wet shoes!*"), prior knowledge about the capabilities and experiences of Water Boy and Water Girl did not appear to be known to the educator before the investigation began. This seemed to compromise potential scientific learning related to pouring and conservation of volume. The situation was also found to produce conflicting expectations between the educator and the children that may have been avoided had more planning, based on the children's capabilities and knowledge, been obtained before the learning experience was offered. Consequently, intended learning outcomes were not achieved.

Likewise, in ELC1, Case Study 3 (*"Now can I draw a spider?"*), prior knowledge was not determined by the educator to establish the pivotal starting point for children before the demonstration lesson commenced. As a result the children revealed during the lesson that they were unfamiliar with the resources being used. In both Case Studies 5 and 3 information about the children's capabilities could have been helpful in the outcome of the lessons (e.g. Case Study 5 revealed the children did not have pouring skills and Case Study 3 illustrated children's inability to operate an eye-dropper). From another perspective (ELC1, Case Study 1 *"You eat it when you watch TV!"*), specific and relevant questions were asked of children to gain their prior knowledge. Yet, the information gained by the educator did not appear to be used to extend science during the learning experience. Nor was it used after the initial experience to develop follow-up lessons (Casual conversation, T1 and researcher, 25.08.08). The prior knowledge of children appeared to be central to the *Interconnectedness* of learning for the overall, richer conceptual understandings seemed to occur when children could make meaning of a situation through personal association, as discussed in Case Studies 2, 4, 6, and 7.

6.3.2 Learning environment, spaces and resources

Whether indoors or outdoors, learning environments with spaces and resources that inspire active investigation by children were described in Chapters 2 and 3 as the contexts in which learning occurs. Contained within the learning environments of each case study were objects of wonder that stimulated the inquisitive characteristics of children and rendered opportunities for them to expand current conceptual understanding and scientific skills. The ELC learning environments in this study housed both loose and fixed features, often called tools, resources and/or structures, in spaces defined for learning. The development of specific learning spaces, by the educator, was found to be a significant strategy used to develop learning across all seven case studies. It was also found that children were keen to adopt and rearrange set spaces, and use whatever tools were available to them, as they created opportunities to develop their own learning. This section of the cross-case analysis confirmed Rogoff's (2008) argument that the environment, along with the people and objects found within that environment, has an important role to play in a socio-cultural setting. Learning spaces and resources associated with different case studies are discussed separately, below.

Learning spaces

Generally the ELC environments had been sectioned into learning spaces within the classroom, the playground or as a self-defined area in each of the seven case studies. The classroom environment featured in four case studies: Case Study 1 (*"You eat it when you watch TV"*), Case Study 2 (*A sound difference*), Case Study 4 (*"They're not toys!"*), and Case Study 7 (*Crayon Boy*). Learning spaces in the playground environment were used in Case Study 3 ("*Now can I draw a spider?"*) and Case Study 5 (*"Uh-oh, wet shoes!"*), and a self-defined area provided the location for the development of Case Study 6 (*Skater Boy*).

Within the classroom environment of ELC1, a space defined by three walls was sectioned off by T1 for the purpose of the demonstration lesson in Case Study 1(*"You eat it when you watch TV"*). Later, T1 explained that sectioning this specific area was necessary to address health and safety issues associated with a science investigation that involved the use of a hot fry-pan with hot oil. Consideration was also given to the age and numbers of the children engaged in this whole-of-class demonstration lesson (Casual conversation, T1, 11.08.08). The context for Case Study 4 (ELC3, *"They're not toys!"*) was also a space defined by the educator, within the classroom. T3 explained she was mindful that spaces prepared for a purpose had to meet certain requirements that addressed the needs of the children; this included their level of confidence, developing attention span, and capabilities. It was noted that, as the children in Case Study 4 had only limited experience in a school setting, they needed to feel secure and therefore remain in proximity of other children. As explained by T3, placement of a specific space and associated resources for an activity was important to develop young children's concentration because they were found to be easily distracted by other classroom activities (Casual conversation, T3, 06.03.09). Both Case Study 1 and Case Study 4 indicated that T1 and T3 had a sensitive awareness about the necessities of learning spaces for young children and had planned accordingly. Additionally, these in-class situations provided, for the educator, a sense of control by over the actions of the children to keep them safe and on task.

Two other learning spaces relevant to this section of analysis were found to be spaces that had been setup by the educators but left for the children to choose whether or not they wished to investigate the area and its resources. In both Case Study 2 (*A sound difference,* ELC1) and Case Study 7 (*Warm crayons work*, ELC2) the children conducted their own learning, mostly independent of an educator and remained on task until they reported their findings at the conclusion of their investigations.

The outdoor playground learning spaces, used for the scientific investigations in Case Study 3 (ELC1, "*Now can I draw a spider?"*) and Case Study 5 (ELC3, *"Uh-oh, wet shoes!"*), appeared to have received less thoughtful preparation by educators than had been given to indoor learning spaces. Notably, each of these defined outdoor learning spaces was subjected to an inflexible time-table imposed by the school community. Chosen by their respective educators due to the 'messiness' of the investigations (Casual conversation, T1, 11.08.08; T3, 13.03.09), the children appeared to be at odds with the use of the playground in these particular case studies. Walker (2011) argued there was a commonly held view that playground environments are essentially for children to be at liberty to investigate, explore and develop perceptions, albeit in an ultimately sectioned space. The playground learning spaces set up for Case Study 3 (ELC1) and Case Study 5 (ELC3), however, were used by the respective educators, T1 and T3 as another form of classroom. This action appeared to be without an appreciation of the children's inexperience of structured learning outdoors, and their view of what the possibility of the space held for them.

The last space analysed, a self-defined learning area used by Skater Boy in ELC2, Case Study 6 (*Skater Boy*), was an uncluttered transitional area. This space presented the advantages of being in close proximity to the resources used by Skater Boy, and offered enough room for him to test his construction. Interestingly, other children in ELC2 respected the working environment chosen by Skater Boy, and permitted him the freedom to explore and use that space for his own purposes. He was therefore at liberty to fulfil his personal interest and conduct an engineering project, without undue interruption.

The cross-case analysis established that most effective learning took place in spaces where children could socially interact within prepared *Learning Environments*. Therefore, to enhance the science knowledge and skills of young children, the learning spaces within the ELC environments are reliant upon the *Active Role of the Educator* to establish the *Interconnectedness* of learning that comes from the interaction between components of established and new knowledge. For beneficial learning and teaching to occur, it appeared that when emphasis was placed on thoughtful planning for creative learning spaces, the needs and capabilities of children who were to use that space were acknowledged.

Resources

Helpful resources that were meaningful to the children acted as props and assisted science learning throughout the cases analysed. It was also found that clever placement of resources, by the teacher, in places unexpected by the children, could provoke positive learning situations. Rubber mallets, for example, were surreptitiously placed by T1 in ELC1 among the 3D wooden construction blocks (see Case Study 2, *A sound difference)*. The action of putting loose objects into an unexpected location was an innovative way for children to investigate, transfer, and improve, knowledge and skills. The vignette of Case Study 2 confirmed Johnston's (2005b) finding that familiar resources placed in unexpected places can stimulate curiosity and cause investigations to extend current knowledge about the purpose of a misplaced object.

The use of the standard ECE resource, a set of 3D wooden construction blocks, featured in both Case Study 2 (ELC1, *A sound difference)* and Case Study 6 (ELC2, *Skater Boy).* For Skater Boy in Case Study 6, and the focus children in Case Study 2, these familiar blocks enabled transference of knowledge (about skateboards and music, respectively) and demonstrated versatility and creativity when resources that are familiar to the children were used.

In the overall analysis, however, it was found that the use of seemingly familiar resources as investigative tools, could sometimes pose a problem. For example, children can became confused and/or concerned when an incorrect assumption is held by the educator that objects, superficially appearing to be a part of the context of young children, are in fact unfamiliar to the children. This situation was found in Case Studies 3, 4 and 5. Confusion was evident in the scientific investigation of Case Study 3 (ELC1,*"Now can I draw a spider?")* when the dual use of allegedly every-day resources such as cotton buds and detergent seemed incomprehensible to Spider Girl. Her prior knowledge and current perception held only one notional use for each of those resources and without explanation about an alternative use, as intended in this investigation, she voiced confusion. Water Boy and Water Girl also showed confusion in regard to the resources provided in Case Study 5 (ELC3, "*Uh-oh, wet shoes!"*). Again, and without an explanation, resources new to the children were provided, by the educator, for a scientific investigation. As a result, these children chose their own trajectory and used the available tools according to their understanding of them, rather than for the educator's intended purpose.

The learning and teaching of science could have been enhanced for the children in both Case Studies 3 and 5 had information about the use of the resources been explained and demonstrated. Similarly, had a trial or period of experimentation been provided prior to undertaking the planned science lessons, the resources could have been better manipulated by the children, and different outcomes achieved. In contrast, when new resources were introduced, by the educator, to the children in Case Study 4 (ELC3, "*They're not toys!")*, the purpose of those resources was explained to Nature Girl and Nature Boy. The children were then able to bring new information to knowledge they already held about the resources and dispel any owned concerns. This action enabled the investigation to be started with confidence.

The examples described in Case Studies 3, 4, and 5 highlighted that essential pedagogy involves guided introductions about the uses of resources, for effective learning and teaching. Even those resources considered by educators to be familiar everyday objects, such as dish-washing detergent and seedpods, were found to be capable of causing confusion when new properties were not properly introduced, or when differing cultural views were held by children. In light of information already established, the successful use of resources to develop science concepts appeared to depend on the educator's appropriate knowledge and pedagogy that, along with scientific understanding, considered differences in prior knowledge and cultural awareness of children.

6.3.3 Time

Time was a commodity over which children in the cases studied held no control. Rather, time in their ELC was governed by routines and time-tables imposed by other people. Kennedy (2006) proposed that, when engaged in early learning, children required sustained periods of time to contemplate and be unhurried. Greenman (2007) supported Kennedy's argument by pointing out that, where rigid time-tables may not suit the learning style of young children, too casual an approach of the use of time can deprive both them and their educators of the security that comes with routine. The conundrum of Greenman's argument was highlighted in both ELC1 and ELC3 when the educators had only limited input into time-tables that were applied when ELC children were under their jurisdiction and was substantiated in Case Studies 2, 4, 6 and 7.

It was generally found that, because the time-table used for the whole school community also applied to the ELCs in this study, inflexible segments of learning time were a circumstance the centres had to accommodate. Although the educator could control smaller segments of time within that time-table it was noted that, for most part, the inflexible periods presented did not agree with Kennedy's and Greenman's notions of children being unhurried in their learning. The socio-cultural approach promotes the importance of children having enough time to sustain their thinking so that satisfactory understandings of a situation or concept can be achieved (Greenman 2007; Kennedy, 2006).

An example of a flexible approach to learning and teaching to accommodate an incomplete science investigation was found in ELC1. Sound Boy1, in Case Study 2 (*A sound difference)*, wanted to continue his investigation about the changing pitch of sound although the time set for free investigation had expired. To compensate, T1 encouraged Sound Boy1 to explain his discovery during a whole-of-class session and called on the help of other children to help resolve his incomplete investigation. This opportunity enabled a conclusion to be reached, albeit detached from the initial experience.

In contrast, a relaxed approach to the rhythms and routines of time in ELC2 was found to enable fulfillment of investigations for children. In this Playgroup situation, time was available for Skater Boy, Case Study 6 (*Skater Boy*) and Crayon Boy1, Case Study 7 (*Warm crayons work*), to prepare, investigate, test, consider and report their investigations in the uncomplicated circumstances of ELC2. The unstructured and unhurried routine in this ELC simply involved one connection to the clock during the children's two hour attendance: 15 minutes prior to leaving the centre all capable children were expected to help pack-away resources used during their attendance.

Constraints for educators (and indirectly, children) in relation to time were reflected in the policies and ethos that governed a centre; for example, the educator's set programs of work (see Case Study 1), academic expectations (see Case Study 3) and shared facilities (see Case Study 5). To recognise the importance of an appropriate balance of time for both children and educators, the following three conditions were perceived as imperative. First, children needed time to participate physically, mentally and socially so they may articulate their ideas and express views in an unhurried and considered manner. Second, educators needed time during scientific investigations "to model thinking out loud, talking about their thinking and actions, and to encourage children to do the same" (Venville et al., 2003, p. 1330). Third, time was required for educators and children to critically observe involvement, processes and connections made during learning. These each included time enough to question and reflect new information. Thus, a flexible time-table, as distinct from a structured or rigid schedule, was preferable for young children to learn and for their educators to develop scientific investigations. The benefits of that flexibility were appreciated in Case Study 4 when the time-table was purposefully manipulated so that useful gains could be made regarding conceptual awareness.

In accordance with the elements of the SCALTELC-S framework and the socio-cultural perspective that combine to underpin this study, the flexible use of time was seen as imperative and corresponded with the *Active Role of the Educator* and the *Interconnectedness* of learning. Unhurried time was, therefore, interpreted as being fundamental to *Cognitive Development* and the success of the science learning and teaching for both children and educators in the overall analysis of the comings and goings of a day in the ELCs of this study.

6.3.4 Collaborative learning

A notable factor in five of the seven case studies was children learning collaboratively. That collaboration was found to emphasise the interrelationships occurring amongst all the elements of the SCALTELC-S framework. It was also interesting to note that, as explained by Vernette, Harper and Di Millo (2004), even without adult assistance or direction, children seemed to naturally apply social collaboration to advance their own learning. Collaborative learning is consistent with socio-cultural theory and confirmed that children could be resourceful and competent interactive social learners.

Although collaboration could be found in each case study, in some instances it worked better than at other times, for the development of scientific concepts and skills. In more positive cases, for example, Case Study 1 (ELC1 "*You eat it when you watch TV!")* children were asked to work collaboratively to find the properties of corn in a compare and contrast situation. This activity enabled children to discover certain characteristics of corn seeds and discuss their observations, with each other, in order to advance current scientific knowledge. Evidence of collaboration in Case Study 2 (ELC1, *A sound difference)* was visible when the three children, who were the focus of this case study, worked as a team to investigate pitch of sound. At different stages of their investigation these children predicted, tested, compared and responded with each other until consensus was reached. In Case Study 4 (ELC3, "*They're not toys!"),* Nature Girl and Nature Boy assisted each other to extend their current knowledge about classification. Together, they used their senses and discussion to find tangible differences to compare, contrast and sort objects. The example in Case Study 5 (ELC3, *"Uh-oh, wet shoes!")* saw the children collaborate playfully and develop, through trial and error, skills related to pouring and measuring. Spontaneous collaboration in Case Study 7, between Crayon Boy1 and an educator (ELC2, *Warm crayons work)*, was found to have enlarged the potential of the child when investigating the scientific concept of heat causing change.

The value of collaboration as a method of learning and teaching in the field of science appears to be immeasurable. According to the socio-cultural approach, children neither exist nor learn in isolation, and the interrelationships that come from collaboration serve also to highlight the *Interconnectedness* of learning and associated links with all parts of the SCALTELC-S framework.

6.3.5 ZPD and scaffolding

The concept of zone of proximal development (ZPD) and scaffolding, used as a teaching strategy to develop science for early learners were found in these five Case Studies: 1, 2, 4, 6 and 7. In Case Study 1 (ELC1 "*You eat it when you watch TV!")* the educator scaffolded responses to questions as she insisted children give 'full sentence answers' to describe an attribute or to make a comparison. A ZPD was used to advance the understanding of pitch change for the three focus children, in Case Study 2 (*A sound difference)*. For this teaching strategy the stage was set by the educator for children to independently investigate and clarify differences in sound. Both scaffolding and ZPD were highlighted in Case Study 4 (ELC3, "*They're not toys!")*. During the session to develop scientific skills associated with the process of classification, scaffolding enabled the two children, Nature Girl and Nature Boy, to learn in small steps, how to confidently apply their senses and make close observations for the sorting of objects under investigation. Each child's ZPD was then challenged when they needed to find additional differences and ultimately create new classifications, without educator assistance.

The ZPD used in Case Study 6 (ELC2, *Skater Boy*) was different in that Skater Boy, rather than an educator, applied the strategy. Each time a rebuild of the skateboard was completed and tested, Skater Boy was observed to reassess the situation and mentally plan an extension of his current thoughts to improve his prototype skateboard. In this case, learning was driven to a new level of understanding by personal ambition. Scaffolding was the strategy used by the educator in Case Study 7 (ELC2, *Warm crayons work*) to help Crayon Boy1 clarify his thoughts and explain what he knew about the science of crayons.

The strategy of scaffolding within a child's ZPD is consistent with socio-cultural theory in that interactive learning and teaching occur simultaneously and children are offered situations to develop their potential. Applications of strategies, throughout the five case studies highlighted scaffolding and appeared to effectively assist the development of science concepts, processes and skills for young children. Further, *Communication* associated with the strategy of scaffolding and the concept of working in the ZPD is complementary to advancing *Cognitive Development*. These elements link the *Interconnectedness* of learning and accentuate the *Active Role of the Educator* further demonstrating the advantage of the SCALTELC-S framework to interpret the complexities of learning and teaching of young children.

6.3.6 Self-regulation

Self-regulation was highlighted in Case Studies 1, 2, 4, 5 and 7 when the focus children demonstrated the relevance of this social and emotional skill used to develop their learning of science. Further, it was found that children were more likely to demonstrate the behaviour of self-regulation when they felt secure and contented in their environment. For instance, Sound Boy1, Sound Boy2 and Sound Girl in Case Study 2 (ELC1, *A sound difference*), who were not under the guidance of an educator, were seen to engage in self-regulation as they collaboratively investigated the science of sound. These children playfully experimented with musical sounds, sang, conversed, tested differences in the pitch, and regulated their participation so as not to interfere with the learning of other children in the vicinity.

Another example of self-regulation came from Case Study 1 (ELC1 "*You eat it when you watch TV!").* In response to the educators' instructions, children demonstrated self-regulation when they obligingly compared and discussed, with the child sitting next to them, their findings associated with corn seed. In yet another example, and after a guided teaching session, Nature Girl and Nature Boy (ELC3, "*They're not toys!")* were seen to practice and demonstrate self-regulation when they remained on task helped each other extend their learning about classification.

Case Study 5 (ELC3, *"Uh-oh, wet shoes!")* highlighted developing self-regulation. After an initial display of directionless and unregulated playful energy, Water Boy and Water Girl settled to solve their perceived problem. In this situation it appeared that together, these children came to realise their unregulated behaviour was not helpful for their investigation and, through discussion, developed a plan of procedure. Although modeling a process was not a strategy used in Case Study 5, self-regulation was seen to improve when guidance, by a more experienced person, modelled expected behaviours associated with scientific investigation (see for example Case Study 2, *A sound difference,* Case Study 4, "*They're not toys!"* and Case Study 7, *Warm crayons work).*

Trust, confidence and simple scientific activities appeared to be the components for the young children in Case Studies 2, 4, 6 and 7 to rehearse the social and emotional skill of self-regulation while they developed science concepts. In each of these cases, children were ultimately seen to 'get on with the task' at hand, without interrupting the learning of others, and achieve an outcome. Interactive science learning conducted with self-regulated composure, albeit in a playful and chatty manner, corresponded with a socio-cultural approach to learning and teaching. These findings specified the importance of social and emotional development for the *Interconnectedness* of learning, and *Cognitive Development,* as described in the SCALTELC–S framework.

6.3.7 Play-based learning

Curiosity, determination and multiple methods of playful inquiry were found to be used, by the children, in this cross-case analysis as they unlocked the puzzling situations and constructed new knowledge. The multidimensional advantages of play have been flagged earlier in this study. From the review of literature it was argued that *Play-based Learning* was a natural learning medium that connected knowledge and optimised growth in multiple ways. It also pointed out that having an educator nearby to guide learning during playful investigations was advantageous for the development of science learning for both the children and the educator.

Children's predilection to be playfully engaged in their learning was elaborated in Case Studies 2 and 4. For example, Case Study 4 in ELC3 ("*They're not toys!"*) revealed that after a guided teaching session, Nature Boy and Nature Girl continued their science learning in a playful yet constructive manner to develop the process of classification. In yet another example, and as a continuation of an earlier lesson, Sound Boy1, Sound Boy 2 and Sound Girl, (Case Study 2, ELC1, *A sound difference)* used Play-based Learning as the medium to extend their scientific knowledge about sound.

The preference for young children to be socially and actively engaged in learning, as distinct from being taught in the confines of direct instruction, was illustrated in Case Study 3 ("*Now can I draw a spider?").* Although Play-based Learning was not counted as a major factor in this case study it influenced a negative outcome for many of the children. Undertaken in a playground environment and while class-mates played about them, small groups of children were led through a mainly observational learning experience. In this environment the children, who were still developing self-regulation, were constantly distracted by the active play of other children. Play-based learning was, at first, seen in a negative light in Case Study 5 when Water Girl and Water Boy did not have guidance for their participation, and learning outcomes appeared doubtful. However, further analysis found that the children had ultimately used the situation to develop their own learning associated with volume, albeit not associated with the expectations of the educator.

From a socio-cultural perspective Play-based Learning is recognised as a conduit that empowers rehearsal of life skills and growth of social, emotional, cognitive and physical wellbeing of children. The analysis revealed that when children had a meaningful connection with an investigation, and were actively engaged, they appeared to remain on task until a result, satisfactory to their curiosity, was achieved, as seen by Skater Boy in Case Study 6. The *Active Role of the Educator* was found to be influential in the success, or otherwise, of *Play-based Learning* to develop science concepts. Multifaceted opportunities for children to grow and better comprehend their place in the world were found to occur when the educator was actively engaged in the children's learning.

6.3.8 Questioning

From the synthesis of all seven case studies it was found that examples of questioning to develop cognition and connect prior knowledge with new information for scientific meaning was highlighted in Case Studies 1, 2, 3 and 7. Across these cases questioning was generally used as an action to seek information or clarification, engage a listener, or to nudge curiosity. However, examples of questioning that did not serve science studies well, also came to light.

As expanded in Chapters 2 and 3, questioning by both children and educators is a strategy found to be consistent with a socio-cultural approach to learning and teaching, and beneficial for the development of science concepts. Questioning, according to literature, requires an exchange of active listening, thought, modelling and especially, time to develop questions and responses. To analyse questions found within the case studies, elements of the SCALTELC-S framework, namely *Active Role of the Educator, Interconnectedness, Communication*, and *Cognitive Development* were found to be helpful.

The complexities of asking questions and responding to questions, can provoke reactions that require different levels of thought, or cognition. The use of different levels of cognition implies need for both the questioner and the responder to be attentive, to be able to recall previous knowledge and to have the ability to align prior information with the new. The interactive strategies of scaffolding, and modelling effective questions were found to be used throughout the case studies and appeared to be beneficial for the development of scientific knowledge and skills.

Wellington and Osborne (2011) argued that it is the classroom teacher (who usually knows the answer) as the one asking the questions, while children who do not know the answer (or need clarification) are the ones left wondering. Case Study 1 (ELC1, *"You eat it when you watch TV!")* was a case in point when the responses provided by the children to questions (e.g. Who has cooked popcorn?) were not used to develop further learning, and opportunities for the children to pose questions to assist their own learning, were not found to be a part of the pedagogy used.

Questions asked of each other, by the focus children in Case Study 2 (ELC1, *A sound difference),* demonstrated the value of using playful situations to rehearse communication skills associated with questioning. In a relaxed situation these children were seen to play with language as they freely posed questions and responses to one another (e.g. Can you hear the difference [in sound]?). The rehearsal of question and answer situations during the testing phase of their investigation appeared to be used to confirm thoughts. Confidence to take the investigation further, during the verbal reporting of the findings, was encouraged when the educator led the initial questioning. During this question and answer phase of Case Study 2, a higher level of thinking was required by the focus children to effectively respond to both open and closed questions (without notice) from the audience. In another example, questioning used in a conversational situation between the educator and Crayon Boy1 was used to encourage extended and thoughtful answers about his scientific discovery in Case Study 7 (ELC2, *Warm crayons work*) (e.g. What made it change?).

In an example taken from Case Study 3 (ELC1, "*Now can I draw a spider?"*), questioning did not appear to add value to the learning and teaching of science when a child was overheard to ask "What's the yellow stuff?" Instead of providing the science behind the investigation, the question drew the response, from the educator, "That's the magic ingredient." This response seemed to effectively dismiss the child's curiosity and carry a twofold result: First the understanding of an essential part of the scientific investigation remained incomplete and, second, the rejection of the child's question could lead to that child withdrawing from asking further questions to learn.

6.3.9 Personal agenda

In the search of answers that unravel the complexities of their immediate world, or to demonstrate a capability, it was noticed that some children used a personal agenda to gain proficiency or follow an investigation that interested them. Examples were found in Case Studies 3, 5, 6, and 7.

As explained in the vignette of Case Study 3, (ELC1, "*Now can I draw a spider?")*, Spider Girl used unrelenting determination to pursue a personal agenda that enabled her to demonstrate her knowledge about a spider. From a different approach, the focus children in Case Study 5 (ELC3, *"Uh-oh, wet shoes!")*, developed a personal agenda when they found themselves in a situation without apparent guidelines. In light of there being no firm direction from the educator, Water Boy and Water Girl, spontaneously tested all available resources and their random procedure appeared to help them advance knowledge about volume. They discovered that scooping large quantities of water filled a container more quickly than did scooping smaller quantities.

In ELC2, both Skater Boy in Case Study 6 (*Skater Boy*) and Crayon Boy1 in Case Study 7 (*Warm crayons work*) pursued individual personal agendas to satisfy curiosity and reveal to others their capabilities. For Skater Boy it was to build a skateboard that he could balance on, while for Crayon Boy1 it included being able to prove to another person that white crayon did not work on white paper.

Children who were seen to achieve their own goals through the use of a personal agenda demonstrated communication skills and the driving influences of curiosity and determination. The discussed results from Case Studies 3, 5, 6 and 7 suggest that a personal agenda can be powerful learning tool when learning environments are established for children to discover new knowledge, or re-establish a current understanding about how their scientific world works. From a socio-cultural perspective these children were seen to engage self-imposed scientific learning, with or without the help of other people, and confidently use a variety of strategies and resources to do so.

6.3.10 Guided teaching and self-directed learning

Case Study 4 (ELC3, "*They're not toys!")* and Case Study 7 (ELC2, *Warm crayons work*), emphasised guided teaching while Case Study 2, (ELC1, *A sound difference)*, Case Study 4 (ELC3, "*They're not toys!")* and 6 (ELC2, *Skater Boy*) highlighted self-directed learning. In each case study the strategies of guided teaching or self-directed learning was found to assimilate with a socio-cultural approach to learning and teaching, and demonstrate the development of science knowledge and skills. The strategies of both guided teaching and self-directed learning, discussed below, reflect interrelationships between the elements of the SCALTELC-S framework that offer potential academic growth for young children.

Guided teaching

Guided teaching is closely linked to the strategies of scaffolding and ZPD, yet differs when applied to unexpected and unplanned teaching and learning opportunities. Guided teaching was seen in three case studies when just-in-time instruction, or when the most was made of an unexpected teachable moment. For example, in Case Study 4 (ELC3, "*They're not toys!"),* a just-in-time example of guided teaching happened when it became apparent to the educator that the children, who were the focus of this case study, were unfamiliar with, and even afraid of, the objects being examined. This situation called for immediate attention by the educator before Nature Girl and Nature Boy would be confident enough to engage in the planned science activity.

As a further example of guided teaching, a teachable moment presented itself for the educator when Crayon Boy1 (Case Study 7, ELC2, *Warm crayons work*) told his story about warm crayons working better than cold crayons. To extend his interest in wax crayons guided teaching enabled Crayon Boy1 to reveal and extend current knowledge as he was encouraged to demonstrate his claims and explain his actions. In Case Study 2 (ELC1, *A sound difference)*, guided teaching was found to occur when the educator spontaneously prompted the children, Sound Boy1, Sound Boy2 and Sound Girl, to complete their investigation and present their scientific findings to an audience.

In accordance with a socio-cultural environment, guided teaching is attended to at point of need. It was found that this sometimes required the educator to be as spontaneous as the children in a bid to help them understand a concept or skill. Depending on the circumstances surrounding an action of guided teaching, interrelationships between practical and theoretical elements of the SCALTELC-S framework came into play and especially called for a preparedness in the *Role of the Educator* to divert from a planned course of action so that teachable moments could be attended to, when they were presented.

Self-directed learning

In contrast to the above, self-directed learning was observed when children conducted their own learning, in harmony with their need, intuitive ideas and curiosity. However, in each example discussed below, the preparation of the environment in which the children conducted their self-directed learning had previously been prepared, by educators, for children to use.

Examples of self-directed learning were found in Case Study 2 (ELC1, *A sound difference)*, Case Study 4 (ELC3, "*They're not toys!")* and Case Study 6 (ELC2, *Skater Boy*). Self-directed learning reported in those case studies required of the children self-regulation and perseverance to follow a line of investigation, and work in accordance with their capabilities. Within self-directed learning children were seen to use opportunities to safely test their concepts, rehearse new knowledge and practise their skills, under their own direction. These actions illuminate a socio-cultural approach in that children are empowered to demonstrate capabilities, resourcefulness and potential.

The three focus children in Case Study 2, for example, found resources placed out of context (rubber mallets among the wooden building blocks). The educator had, without the knowledge of the children, so placed these loose objects to act as a provocation for self-directed learning. As a result, the children were seen to devise a reason to use their unexpected find and direct their play without verbal prompting or demonstration by an educator. Unassisted, they playfully followed their own line of investigation and applied purpose and perseverance to respond to their curiosity. In contrast, the children reported in Case Study 4 were, in the first instance, guided to explore the process of classification. However, after that initial guidance, Nature Boy and Nature Girl self-directed their learning, renamed objects and created new ways to classify the objects. Through repetition and conversation these children advanced newly acquired skills, independent of the educator. Self-directed learning was seen in a different light when Skater Boy, in Case Study 6, was found to use vicarious knowledge to direct his own experiment. Although Skater Boy received no guidance from an educator while he developed his investigation, he found suitable resources and constructed a skateboard to imitate the ones he had reportedly seen other people using.

Described in the preceding section, the children in Case Studies 2 (ELC1), 4 (ELC3) and 6 (ELC2) were found to report their findings to others, giving purpose to their self-directed investigation. The analysis revealed that, in line with a socio-cultural approach, and in the midst of people, the environment and resources in each of the three ELCs of this study there were opportunities for children to use their own line of investigation and conduct self-direct learning.

6.3.11 Lost opportunities, one-off lessons, inflexible teaching strategies

In the cross-case analysis, three factors came to light that appeared to be ineffective for young children in the learning and teaching of science: lost opportunities, one-off lessons and inflexible teaching strategies. These factors were found to occur in Case Studies 1, 3, and 5 and are described below.

Lost opportunities

Opportunities to enhance learning appeared to be lost when new learning was presented as a single experience. Without evidence of lead-up or follow-up sessions to extend the science concepts presented to children in each of Case Study 1 (ELC1, "*You eat it when you watch TV!"*), Case Studies 3 (ELC1, "*Now can I draw a spider?"*) and 5 (ELC3, *"Uh-oh, wet shoes!"),* the opportunity to elaborate specific information was lost. In both Case Studies 3 (ELC1, "*Now can I draw a spider?"*) and 5 (ELC3, *"Uh-oh, wet shoes!"),* opportunities to develop new learning appeared to be lost when the use of resources, unfamiliar to the children, were used without introduction. Also, restricted interactive learning in Case Study 3, also appeared to lessen opportunities for children to develop the scientific concept being demonstrated. Another example of a lost opportunity was found in Case Study 5 when Water Boy and Water Girl were not given a purposeful direction to assist their science learning.

One-off lessons

One-off lessons are those that are disconnected from other learning experiences. Literature reviewed in Chapters 2 and 3, demonstrated children's need to connect old knowledge with new experiences, practice skills and rehearse complex processes time and again before a useful understanding of new skills and knowledge can be retained (see Epstein, 2007; Foreman & Fyfe, 1998 and Worth & Grollman, 2003).

Disconnectedness of learning and teaching were found in the one-off lessons recorded for Case Study 1 (ELC1, "*You eat it when you watch TV!"*), Case Study 3 (ELC1, "*Now can I draw a spider?"*), and Case Study 5 (ELC3, *"Uh-oh, wet shoes!"* when isolated experiences were used to develop science. The process of these case studies did not appear to be helpful for young children's complex learning styles when circumstances, that acknowledge differences in learning styles and capabilities of children, were not visible. Connections made between implicit knowledge and explicit information could not be assumed when one-off experiences were presented.

Further, one-off lessons do not reflect a socio-cultural approach to learning and teaching because they seem to be disconnected from all else that is happening within a child's life. Connecting new learning through the integration of multiple representations (i.e. the use of art, mathematics, associated artefacts, stories and related language) was also supported in the literature to assist the development of a science concept, but not consistently seen in these case studies.

Inflexible teaching strategies

Experiences presented for children in Case Study 1 (ELC1, "*You eat it when you watch TV!"*) and Case Study 3 (ELC1, "*Now can I draw a spider?"*) were analysed as being disconnected and inflexible demonstration lessons that limited children's contributions to their own learning. As described by T1, lessons in Case Study 1 and Case Study 3 were presented to children for their 'wow' factor and for those children to see (rather than actively find) that things can be made to happen (Semi-structured interview, T1, 13.08.08). However, at the conclusion of these lessons and, after casual conversations (between the researcher and children) it seemed that little had been achieved in the way of scientific knowledge by the children. Indeed, these children were generally found to have become disinterested in the experiences presented due in part to their poor understanding of the process and/or because their engagement was regulated and limited. In contrast, and when Case Study 5 (ELC3, *"Uh-oh, wet shoes!")* was analysed, it was found that Water Boy and Water Girl had too much freedom to explore the possibilities of their science experience. It appeared that, because the focus children were not given boundaries, explanations or guidance, they were unsure about their engagement and exhibited dysfunctional participation.

Collectively, the factors of lost opportunities, one-off lessons and an imbalance of flexible teaching strategies resulted in children displaying difficulty when asked to recall the process of each experience for reporting purposes. From the cross-case analysis it was found that science learning and teaching, suitable for young children occurred in cases other than Case Studies 1, 3 and 5, when purposeful planning and guidance by the educator was highlighted (see for example, Case Studies 2 and 4). Further, a socio-cultural perspective is absent when affirmed and supported proactive learners, working in collaborative learning experiences, are not part of the classroom fabric.

6.3.12 Other factors affecting the learning and teaching of science

Found less frequently in the synthesis of the seven case studies of this research, yet bearing on the development of the learning and teaching of science for young children are the following factors: reporting findings, working like a scientist, explicit transference of learning, guided play, modelling and vicarious learning. These factors relate to interactive involvement and contribute to a socio-cultural approach to learning and teaching. Also, these factors reflect interrelationships between the practical and theoretical elements of *Interconnectedness, Communication, Cognitive Development, Play-Based Learning, Learning Environments* and essentially, the *Active Role of the Educator*, as presented in the SCALTELC-S framework. Each of these 'other' factors is briefly described, below.

Reporting findings

When children reported their science investigation to an audience, for instance in Case Studies 2, 3 and 7, multiple methods of communication were found to be highlighted along with connections between implicit and explicit knowledge associated with cognitive development. The demonstration and verbal recount offered as a report to explain the findings related to the pitch of sound by the three focus children in Case Study 2 (ELC1, *A sound difference)* is one such example. In a different case, Crayon Boy1 (Case Study 7, *Warm crayons work)*, with assistance of an educator, was able to present a report about his new knowledge. The complexity of applying implicit and explicit knowledge to report findings was visible when Crayon Boy1 used multimodal signs of communication. These included a physical demonstration, drawings and a verbal account to report his conceptual understanding. Although reluctant at first, Spider Girl (Case Study 3, "*Now can I draw a spider?"),* reported her findings of the Magic Milk experience in a sequence of four drawings before confidently going on to report her knowledge about spiders, through the use of a drawing and an accompanying story.

Found to be used as a teaching strategy in the case studies discussed, reporting their findings appeared to help inform other children, and honour the developing scientific understanding of the children making the reports. Seemingly, the strategy of encouraging children to report their findings is a powerful way to consolidate learning and conceptual knowledge. Also, this factor reflected relationships between the elements of *Interconnectedness, Communication, Cognitive Development* and the *Active Role of the Educator* when the SCALTELC-S framework was used to analyse the benefits for science learning and teaching, when children reported their findings to an audience.

Working like a scientist

The children working in Case Study 2 (ELC1, *A sound difference),* Sound Boy1, Sound Boy2 and Sound Girl, demonstrated Forman's (2010) description of children being able to work like scientists. Their process of learning started with a curiosity and saw them discuss possibilities, collaborate a plan, select resources then test and retest their ideas before reporting their findings. Likewise, Skater Boy (ELC2, Case Study 6, *Skater Boy),* was also found to be working like a scientist when he researched, planned and collected resources before making, then modifying a skateboard. Skater Boy repeated his cyclic process of plan, make, test and evaluate stages of his construction until he had achieved a model satisfactory to his needs.

Explicit transference of learning

Being able to explicitly transfer to a new situation, that which had been previously learned, was found in Case Studies 2 (ELC1, *A sound difference), 4 (*ELC3, *"They're not toys!")* and 6 (ELC2, *Skater Boy)*. Forman (2010) argued that the transference of knowledge is a developing skill in young children that generally improves as they grow and experience new situations onto which they can connect 'old' learning. To assist transference of previous learning an educator can remind children of their earlier encounters, such as the music lessons as described in Case Study 2. This subtle reminder, through the placement of specific resources, helped children make essential connections. Alternatively, connections can come in the form of explicit verbal instruction, as seen when classification skills were being developed in Case Study 4, or vicariously, as reported in Case Study 6 (ELC2, *Skater Boy)*. In Case Study 6, Skater Boy demonstrated an explicit transference of pervious knowledge when he voluntarily rehearsed one-to-one counting associated with the rollers being added to his model. Further, and after completing the construction of his skateboard, Skater Boy was then found to transfer that new knowledge to another situation as he designed the construction of a ramp, purposefully built for skateboards. Transference of learning in the case studies discussed in this section have illuminated interrelationships between the *Interconnectedness* of learning, *Cognitive Development*, *Communication*, *Play-based Learning*, the *Learning Environment* and the *Active Role of the Educator,* all of which contribute to embedded learning.

Guided play

When discussing the limited in-school learning experiences of children in ELC3, T3 claimed that until these children learned to play together they would struggle with their social and emotional development (Casual conversation, T3, 13.03.09). In recognition of the immaturity of the children in ELC3, and especially those in the vignette of Case Study 4, (*"They're not toys"),* the strategy of guided play was included by the educator so that purposeful learning could occur. First, Nature Girl and Nature Boy were guided to discuss attributes and possibilities of the objects of investigation, and second, they were guided by each other as they playfully rearranged those objects into groups. Self-regulation and thoughtful collaboration were two of the social and emotional skills mentioned by T3 that can assist academic learning and that these skills are mostly acquired through guided or social play (Casual conversation, T3, 13.03.09).

Modelling

Modelling, discussed in Chapter 2, is a strategy that extends learning through the use of strategies such as guided teaching, guided play and scaffolding. Although modelling can include direct and focussed teaching, it can also include teaching in an indirect or vicarious manner. Educators were found to model actions and behaviours that children were able to directly, or indirectly, copy throughout this cross-case analysis. An example is presented in Case Study 4 (ELC3, "*They're not toys!")* when the children were, at first, anxious and unwilling to participate in the planned science activity. After the educator modelled how to hold and inspect the objects of concern, the children overcame their unwillingness to participate. Another example was presented in Case Study 1, (ELC1, "*You eat it when you watch TV!"*) when the educator modelled for children how to respond with 'full sentence answers' to questions she posed. In this instance, children were being encouraged to develop communication skills that applied to the scientific concept of compare and contrast.

Vicarious learning

Vicarious learning is another form of modelling. By vicarious means, Skater Boy (Case Study 6, ELC2, *Skater Boy*) brought information to his learning experience that he had gained by watching older boys ride skateboards in the car park of a shopping centre. Skater Boy's vicarious learning was also developed from pictures in books, sports catalogues, a visit to a shop that sold skateboards, and his visualised skateboard models, before he attempted to build his own (Casual conversation, P2.2, 27.11.08). In the analysis of this study, vicarious information appeared be the powerful teaching tool that helped Skater Boy come to question and test the science of constructing a skateboard.

6.3.13 Underlying factors

Underlying factors, for instance, the beliefs of educators, governing school policies and spaces that were shared with other classes were found in the analysis to impact science learning and teaching, in different ways, in each of the three ELCs of this study. For example, impacting centres attached to schools (ELC1 and ELC3) were underlying factors related to formal reporting, religious adherences, academic expectations and the school ethos. The personal beliefs of educators, a whole-of-school-time-table that marked out segments of the ELC day, and restricted the use of some learning spaces, were similarly found to contribute to science experiences that built the Cases in ELC1 and ELC3. Educators' personal belief was the main underlying factor in the Playgroup (ECL2).

Personal beliefs of the educators, about the topic of science, varied from centre to centre. Parents in ELC2, for example, held opposing beliefs about the value of including science concept learning into the curriculum for their children (Casual conversations, P2.1, P2.2, P2.3, 30.10.08 and 06.11.08). Educators in the classroom also held varying views about the value of science in ELCs. T3, for example, believed that the learning areas of literacy and numeracy should be emphasised in the curriculum before science was introduced in ECE (Semi-structured interview, T3, 20.03.09). On the other hand, T1 believed that science was an essential part of the ECE experience, but acknowledged that skills in literacy and numeracy where emphasised as being more important for young children's learning by the school community (Semi-structured interview, T1, 13.08.08).

Although there was an expectation within a school's governing policy (ELC1 and ELC3) that science would be a part of the learning and teaching program, direction in that discipline was unclear for these educators of 3- and 4- year old children. Without a comprehensive curriculum to follow, it was found that T1 and T3 were asked to formulate and implement their own curriculum for science. However, it appeared that governing policy expected the curriculum would move children towards anticipated academic standards and dovetail with both the whole-of-school-policy and future curriculum direction. To meet those expectations, T1 (ELC1) and T3 (ELC3) wove science into their classroom program when they deemed its inclusion appropriate. Science was usually initiated by a 'good idea'. From data collected, those ideas came from children's curiosity, or from the educator, rather than a curriculum direction and the development of science skills (Casual conversations & Semi-structured interview, T1, 13.08.08; Semi-structured interview, T3, 20.03.09).

A governing policy for ELC1 emphasised the presentation of formal reports for parents that revealed academic progress by their children. Reporting included the production of a portfolio, the contents of which contained evidence-based learning. Examples of that evidence contained in each portfolio were similar in product for each child, and this, according to T1, impacted the development of science in ELC1. Therefore, whole-of-class-structured science teaching was conducted, as distinct from spontaneous or interest based guided learning (Semi-structured interview, T1, 13.08.08).

On a scheduled basis, facilities and learning spaces attached to the ELCs were shared with other classrooms. This shared arrangement inevitably contributed another underlying factor for the educators in ELC1 and ELC3 because of time constraints. At times this restriction caused developing learning to be truncated (see Case Studies 3 and 5).

Pedagogy that catered for special needs and learning styles was found to be difficult to administer when time-tables and policies were inconsistent with the characteristics and uniqueness of how young children learn. Often, the dominant influence of policy seemed to result in capabilities, spontaneous learning nature and the developing needs of young children not being respected (Casual conversations, T1, 20.08.08; T3, 27.03.09).

Impending changes to policies governing all ELCs in Australia for children aged from birth to 5 years (as reported in Chapter 1) was another underlying factor. Although this factor did not relate to any case study in particular, casual conversations with educators throughout the data gathering period revealed that the forthcoming changes served as a distraction.

6.3.14 Overview of factors discussed and the SCALTELC-S framework

The complex nature of learning and teaching for young children to develop science in the seven case studies presented in Chapter 5 has been found in this analysis to consist of a combination of major, minor and underlying factors.

The cross-case analysis uncovered factors and circumstances contributing to children's science education that appeared to influence the successful (or otherwise) learning and teaching of science in the ELCs. For example, and from the in-depth analysis of this pragmatic study, factors reflecting a socio-cultural approach that assisted learning included, from the SCALTELC-S framework, aspects of *Learning Environments*, *Communication* through collaborative interaction, guided teaching and *Play-based Learning*. Yet factors representing inflexible teaching strategies and one-off sessions did not appear to support science learning and teaching, from the socio-cultural approach when the *Interconnectedness* of learning and associated *Cognitive Development* were not accentuated.

The interrelationships between the theoretical and practical elements of the SCALTELC-S framework that gave structure to this study has highlighted the major, minor and underlying factors that have surfaced during this cross-case analysis. Overall, the analysis found that the essential and active role of the well informed educator was indispensable in the development of science in ELCs. Indeed, the *Active Role of the Educator* has been established as both a major factor in this analysis, and a major element of the SCALTELC-S framework, and as such, that role is seen to have a profound effect on the outcomes of this study. Figure 6.1 that precedes a discussion that emphasis the *Active Role of the Educator* from the findings of this analysis, now presents the evolving SCALTELC-S framework, refined to include major factors identified from the cross-case analysis.

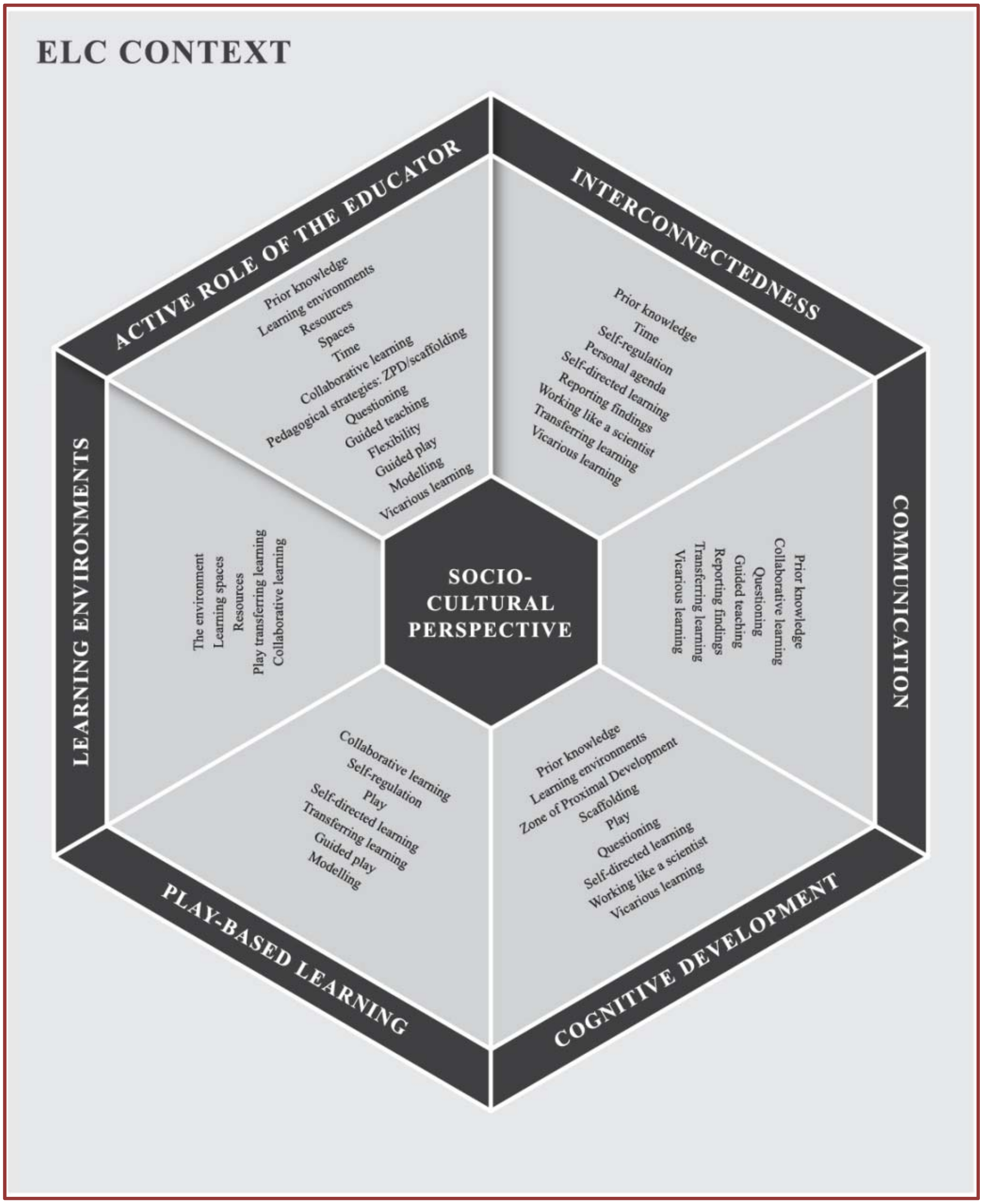

Figure 6.1 The SCALTELC-S framework: Factors influencing science learning and teaching in an ELC context

6.4 The Active Role of the Educator

From the cross-case analysis, and specific to ELC1 and ELC3, a unique perspective in relation to the *Active Role of the Educator* has been provided by this study. As foreshadowed in Chapter 1, the term 'educator' continues to refer to the person mentoring children's learning: a parent, a qualified classroom teacher, the qualified education assistant, or the researcher. For the purpose of comparison of science learning and teaching between ELCs, this section will, however, refer mainly to the qualified classroom teachers, T1 and T3.

T1 directed three case studies: "*You eat it when you watch TV!*" (Case Study 1), *A sound difference* (Case Study 2) and "*Now can I draw a spider?*" (Case Study 3). T3 supervised two case studies: *"They're not toys"* (Case Study 4), and *"Uh-oh, wet shoes!"* (Case Study 5). While it might have been expected that the approaches of T1 and T3 would have been consistent across their respective case studies, this was not the case. Instead, inconsistencies appeared in ways science experiences were managed and presented for the children. To explain these inconsistent applications a brief review of the educators' beliefs, in relation to science and ECE, is presented.

T1, who had considerable experience in teaching young children, attended professional learning that accentuated science in ECE. Although there was a school priority to develop literacy and numeracy, T1 maintained her interest in science and believed it should be included in an ECE curriculum. Further, she felt confident to include science experiences in the learning and teaching program. At the same time, T1 revealed a lack of confidence about science content knowledge. She maintained it was more important to develop 'wonder' and speculated that content knowledge would confuse young children (Semi-structured interview, T1, 13.08.08).

Of the three case studies conducted by T1, Cases 1 and 3 were presented as demonstration lessons: Case Study 1 to the whole-of-class and, for Case Study 3 the demonstration was repeated for the rotation of small groups of four children. An alternative method was used to develop science in Case Study 2 whereby T1 managed a lesson that invited children to do a self-directed investigation. In this case study, T1 set up a learning space that enabled children to follow their own line of investigation related to music. Later, and with the whole class as audience, T1 then guided the children, who had done the investigation, through a process of a review of learning and a report of their outcomes. This model appeared to help not only the children who were the focus of Case Study 2, but was also helpful for children in the audience as new knowledge was shared and the process of science learning demonstrated.

In comparison, T3 in ELC3, who also had previous experience in ECE, described herself as being unsure about the learning and teaching of science for the 3- and 4-year old children. Based on previous experience, T3 considered that teaching science to older children was more appropriate because science concepts were easier for older children to understand. Further, T3 chose not to seek professional learning to address her degree of uncertainty about bringing science to younger children because she held the view that ECE learning and teaching should emphasise literacy and numeracy (Semi-structured interview, T3, 13.03.09).

The two vignettes that contributed to the case studies from ELC3 saw T3 place the reported science experiences into the hands of the researcher (in Case Study 4) and the EA (in Case Study 5). T3 was, therefore, not practically involved in the science activities recorded. Some thoughts and instruction about the direction and preparation of these separate lessons were provided by T3 to the researcher and the EA. Those learning and teaching arrangements, however, caused inconsistent approaches to science and uncertain outcomes for children's science knowledge. However, on a later date a classification activity used to develop language learning, by T3, brought an integrated connection for the children in Case Study 4.

Varying circumstances permeated the Case Studies 1, 2, 3, 4 and 5, with disparity in the development of science seemingly associated with educator beliefs and practice in that field. Other perspectives, however, associated with the general learning and teaching of young children, appeared similar. For example, emphasis on literacy and numeracy development, and differences in the ages and previous experiences of the children in their school situation were serious considerations by T1 and T3 when outcomes were discussed in casual conversations (T1, 11.08.08; T3, 06.03.09). In relation to the age of the children, in ELC1 they had had the experience of being at school for three school-terms, and were mostly four years old, or within one or two months of achieving that age. By comparison, the children in ELC3 were at least six months younger in age, than their counterparts in ELC1, and had less than one term's experience of learning in a school environment. Focussing on the ages of children in these two centres served to accentuate two areas of consideration for the educator: First, the vast differences in capabilities and competencies of 3- and 4- year old children; and second, beliefs about what children in this age group are capable of learning. These findings suggest that the *Active Role of the Educator* intentionally cater for gaps that appear to exist between individual children's experiences and skills, and own beliefs about children being able to understand science concepts at a young age, providing experiences were appropriate to their capabilities.

In further comparison between ELC1 and ELC3, where a qualified classroom teacher was responsible for the presentation of science learning and teaching, decisive results seemed to occur when the educator was instrumental in preparing the learning spaces and experiences. However, from the literature reviewed for this study, achieving optimal results for science learning and teaching would also include educators having knowledge of science processes and concepts, and the confidence to accurately guide children being taught. Confidence seemed to be a common factor that was missing for both educators: T1 explained she lacked knowledge in understanding scientific concepts and T3 devolved to others, the role of teaching science. The literature review also highlighted the need for educators to be thorough planners by being aware of children's prior knowledge and their capabilities, and also, to use resources that were appropriate and familiar. Regrettably, those points were not always visible in the pivotal role of the educator, as the following case study examples serve to illustrate.

While accommodating the underlying factors of governing policies and personal belief, variances between pedagogy and strategies used by T1 in ELC1 revealed differences between Cases Studies 1, 2, and 3. For example, behind the self-directed learning that occurred in Case Study 2 (*A sound difference)* it appeared that an educator was not involved. Although not overt, T1 played a significant role as a facilitator in Case Study 2 that brought about the enhancement of scientific knowledge for three children. In the first instance a learning space was prepared with appropriate resources. Second, children were encouraged to playfully follow their own line of investigation and third, when the children had investigated but could not fathom what caused the change they found, the educator listened to their experiences and helped them, through discussion and demonstration, come to terms with the science concept they were seeking. It was found that T1 had reflected upon previous learning by the focus children, knew their learning style and needs, and accordingly, planned so the children's current knowledge could be advanced.

In contrast, the two other case studies from ELC1, "*You eat it when you watch TV*" and "*Now can I draw a spider?*" saw the educator control the lesson and limit interactive engagement by the children. Further, their present capabilities and ability to contribute to learning did not appear to be recognised. Other variances between Case Studies 1 and 3 appeared. Children in Case Study 1 were familiar with the resources used and invitational questioning elicited their current knowledge. In Case Study 3, children were unfamiliar with the resources and were not invited to engage in dialogue to help them understand concepts associated with the experience. Case Study 1 ended when the demonstration was over with no apparent follow-up to extend learning, yet Case Study 3 involved a follow-up activity that required the children to draw a pictorial representation of the process of 'Magic Milk' for a portfolio inclusion. Between the three case studies from ELC1, Case Study 2 indicated a socio-cultural approach, whereas Case Studies 1 and 3 did not.

The two case studies that came of science experiences held in ELC3, Case Study 4 *"They're not Toys!"* and Case Study 5 "*Uh-oh. Wet Shoes!*" were each developed by educators other than the qualified classroom teacher, T3. Case Study 4 was implemented by the researcher who had previous experience in teaching science; Case Study 5 was conducted by EA1 with uncertain experience in this field. The focus children in Case Study 4 were guided with strategies that included scaffolding and ZPD to develop the process of classification, whereas the children in Case Study 5 were seen to participate in their water pouring activity without direction or specific guidance. Because T3 chose to hand over the practical science teaching to educators who did not have insightful knowledge about the children in Case Studies 4 and 5, the outcome of these science experiences varied.

The foregoing discussion reveals that meaningful comparisons between methods employed by like-qualified educators are difficult to make. It is important to note, however, that although both classroom educators had achieved the same pre-service university qualifications, differences in capability came to light. Where one felt confident to teach science and thought it appropriate for ECE, the other felt less confident and articulated that science was an inappropriate inclusion in the curriculum for 3- and 4- year children. Correspondingly, inconsistent beliefs between ELC1 and ELC3 about the value of science in the ECE curriculum became apparent during this study's cross-case analysis. Furthermore, where both T1 and T3 supported the notion of a socio-cultural learning environment, regrettably, evidence of that perspective was not consistently visible in either ELC.

Differences in pedagogy and strategies used in ELC1 and ELC3 stressed the importance of the educator knowing the current capabilities and cultural understanding of the children to which science was being taught. Similarly, active participation by the educator in the science experiences was found to be pivotal if children were to be helped to find the true meaning of a situation. On the one hand, assistance by knowledgeable others typically meant that the development of a correct science concept was more likely to occur. When an educator intentionally provoked, supported and challenged learning, skills were honed and cognition heightened while the understandings about scientific concepts deepened (see for example Case Studies 2 and 4). On the other hand, a disservice appeared to be brought to bear for children's science learning when attention to their capabilities questions and desire to learn did not seem to be an action by the educator. Examples of these instances came to the surface in Case Studies 1, 3 and 5, and were compounded when the educators acknowledged having little understanding of the science concepts being developed.

Successful engagement in science learning was found in case studies where the *Active Role of the Educator* accentuated connections between new learning and children's current understanding of a concept. The positive consequence of pedagogy using appropriate tools, unambiguous instructions and modelling actions for children to copy also appeared to have been advantageous for science learning and teaching in this study.

The *Active Role of the Educator* to guide science from a socio-cultural perspective involves having knowledge of the social and interactive complexities of learning for young children and recognition of the interrelationships that occur between the physical attributes of a learning environment, the people and the objects within that environment. To guide those interrelationships the SCALTELC-S framework has been developed to provide guidance for educators as it elaborates the major and underlying elements found to contribute to the holistic and complex nature that permeates young children's science learning.

6.5 Summary

Research sub-Question 2.1 asked: *To what extent does effective learning and teaching of science take place and under what circumstances?* The circumstances that formed a basis for effective learning and teaching of science were found to be reliant upon essential guidance and pedagogical strategies presented by a confident and competent educator who supported the uniqueness of children' learning, and connected their prior knowledge to current learning situations. The extent, to which this effective learning and teaching of science took place, was found to be inconsistent.

Research sub-Question 2.2 asked: *To what extent does the learning and teaching of science appear to be informed by socio-cultural theory?* The study revealed that science learning and teaching was best served from a socio-cultural perspective. However, from the cross-case analysis, the degree with which this perspective was applied was found to be inconsistent. In situations where children's interest was ignited by the relationships between the people, objects and the learning environment the interactive learning circumstances reflected those prescribed by socio-cultural theory. Therefore, science learning and teaching appeared to be informed by socio-cultural interactions that accentuated children as capable, inquisitive social beings who learn in the company of others.

Research sub-Question 3.1 sought to find, *What can be learned to inform the enhancement of learning and teaching of science for 3- and 4- year old children in ELCs?* To enhance science conceptual understanding for young children it was decisive that the active role of the educator was paramount. In that role, the educator would own a firm understanding about the complexities associated with young children attaining and retaining new knowledge. Further, circumstances created to enhance science learning and teaching for 3- and 4- year old children would be intentionally introduced, or familiar to the children, so that internal and external processes of learning could be united, as indicated by socio-cultural theory. Evidence gained from this study suggested that an educator be actively engaged in science learning and that several opportunities, using diverse strategies are presented to develop the notion of a new science concept, and acknowledge the dissimilar capabilities of the children they teach. In light of these findings, the interrelationships between the practical and theoretical elements of the SCALTELC-S framework would enhance educators' information and enlarge opportunities to develop the learning and teaching of science.

Chapter 7

Review, implications and conclusion

7.1 Introduction

The purpose of Chapter 7 is to present a summary of the study and a synthesis of its outcomes, specifically in relation to the four Research Questions that guided it. Following the summary provided in the next section, the chapter addresses each of the Research Questions in turn. For the first three Research Questions, the study's outcomes are distilled from Chapters 2, 3, 5 and 6. Addressing the fourth Research Question, however, required new reflections on the implications of the research. While recognising the study's limitations, as outlined in Chapter 1, it is useful to reflect on the ways in which the findings can inform future research and practice. These reflections are presented as implications in four sections: for practice; for undergraduate training of ECE teachers; for the professional learning of ECE educators in ELCs and settings other than schools, including Playgroups; and for future research and theory. A conclusion of the study ends the chapter.

7.2 Summary of Study

This study set out to find what science currently looked like for 3- and 4- year old children in ELCs and, whether or not that science reflected socio-cultural theory. It reflected the curiosity which had grown in the researcher during a career that has spanned more than two decades as an educator of children in ECE. It was timely in the sense that, especially during the preceding decade, ECE, both nationally and internationally, had undergone many changes that bear directly on the operation of ELCs. It was also timely in the sense that there is an increasing recognition of the significance of science for young children, and therefore a need for more knowledge about the reality of science learning and teaching in ELCs.

The research began with a preliminary overview of relevant literature that led to the framing of the study in terms of socio-cultural theory and the formulation of four major Research Questions to guide the study:

Research Question 1

How is the learning of science by 3– and 4- year old children in ELCs informed by a social-cultural approach?

Research Question 2

To what extent are the science learning opportunities provided in three ELCs for 3- and 4- year old children informed by socio-cultural theory?

Research sub-question 2.1

To what extent does the effective learning and teaching of science take place and under what circumstances?

Research sub-question 2.2

To what extent does the learning and teaching of science appear to be informed by socio-cultural theory?

Research Question 3

How can the learning of science by 3- and 4- year old children in ELCs be advanced by the use of pedagogical strategies derived from a socio-cultural approach.

Research sub-question 3.1

What can be learned to inform the enhancement of learning and teaching of science for 3- and 4- year old children in ELCs?

Research Question 4

What implications do the findings of this study have in relation to the refinements of socio-cultural theory and the learning of science by 3- and 4- year old children n ELCs?

These questions were addressed systematically and rigorously. First, Research Question 1 was answered by means of an extensive review of the literature, which resulted in an initial theoretical framework to underpin the study. As described later in this chapter, the framework, with the acronym SCALTELC, was refined progressively throughout the study and informed by findings of the empirical research carried out.

Research Question 2, and its sub-questions 2.1 and 2.2, called for an investigation into what was actually happening in relation to science learning and teaching in the ELCs. The research sites selected for the study were three ELCs in metropolitan Perth, Western Australia. Appropriate methodology and methods were employed to allow for the pragmatic nature of the study and the very young age of the children participating. An interpretive research paradigm, using grounded theory and ethnography, with multiple methods of data collection and a multiple case study design were utilised (see Chapter 4). Responses to the first and second sub-questions of Research Question 2 were developed from the seven case studies that were constructed from the empirical research. These are presented in Chapter 5.

Data were collected during a total of 22 visits to the three fully operational ELCs (designated ELC1, ELC2 and ELC 3) as shown in Table 4.2. Specifically, 11 3- and 4- year old 'focus children' drawn from the total population of 56 children in the three ELCs, participated in a variety of scientific pursuits as individual investigators, as collaborative contributors in small group work or as participants in whole-of-class science related activities. Data collected from the activities were then used in the construction of the seven case studies. Five of these were framed around close and intensive observation of a small number of focus children – either as individuals, in pairs or threesomes. The other two case studies involved whole class participation. The synthesis of all case studies, by means of a cross-case analysis, built a broader and more sophisticated picture of science learning and teaching in the three participating ELCs. From the analysis (as seen in Chapter 6), common and unique factors emerged to describe principles and applications of science engagement in these ELCs.

The major (and unique) outcome of the study as a whole is that it fills a major gap in research and theory in this area, through

- An in-situ study that emphasises the development of science studies for 3- and 4-year old children
- The SCALTELC-S framework which applies to the learning and teaching of science in an ELC context and has potential to inform future practice in this area
- Seven vignettes depicting the pragmatic experiences of children engaged in science activities in three fully operational ELCs and presented as seven case studies
- A cross-case analysis, which highlights the commonalities and unique factors that contributed to the findings of science experiences in the three participating ELCs
- Pointers to possible enhancements and directions in pedagogy, policy and research in relation to science learning and teaching for young children

These outcomes are developed more fully in the remainder of this chapter.

Throughout this study and in the interpretation of the findings and the consideration of their implications, the researcher was acutely conscious of the possible limitations of the research design. She was aware that the study achieved glimpses, rather than longitudinal examples of the application of science in the participating ELCs and that the findings might not be generalisable beyond the immediate context of the research. As described in Chapter 1, the limitations reflected researcher bias, ethical issues, constraints related to the spontaneous nature of children less than 5 years of age and impending policy changes impacting on educators' principles and practice within the participating ELCs. As also described earlier, strategies were implemented to ameliorate these limitations.

7.3 Answering Research Question 1

7.3.1 How is the learning and teaching of science by 3- and 4- year old children in ELCs informed by a socio-cultural approach?

To establish information related to Research Question 1, an extensive review of relevant literature was undertaken. This revealed significant gaps in relation to research on the learning and teaching of science for 3- and 4- year old children. As discussed in Chapter 3, relevant literature tended to support the theory of learning and teaching from an educator's point of view rather than that of the child. Where specific examples, related to the child's engagement in science, were provided, they were more likely to relate to children older than those in this study, or did not provide ages of the children.

The purpose of the literature review was threefold. The first part emphasised ECE generally and related to learning and teaching for 3- and 4- year old children in ELCs. The second part reviewed the extent to which that information appeared to be situated within socio-cultural theory and revealed, to this researcher, a number of key elements associated with this approach. These elements (namely: *Interconnectedness, Communication, Cognitive Development, Learning Environments, Play-based Learning* and the *Active Role of the Educator)* were represented in the initial theoretical framework (SCALTELC) generated for the study (see Figure 7.1, p. 256). The third part of the literature review sought to link the first two parts to find how science could be developed for young children. Specifically, Chapter 2 of this thesis reviewed literature in relation to how young children developed ECE <u>in general</u>, while Chapter 3 focussed on how that ECE applied to the development of <u>science</u> in ELCs. Together, Chapters 2 and 3 explored the complexities of learning and teaching from a perspective derived broadly from socio-cultural theory; at first generally, and then specifically in relation to science.

The literature revealed a large amount of information about the characteristics of learning for young children. Overtly, a link between children's intrinsic motivations, their curious nature that tends to be related to extrinsic stimuli, and the importance of social development to support their early education, was established. Those links connected information about the principles and practices associated with learning and teaching to maximise children's potential in ECE and supported a view that, generally, young children are curious participants with a preference to be socially and actively engaged. It was agreed within the reviewed literature that children bring to their ELC a body of knowledge and skills accumulated from their personal experiences and cultural understandings, developed from birth and, typically, under the guidance of their family.

ECE was documented throughout the literature as a complex and dynamic affair that required multifaceted learning and teaching strategies for beneficial education to occur. Within that complexity, maturation of social and emotional development and the child's well-being were emphasised as important components to be established for notable cognitive gains in early learning situations. Generally, the constant cognitive interplay that simultaneously occurs between intrapersonal understanding and interpersonal information, within the context of their own historical and cultural knowledge, children form relationships between their prior knowledge, other people and environmental circumstances to conceptualise new ideas. These points of view are widely discussed in literature and frequently linked to Vygotsky's socio-cultural theory.

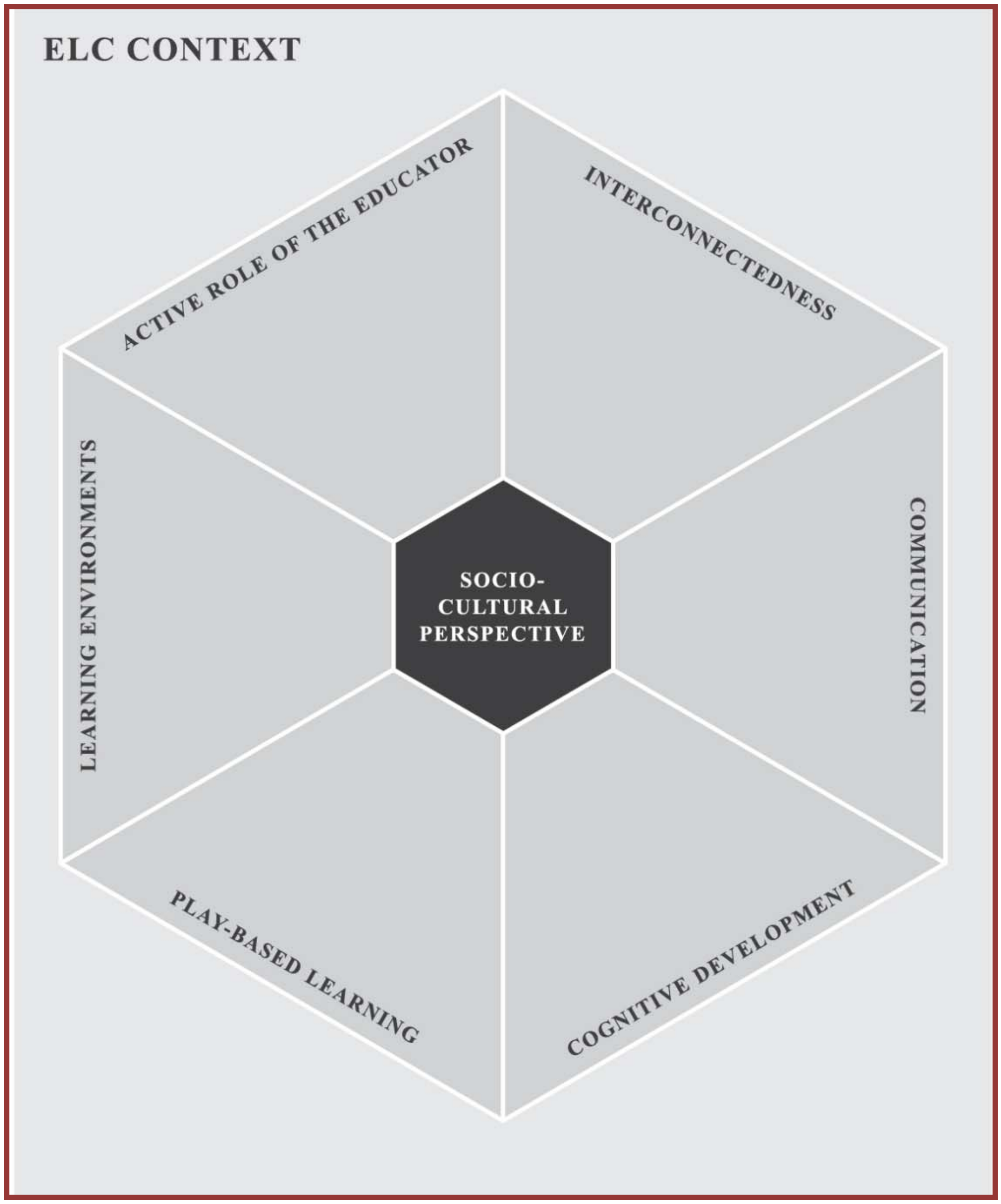

Figure 7.1 The initial SCALTELC theoretical framework

The review of literature in Chapter 3 specifically emphasised the interplay between the original six practical and theoretical elements of the SCALTELC framework to inform science learning and teaching, in an ELC context. To distinguish the science approach, from the view of general learning, the name of the framework now included Science in its title. The original acronym had the letter S added to become SCALTELC-S (see Chapter 3). The elements of the SCALTELC-S framework were then explored for their capacity to empower practice and pedagogy associated with teaching science, and in line with the holistic learning of young children.

7.4 Answering Research Question 2

7.4.1 To what extent are the science learning and teaching opportunities provided in three ELCs for 3- and 4- year old children informed by socio-cultural theory?

Research sub-question 2.1

To what extent does the effective learning and teaching of science take place and under what circumstances?

Research sub-question 2.2

To what extent does the learning and teaching of science appear to be informed by socio-cultural theory?

In the empirical research carried out as part of this study, opportunities provided for children to engage in science activities were found to come in three forms:

- as an individual investigation where children followed a personal interest (see Case Studies 6 and 7)
- from small group activities that generally enabled children to either make their own discoveries or collaborate with others (see Case Studies 2, 3, 4 or 5)
- whole-of-class demonstration lessons where children participated as a whole group (see Case Study 1 and partly, Case Study 3).

In the Playgroup situation of ELC2, the social and collaborative nature of a socio-cultural approach was evident when two individual investigations were recorded as case studies and later analysed. Learning spaces in this centre were furnished with resources designed to provoke curiosity and imagination in young children. Parents (as educators) were found to be always at hand to assist children as they pursued their interests in play-based learning, either individually or in the company of other children. In this situation, Case Study 6 (*Skater Boy*) and Case Study 7 (*Warm crayons work*) revealed that two young boys individually and actively engaged in their own investigations. Although they preferred to work mostly alone, the social atmosphere of the centre enabled interaction with an audience of onlookers, when the boys thought it necessary to engage other people. In Case Study 6, for example, Skater Boy's communication revealed him to be well informed about the rudiments of makings a skateboard. Although he worked independently Skater Boy engaged bystanders with a commentary of actions through the use of self-talk as a method of keeping his audience informed of his progress. Without assistance he appeared to use his prior knowledge to follow his own scientific process to design, make and test the construction of a skateboard. Not long after that construction activity, Skater Boy was seen to transfer his new knowledge to the building of a ramp, suitable for skateboard use.

The interrelationship amongst elements of the SCALTELC-S framework was found to be particularly evident in Case Study 6. The interconnectedness between self direction, available tools and cultural information from other people appeared to be the stimulus for Skater Boy's new ideas. Although cognitive development cannot be seen, behaviour during Skater Boy's investigation, that included trial and error and self-talk when modifications were made to his model skateboard, was interpreted as links between implicit knowledge, explicit stimulus and new action. Cognitive knowledge, gained from his model making, was then transformed for a new situation, for example, when he discussed the width of a ramp required to carry his skateboard. Verbal and non-verbal communication was made through Skater Boy's announcements, his self-talk, the 3D image of his construction, and body language. Playful interrelationships between the appropriate use of space and resources also contributed to his learning. Missing from the interrelationships amongst the elements of the SCALTELC-S framework was the active role of the educator. Had an educator been involved, the boy's learning opportunities may have been expanded through the concept of a ZPD and pedagogical strategies that included scaffolding.

In the same learning environment (ELC2) Crayon Boy1, involved in Case Study 7, also used an individual approach to develop his initial concepts about crayons. However, this boy chose to engage an educator during his investigations. In doing so Crayon Boy1 clarified his understanding that when warmed, crayons worked more effectively. In both Case Studies 6 and 7 opportunities for the learning and teaching of science occurred incidentally, and from an individual pursuit. Where child-centred engagement in play-based scientific investigations was central to these cases, it was found that, without the active role of an educator to extend conceptual knowledge and associated skills, development was limited to the children's current range of understanding and capabilities.

Generally, educators in each of ELC1, ELC2 and ELC3 held a view that small groups of children would collaboratively pursue investigations that benefited integrated learning. Thus, specific learning spaces were mostly constructed with resources chosen by an educator to inspire interactive and purposeful investigation by the children, as seen in the preceding examples and in Case Study 2.

Case Study 2, ELC1 (*A sound difference*), revealed small group work that enabled three young children to advance their scientific knowledge related to the changing pitch of sound: initially, by chance discovery and then under the guidance of an educator. The open-ended conditions of this experience included the use of resources that were familiar to the children who were the focus of this case study. The children's confidence appeared to be related to a familiar situation that enabled them to integrate a variety of interactive investigative methods to solve what they viewed as a complex problem. After narrowing possibilities for a solution, the children were assisted by an educator. The educator posed open ended questions and guided actions that helped to draw the investigation to a satisfactory conclusion for the children. The uninterrupted opportunity for children to collaboratively develop an understanding to their self-selected science investigation reflected a socio-cultural approach. In terms of the SCALTELC-S framework, this small group work revealed interconnectedness between the children's prior learning and explicit collaborative actions to gain understanding of their problem. To attain new knowledge cognitive development appeared to occur as ideas were discussed and sequentially tested. Results were then communicated between the three focus children and other children in the classroom. Strategies used in Case Study 2 included the preparation of an appropriate environment with resources designed for play-based learning. Then, in an active role, the educator used dialogic communication to help the children reflect their scientific process and embed new knowledge.

The use of small group work was also explored in Case Studies 3, 4 and 5. It was noted that, although Case Studies 4 and 5 were both enacted in ELC3, they produced dissimilar results. Case Study 4 (*"They're not toys!"*) reflected a socio-cultural approach when guided teaching strategies helped children, who were the focus of this case, develop a scientific process. In an environment purposefully constructed by the educator, and acting on the children's prior knowledge, new learning was consolidated during self-directed, play-based learning that followed initial guidance by the educator. Newly acquired science skills were then rehearsed, discussed and connected, by the children, to familiar family situations.

By way of contrast, the outcome of the small group investigation reported in Case Study 5 (ELC3,*"Uh-oh, wet shoes"*) did not appear to represent effective science learning and teaching, notwithstanding that the equipment and materials used were purposefully selected by an educator in ELC3, and children's social interaction engaged (as occurred in Case Studies 4 and 5). Instead it was found that in the absence of an active role by an educator during the science experience, the learning objectives were unclear and the opportunity for children involved to advance their learning appeared to be limited, incidental and disconnected. Case Studies 4 and 5, from the same ELC, indicated that although the components of a socio-cultural approach and interrelationships within the SCALTELC-S framework were found, the outcome of the learning and teaching of science was different, the main difference appearing to be the absence of educator guidance in Case Study 5.

In Case Studies 1 and 3 (ELC1) social collaboration and interactive engagement were found to be controlled by the educator, thus emphasising that a socio-cultural approach may not fit well within whole-of-class demonstration pedagogy. From the perspective of the SCALTELC-S framework, marginal interrelationships were enacted in Case Studies 1 and 3 as the children's contribution to their own learning was sought by the educator rather than being driven by child curiosity or interest. Additionally, children's background knowledge and capabilities did not appear to be applied by the educator in a way that would enhance their scientific learning in these case studies.

Overall, the circumstances in which young children were actively engaged in successful science experiences in the seven case studies were found to occur when, overtly or covertly (S. Edwards, 2009), a socio-cultural approach assisted science learning, as in Case Studies 2, 4 and 7. Those circumstances came into view when the educator enabled the children to be active participants in their own learning, and when the learning environment acknowledged prior cultural knowledge and skills. During social interactions between children, or children and adults, social communication seemed to liberate curiosity and stimulate cognitive development suggesting that social collaboration and scaffolding assisted new learning.

Although commonalities and unique factors were found across the case studies, overall the opportunities for 3- and 4- year old children to engage in science experiences revealed differences amongst case studies, and between the ELC contexts of this study. In some cases, those differences appeared to be linked to a lack of consistency in the application of science experiences. Therefore, socio-cultural activities also varied.

7.5 Answering Research Question 3

7.5.1 How can the learning and teaching of science by 3- and 4- year old children in ELCs be advanced by the use of pedagogical strategies derived from a socio-cultural approach?

Research sub-question 3.1

To inform the enhancement of learning and teaching of science for 3- and 4- year old children in ELCs, what can be learned?

The success, or otherwise, of science experiences provided for children in the ELCs of this study were revealed in the cross-case analysis used to synthesise the seven case studies (see Chapter 6). From that analysis factors emerged to indicate what could be learnt from the application of the socio-cultural approach to enhance science learning and teaching in ELCs. These factors related to practical and theoretical learning and teaching and contextual circumstances. Understandably, given the ever-present pressures of the teaching situation, the analysis indicated that teaching strategies were at times inconsistently applied and, therefore, did not always advance science learning for the young children in this study.

When educators were alert to what children already knew, enabled them to participate in their own learning and applied pedagogy that extended their established knowledge, and helped them gain confidence within new experiences, positive outcomes followed, as seen in Case Studies 2, 4 and 7. In contrast, it appeared that when platforms for new learning were not informed by children's prior knowledge, science learning and teaching experiences tended to go awry (see Case Studies 3 and 5 for example). It was learned from the analysis of the seven case studies that it was not just the collection of children's prior knowledge that counted, but rather how that cultural information was used that affected the advancement of science experiences (see Case Study 1).

The suitability of learning spaces within the ELC environment and the appropriateness of the resources used were similarly featured as factors that appeared to influence the children's science experience. Conflicting ideas, held between the educator and the children about what was, and what was not, an everyday object, (see Case Study 3, for example), were found to generally thwart learning if the situation was not addressed early in the experience. It was learned that successful outcomes were more likely to occur when the resources used to develop a science concept were either familiar to the children or introduced to them prior to new experiences, as indicated in Cases 2, 4, 6, and 7.

The analysis also revealed that the environments in which children learn contributed significantly to the science experiences in ELCs and confirmed that children do not learn in isolation, even when they appeared to be individually motivated by an investigation (see Case Study 6). Appropriate spaces, prepared to inspire children's curiosity and furnished with provocative resources, demonstrated the potential of prepared learning spaces and were found to assist the enrichment of children's knowledge and learning capabilities (see Case Studies 2, 4 and 7). It was revealed that an educator's consideration for children's capabilities and cultural understandings were important components when preparing a learning environment (as seen in Case Studies 1 and 4). On the downside, it was learned that an environment could be a distracting influence and knowledge building inhibited when science experiences were undertaken in an environment that was unexpected by the children (see Case Study 3 and Case Studies 5). Similarly, it was found that materials and implements, used by the children to develop a science concept, needed to be familiar to their cultural understanding before connections, held at their cognitive level, could be associated with the intended concept. Developing new concepts therefore, seemed to be advantaged when the children could question misunderstanding and playfully examine the implements in social situations, prior to using them as learning tools (see contrasting Case Studies 3 and 4, for examples).

Within planned situations and learning spaces, play-based collaborative learning enhanced science concept development through interactive and social encounters, as found in Case Studies 1, 2, 4, and 7. These circumstances appeared to motivate children to act as both learner and teacher (see compare and contrast activity in Case Study 1). Consequently, children were seen to be resourceful and capable of purposefully following a line of self-directed investigation (see sorting and classifying activity in Case Study 4). Through communicated connections and creative endeavours the children made new learning visible as they exchanged meaningful knowledge with each other (see testing predictions Case Study 2). That children were capable of informing their own learning became apparent in the cross-case analysis when they developed ideas collaboratively tested and evaluated their notions then transferred them to different situations (Case Studies 1, 2, 4 and 7 provide examples). Children's self-directed learning in play-based circumstances was also seen to be assisted when the strategy of scaffolding, for example, was incorporated by an educator who could confidently guide and consolidate new science learning (see Case Studies 4 and 7). In each of the case studies children were found to interchange their roles between being the informer, or the informed, in response to their own need and the needs of others.

Highlighted actions that were found to enhance science learning included multidimensional opportunities for children to engage in learning experiences that started in line with their current capabilities and understanding (see Case Studies 2, 6 and 7) and included modelling or scaffolding desired actions (see Case Studies 1 and 4), using multiple representations to review cognitive understanding (see Case Studies 2, 3, 4, 6 and 7) acting out the process of sequencing, i.e. thinking out loud (see Case Studies 2 and 6), and collaborative connections in the ZPD (see Case Studies 2, 4 and 7). These actions, as found in the socio-cultural approach to learning and teaching, seemed to assist cognitive development and encourage the interconnectedness of science within the day-to-day lives of children and their integrated curriculum learning. Moreover, it highlighted the necessity of an educator to take an active role in the learning/teaching situation.

It was learned from the cross-case analysis that time management was a major factor for educators and children, in that it served to either assist or hamper experiences designed to develop scientific concepts across the cases. In the literature reviewed, the importance of routine and rhythm for young children's learning was acknowledged. The cross-case analysis confirmed that unhurried time to contemplate the makings of their immediate investigations appeared to suit the learning style of the young children in this study. That unhurried approach was reflected in Case Studies 6 and 7 from the ELC2 Playgroup.

However, the whole-of-school timetable and formal learning situations found in ELC1 and ELC3 caused angst for T1 and T3 due to shared learning areas and an inflexible timetable that seemed to truncate the development of science learning situations (see Case Studies 1, 3 and 5). Nonetheless, success in relation to whole-of-school timetables appeared to be greater when lessons occurred inside the ELC1 and ELC3 classrooms because educators could exercise some flexibility to suit a learning situation, as seen in Case Studies 2 and 4. From the examples in Case Studies 3 and 5 it was apparent that flexible lengths of time to develop science related concepts are also desirable for out-of-classroom experiences.

An essential strategy for the enhancement of science knowledge seemed to be connected to multidimensional pedagogical planning. Efforts by the children in Case Study 5 to make sense of their situation indicated unforeseen competency not taken into account when the activity was planned. In the absence of planning that anticipated, accommodated and aimed to enhance the competencies of children to develop a science concept, expected learning did not appear to be achieved. Similarly, Case Study 3 revealed the importance of thorough planning so that children's current cultural understandings could be meaningfully connected to new experiences.

Generally, it was found that children spontaneously made the best of any learning situation. Where possible, they intuitively made adjustments to circumstances for their own benefit (as seen in Case Studies 2, 5 and 6). Whether the adjustments that children instinctively make are to inform new learning, accommodate their learning style, match capability or to link current conceptual information is uncertain but it is useful to know that typically children can, and will, adjust their engagement in a learning situation according to their need. Accordingly, framing open-ended learning situations that aim to accommodate the apparent array of developmental needs of children highlights the essential place of thorough planning by an educator so that suitable science learning and teaching can occur for 3- and 4- year old children.

Integrating science across the curriculum has been advocated by some researchers as an ideal to aim for. In this study, however, the integration of science with other learning areas was a strategy overtly presented in just one of the seven cases analysed (Case Study 1). Vague examples were found in Case Studies 2, 4, 6 and 7 when music, literacy and/or mathematics were loosely aligned with science learning. Overall, in this study, science was typically represented in the curriculum as a discrete subject.

In recognition that the impetuous learning styles that some children use when they divert from the educator's planned strategies, it was learned that competent educator knowledge to develop science concepts is also required to ensure conceptual knowledge is accurate and useful. Educators who could help children make meaningful connections between what they already knew and new learning situations appeared, in this study, to be successful in helping them reconstruct information. On the whole, the cross-case analysis reinforced that effective science learning and teaching for 3- and 4- year old children occurs under the guidance of a well-informed educator when empirical activities and multifaceted connections are in harmony (either knowingly or unknowingly) with a socio-cultural approach.

Figure 7.3 is presented here to reiterate the factors that emerged from the cross-case analysis and initially revealed in Figure 6.1. These factors contributed to science learning for 3- and 4- year old children, in this study, in the context of an ELC.

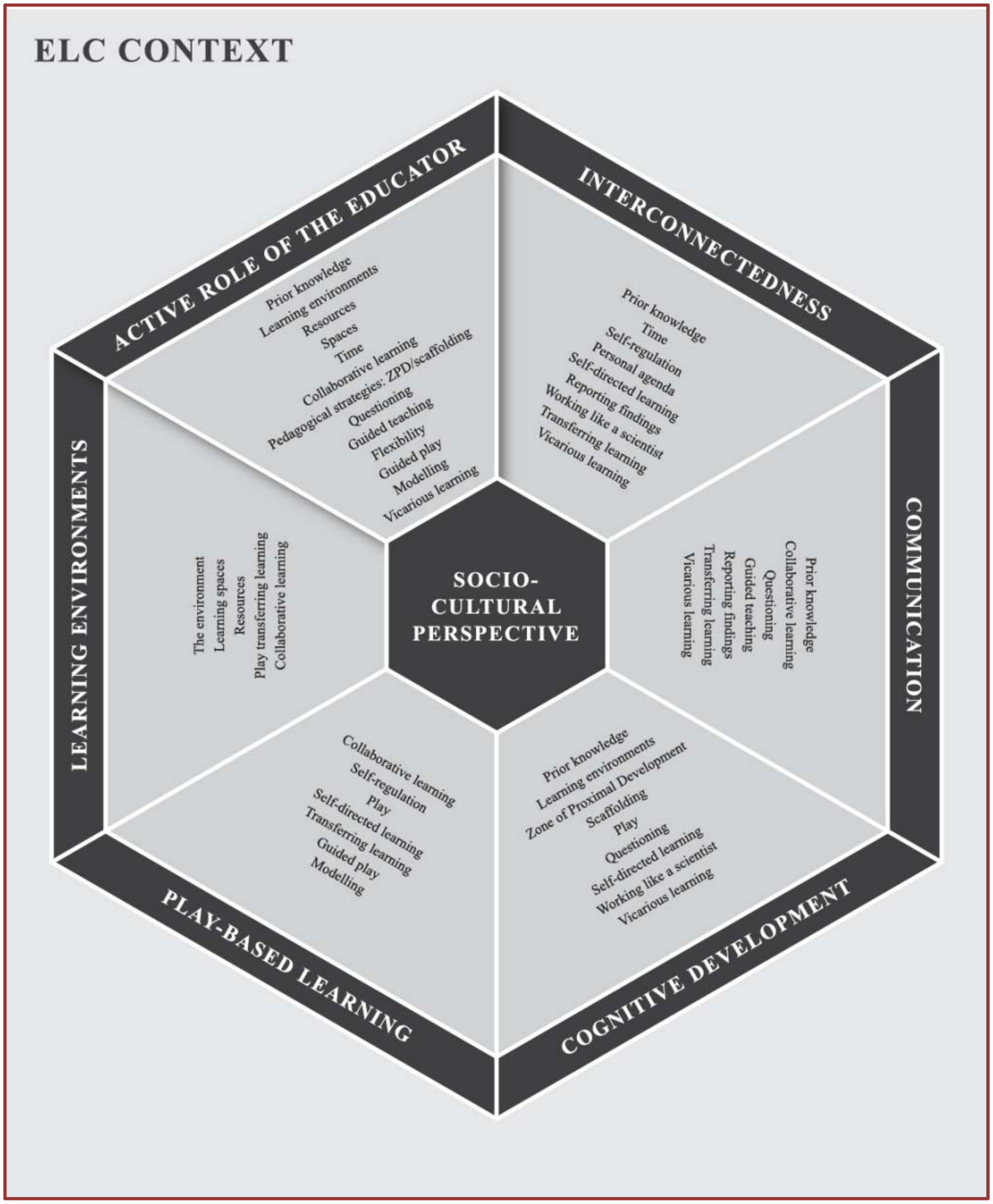

Figure 7.2 The evolved SCALTELC-S framework

7.6 Answering Research Question 4

7.6.1 What implications do the findings of this study have in relation to the refinements of socio-cultural theory and the learning of science by 3- and 4-year old children in ELCs?

Considered reflection on the findings of this study reveal its possible implications for practice, theory and research related to the learning of science by 3- and 4- year old children in ELCs. These are discussed below.

7.6.2 Implications for practice

Where many helpful strategies and supporting pedagogy were found to advance science for early learners across the seven case studies, disconnected practices were also found in the ELCs of this study. Implications are that, when disconnected science experiences do not reflect the reality of the children's cultural place in the world, or their capabilities, practice does not serve to advantage the development of their science skills and concepts.

Educator beliefs regarding the practice of including science experiences in the daily teaching programs for 3- and 4- year old children differed in participating ELCs. Although T1 considered science to be a worthy inclusion in the ECE curriculum, T3 did not. From parent educators in ELC2, the response was mixed. While two parents supported the inclusion of science experiences for young children, another suggested science was a subject to be experienced later in their school life. There was, however, found to be an overriding emphasis from all parties that implied science was not as essential as were literacy and numeracy in the ECE curriculum. Nevertheless, in light of recent and continuing changes in both ELCs and ECE that are working towards stronger beginnings for children in the earliest stages of schooling, educators are required to rethink the early learning experiences they provide for young children and how those experiences are delivered.

The practice of using the children's prior knowledge to inform planning for science experiences appeared to be generally undervalued in the three ELCs in this study. This finding implied that, for science learning and teaching to match the reality of the children and benefit their learning the practice of starting new concepts from a known place, as recommended in the socio-cultural approach, was essential. Likewise, a fundamental understanding of science conceptual knowledge is required to be used by the educator if learning is to be accurately enhanced in teaching situations. Abstract conceptual knowledge seemed to be missed in Case Study 1 when the application of heat to change matter was not discussed to help children make connections between cause and effect. In contrast, guided learning helped make 'cause and effect' concepts visible in Case Studies 2 and 7.

Current perceptions held by children, about their close and immediate world, would imply a stable place to secure new science learning. However, overall, this study did not find that science experiences were being refined to establish a basis for future science studies. Instead, science was generally found to remain a ‘stand-alone’ subject without multiple and repetitive representations of a concept being presented to the children. This finding did not appear to augur well for future development of science and suggested that children were not always seen for the thoughtful competent and capable learners they are.

Prominence placed on the overriding importance of literacy and numeracy development in ECE is a compelling one and identified as such by the focus children in Case Study 4. They voiced their concern about taking part in science learning while other children appeared to be learning to read. To address the children’s immediate concern and illustrate the integration of literacy with science, the name of objects under investigation was written onto cards. These words were then read and rehearsed in the context of the activity. Likewise, the objects were counted to incorporate math as they were placed into groups. The action amplified socio-cultural benefits of interdisciplinary learning and teaching, and implied that science is not a ‘stand-alone’ subject but rather, one that contributes to other areas of the curriculum.

Typically, children throughout this study appeared to hold a genuine desire to learn. However, the consequences of some practice that seemed to lack preparation caused a few children to become perplexed thus, new learning was, at times, jeopardised. This finding implied that educators have an obligation to be knowledgeable about the complex nature of children's learning, and hold a competent understanding of the science concepts they are teaching.

The overall implication is that, ideally, successful practice for science learning and teaching will be directed by educators who know how to create, and facilitate multiple experiences and intentionally provoke imaginative learning. A fundamental tenet of the implications presented in this study is that building scientific knowledge, onto which future learning can be placed, is achieved when explicit pedagogy is foregrounded by a deep knowledge about how learning is structured. The SCALTELC-S framework has been specifically developed so educators may better understand that the complexities and implications of science learning and teaching for young children are achieved by intentionally supporting and balancing children's interests and capabilities, alongside sound conceptual knowledge and effective pedagogy.

Overall, three major implications appear to reflect refinements that would benefit the future practice of science in ELCs. First, for strong early learning in science, concepts need to begin from a place of knowing and be associated with children's immediate world and their everyday experiences. Second, to encourage children's future ambition in science-related subjects, emphasis on the reality of the subject is required from well informed educators, starting in ELCs. Third, robust advocacy is required to present a positive image for the holistic learning of science and its place in ECE.

7.6.3 Implications for initial training of undergraduate ECE teachers

The initial training for undergraduate ECE teachers in the field of science was not an area investigated in this study, being well-documented in other research (see Howitt, 2007; Pearson, 2002). However, findings in this study implied that the initial training of the educators with a role to play in science for 3- and 4- year old children in ELCs did not provide a consistent level of understanding, for educators, about how to, or in fact whether to, include science in their day-to-day ELC practice.

Two of the three ELCs of this study did not reflect contemporary thought that science for young children evolves from natural curiosity. Instead, in the ELCs attached to larger schools, it appeared that qualified educators included science in the learning and teaching program as a matter of policy direction and timetabled planning rather than developing science as an integrated subject according to the capabilities and interests of the children.

Creating science for the sake of science could curb individual thinking and discovery, and carry a possibility of dislike for the subject. Implications are that, if the prominence of science is advocated in the initial training of ECE teachers, future practice can aim to amend the possibility of this problem. Emerging science skills developed in ELCs can, in a small way, offer a foundation for future academic journey into the sciences. This implication resonates for teacher educators in the preparation of training manuals and direction for practical applications of science during undergraduate pre-service ECE teacher training.

Facilitating new science learning and teaching ideas that demonstrate empathy with how young children learn, acknowledges the principles and practices of the EYLF (DEEWR, 2009b). However, as stated by Campbell and Jobling (2012), when discussing implementation of the EYLF "…it is up to each individual educator to be open and to search for opportunities to embed scientific skills, knowledge and processes into everyday programming" (p. 20). These comments appear to reflect some of what was occurring in the ELCs of this study and implied that, for meaningful science learning and teaching to occur, new educators would require guidance so they may be equipped to find and recognise the appropriateness of experiences, and opportunities within those experiences, to develop science for young learners. Consequently, when educators are not disposed to include science in their learning and teaching programs, and without a syllabus to assist graduating teachers, science in the ELC curriculum may be avoided and children's intuitive learning skills not accentuated. These points imply that some direction is needed for graduating teachers.

The SCALTELC-S framework represents the theoretical and practical elements of learning and teaching in ECE that accentuate influences causing cognitive development to be constantly transformed for new learning. Further, the elements are anchored in recognition that children are connected to their world and involved learners with effective communication skills (DEEWR, 2009b). The SCALTELC-S framework appears to offer some potential to those responsible for undergraduate and early career education, in that it frames learning in a helpful and practical way.

7.6.4 Implications for professional learning of educators in ELCs

As indicated in Chapter 1 new directions and emphasis placed on integrated learning in ELCs are supported by recently adopted ECE policy documents, such as the EYLF (DEEWR, 2009b). In the case of children who have attained 5 years of age or more, the Australian Curriculum (ACARA, 2010) can guide science learning and teaching. These new directions, however, were not available when data were collected for this study, and do not specifically advocate the science needs for 3- and 4- year old children. Instead, a general ambivalence toward developing science for young children was found to underscore this study and from that situation the following question arose:

If the present practice of science in other ELCs is as varied and disconnected from other learning, as was found in the three ELCs of this study, how can that current approach to developing the skills and knowledge of science be improved for the advantage of young learners?

It was of concern to find that at the time of this study no recent professional learning, in relation to science, had been sought by the practising educators in ELC1 and ELC3, with more than four years of qualified teaching service. Also noted during casual conversations, neither educator was officially required to attain professional learning and teaching knowledge associated with science in ECE.

The participating classroom teachers attached to the ELCs of this study (as presented in 4.5.2) had, when this study took place, been qualified to teach for some years: T1 for 15 years and T3 for 12 years. Both educators gained their Bachelor of Education qualifications to teach Primary School children before the contemporary four-year-tertiary-qualification for ECE training became specific for educators attached to ELCs. Although neither T1 nor T3 had acquired specific ECE training, they each had considerable experience teaching ECE: T1 for 15 years and T3 for 4 years. In light of impending political changes to ECE, and in particular the outcomes of the learning and teaching of science in the ELCs of this study, an implication is that relevant professional learning for in-service educators that accentuates the relevance of science in the lives of 3- and 4- year old children be developed, sooner rather than later, to reach all educators.

The importance of pedagogical knowledge for the parents of children participating in Playgroups was also found to be significant. The Playgroup parent educators were in a position to prepare learning opportunities designed to encourage natural play-based investigations for their children, in the company of other adults and children. These parents had the advantage of being aware of their children's interests, their prior knowledge and potential to build skills ready for school entry. In recognition of that awareness stimulating learning spaces with appropriate resources to inspire curiosity and engagement were provided for general learning potential. Developing specific science knowledge and skills for the Playgroup children in ELC2, however, was not overt. This implies that the science investigations made by the focus children in this study came about when interested parent educators presented opportunities for children to discover science in their learning. Bearing in mind that the primary role of a Playgroup is to develop community identity and assist the development of social and emotional needs for the children before they begin school, specific assistance, in which science activities were highlighted, could be sought by parents through Playgroups Australia (see Chapter 1).

The findings of this study suggest that professional learning and designed pedagogical practices and theoretical positioning for those who play the role of educator in ECE were required for the enhancement of science prospects for 3- and 4- year old children. To achieve this, either professional ECE educators who are knowledgeable in the field of integrated science learning could advise ELC educators, or they could be supported by resources such as, *Planting the Seeds of Science* (Howitt & Blake, 2010). Further, professional learning designed to rejuvenate interest in and the appropriateness of science as a natural place to start learning and teaching should not be restricted to the qualified educators in ELC. The professional learning for EAs and other support staff in ELCs who play a critical role in the education of 3- and 4- year old children should also be included. For the greatest benefit, professional information about the early engagement of science for young children should stretch further than the physical ELC. This implication includes the involvement of significant others, and especially those in the role of administrating policy for ELCs. Grandparents and care groups in the communities where children's learning is informed are included in this implication, as opportunities to create playful places of wonder where guiding learning for children, in the field of science, is omnipresent.

7.6.5 Implications for future research and theorising

Implications of this study for future research and theorising are discussed here in terms of three critical needs in relation to knowledge about learning and teaching science in ELCs. The first need, emphasising the relatively limited existing research in this area, has been reiterated numerous times throughout this thesis. While this study has made some progress in addressing this need, more research is required, especially in the context of increased global attention to the education of very young children, and in the context of growing awareness of the importance of science learning for these children.

The second need emerged from the analysis of the empirical data gathered during this study. The importance of educators' beliefs regarding the value of science learning and teaching, and the influence of educators' previous knowledge and experience related to science teaching was revealed as critical to the effectiveness of the their actions as educators. Again, more research is required here, particularly focused on integrating learning with pre-service and in-service educators involved in ECE.

A third need relates to the lack of availability of suitable theoretical frameworks to support research and practice centred on the learning and teaching of science for 3- and 4- year old children in ELCs. Again, this study has produced one such framework – the SCALTELC-S – distilling it from the literature and elaborating the theoretical and empirical substance of the study. While the framework, SCALTEC-S, demonstrates considerable promise as a tool to inform further research and practice, this model was not intended to be a definitive statement about a socio-cultural approach in this new research area. Rather, both this and other frameworks have room for development and on-debate as future studies see them tested further.

7.7 Conclusion

Science and children are a natural combination because curiosity and asking questions are the speciality of both children and science. Typically children possess a curiosity that entices them into investigation and, when they have made a discovery, to reveal an innocent delight in new learning. Those characteristics are celebrated when the field of emergent science situates children in the reality of their immediate world. Science was found to accommodate the creative and spontaneous nature of children's pragmatic learning, and therefore augurs well for further development and long term research.

This study has emphasised that children can and do contribute to their own science learning through competent self-directed, interactive engagement and social collaboration. The intentional and well informed active role of an educator was also emphasised to provide the pragmatic circumstances in which that collaboration occurs. Science development appeared to produce the most satisfying results for 3- and 4- year old children within an amalgamation of purposefully planned learning and teaching scenarios that echoed the socio-cultural approach. From their evolving understandings of phenomena, children typically have a wealth of cultural and social understanding when they enter an ELC. In the world of science that permeates the lives of 3- and 4- year old children it is important that this wealth of knowledge is accepted, and incorporated, by educators who help children grow to understand the reality of their world.

AFTERWORD

"I have hated the words and I have loved them, and I hope that I have made them right" (Zusak, 2005, p. 528).

After a reflective look at the journey taken with this research, I find that Patton's comments are more significant now than they were when the journey began. Patton (1990) argued that the "human factor is the great strength and fundamental weakness of qualitative inquiry and analysis" (p. 372). My construction of this study has revealed the truth of that statement. I now see the process of analysis of qualitative data to be "a creative process" and that it is "a process demanding intellectual discipline, analytical rigor, and a great deal of hard work" (p.381).

Along with a willingness to be in a constant state of intellectual growth, hard work was the operative phrase. It is my greatest hope that the "hard work", as described by Patton, will find a way to significantly affect opportunities for improvement of science learning and teaching for the young children who are already making their mark on the world. This hope can be achieved in three ways. First, that the children currently enrolled in ELCs, and with a desire to participate in investigative science, are encouraged and supported to do so. Second, that useful science learning and teaching becomes an essential addition to the teacher training courses so the science needs of young children are met. Third, within a context that echoes thoughtful planning and teaching, children's unique ways of knowing, and becoming, are honoured. *The Hundred Languages of Children* (Malaguzzi, 1998), eloquently highlights how learning can be curbed if educators do not bring into focus children's multifaceted and unique ways of knowing.

The child is made of one hundred.
The child has
a hundred languages
a hundred hands
a hundred thoughts
a hundred ways of thinking of playing, of speaking.

A hundred,
Always a hundred
Ways of listening, of marvelling, of loving.
A hundred joys
for singing and understanding

a hundred worlds
to discover
a hundred worlds
to invent and
a hundred worlds
to dream.

The child has
a hundred languages
(and a hundred, hundred, hundred more),
but they steal ninety-nine.
The school and the culture
separate the head from the body.
They tell the child
to think without hands
to do without head
to listen and not to speak
to understand without joy
to love and to marvel
only at Easter and at Christmas.

They tell the child
to discover the world already there
and of the hundred
they steal ninety-nine.

They tell the child
that work and play
reality and fantasy
science and imagination
sky and earth
reason and dream
are things
that do not belong together.

And thus they tell the child
that the hundred is not there.
The child says
No way. The hundred is there.

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APPENDIX A

Participation information booklet and consent forms

Elaine J Blake

Research supervisor: Dr Christine Howitt PH: 92662328 HREC Approval number: HR69/2008
Researcher: Mrs Elaine Blake 94444912

APPENDIX A

Science and Mathematics Education Centre
Curtin University of Technology

PARTICIPATION INFORMATION BOOKLET & CONSENT FORMS

What does young children's curiosity in science look like and how can early childhood educators take advantage of this?

My name is Elaine Blake, a student at the Science and Mathematics Education Centre at Curtin University. I am currently completing research to investigate the development and pursuit of science education for children under the age of five years.

This booklet contains important information for participants relating to the methods, results, benefits and risks of participating in this research project. Please read it carefully and store for future reference.

This research is considered an important undertaking for the following reasons:

1. Outcomes will inspire educators to value science education for young children.

2. Children will be encouraged to develop scientific curiosity and advance knowledge and skills from positive participation within a socio-cultural classroom.

Methods

Case studies will be collected from three settings: a playgroup and two early learning centres: one in a private school setting the other, part of a religious education system. No data may be gathered nor children observed, without parental consent.

Children

Considerable time will be spent on site at each setting so the context surrounding a case study can be observed and researcher becomes known to the participating children. In each setting, two children will be observed while they interact within their learning environment. Conversations with these children will be collected as data. Written notes relating to conversations and audio recordings will be used for analysis. As young children can be unpredictable with responses, and prefer a range of activities to develop their answers, extensive data including singing, drawing, playing or constructed results, may be gathered as evidence of engagement in science activities. Questions asked of children will be plain, in context and uncompromising such as: What happened when you poured water on ….? How does that work? Each child will know they may cease participation if they wish.

Teachers

Semi-structured interviews relating to science teaching experience and confidence will be required for data to ascertain science professional development opportunities and experience afforded to teachers and young children in their care; where they obtain their science teaching ideas; the types of science resources used; and how they cope when science questions get 'too hard'. These interviews will be audio-taped and should take no longer than 45 minutes.

Results and confidentiality

Confidentiality of results will be maintained at all times. Information gathered will be viewed by only me and my university supervisors. Analysed data will be published without identifying references to actual children, school or teacher. No drawing or work of the child will be kept by the researcher without a child's consent and if kept, all identifying items will be removed.

Surveys and interview transcripts will be stored in a secure, locked cabinet, separate to keys and codes for a period of five years before being destroyed. Interview tapes will be erased after transcription to avoid voice identification. Overall results of the study will be available for teachers, principals and parents.

Risks and benefits

All participants will be informed of the voluntary nature of the research, and that they have the right to withdraw from the research at any time without prejudice or negative consequences.

Children will have the research explained to them in simple language. They will be instructed to indicate to either the researcher or their teacher should they become uncomfortable participating. At all times, an authorised adult of the learning centre, is to be in the classroom when the researcher is visiting.

If a parent feels their child may suffer emotional stress as a result of participating in the research, then that child shall not take part in this project.

The researcher will be available, for questions and clarity during the case studies. Accepting a booklet is not an indication of compulsory engagement in the research.

Curtin University of Technology

Contact Information

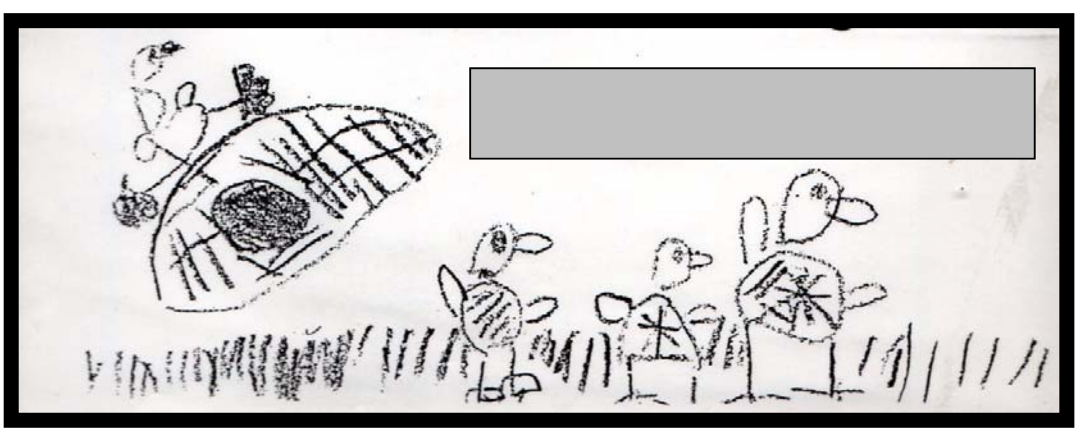
Researcher: Mrs Elaine Blake
Ph 9444 4912 eblake@postgrad.curtin.au

Research Supervisor: Dr Christine Howitt
Lecturer in Science & Mathematics Education Centre
Curtin University of Technology
Ph 9266 2328

Assistant Supervisor: Professor Lesley Parker
Science & Mathematics Education Centre
Curtin University of Technology
Ph 9266 4840

Curtin University Higher Research Ethics Committee (HREC): Dr Christine Howitt

This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number HR69/2008). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, 6845 or by telephoning 9266 2784 or emailing hrec@curtin.edu.au



Curtin University of Technology

Science and Mathematics Education Centre
Curtin University of Technology

What does young children's curiosity in science look like and how can early childhood educators take advantage of this?

The teacher, Room ____________ _______________________Learning Centre

My name is Elaine Blake, student of Curtin University's Science and Mathematics Education Centre. I am currently engaged in research aimed at investigating the development and pursuit of science education for children under the age of five years using conversations with two children from the same classroom.

Your centre/school has shown an interest in this research which requires my gaining information about how children engage in science activities; the environment in which they learn and, about teaching strategies employed to develop science skills.

Participation in this research is entirely voluntary and if you agree to participate the following would be asked of you:

1. Permitting me to come into your classroom to observe the interaction between the environment, children and adults in relation to scientific studies.

2. Discuss with me your feelings about science being a meaningful part of early childhood studies.

3. Enabling me to record interviews/conversations with you regarding your confidence, skills and beliefs about science education for our youngest students.

Once data has been collected and analysed, a report will be made available to you, as the children's teacher. The school and parents will also gain overall results of the research.

If you wish to participate, I will arrange a meeting at which full details of the methods can be discussed and any questions you may have, be answered. Use of your time will be kept to a minimum.

Yours sincerely

Elaine J Blake

Research supervisor: Dr Christine Howitt PH: 92662328 HREC Approval number: HR69/2008
Researcher: Mrs Elaine Blake 94444912

Curtin
University of Technology

PARENT SURVEY AND CONSENT

Dear Parent / Guardian

Your child's early learning centre/school and teacher have agreed to participate in the research: What does young children's curiosity in science look like and how can early childhood educators take advantage of this?

By completing and returning this survey you are giving consent:

- For your child to participate in this research
- For your child's conversation whilst engaging in scientific skill development to be recorded.
- For any written/drawn/created reporting done and not wanted by the child, to be collected as data to assist research conclusions.

Please sign below to acknowledge that:

- You have read and understood the information booklet
- You understand participation is voluntary
- You are aware you and your child are free to withdraw at any time without consequence
- No identifying information related to your child, your child's teacher or the school will be released to anyone other than the researcher and the research supervisor.
- You have been given an opportunity to ask questions
- You agree to participate in the study outlined in this document.

Signature of Parent/Guardian　　　　Witness

____________________________　　　　__________________________

Full Name of Parent/Guardian　　　　Full name of witness

_______________________________　　　　__________________________

Date____________________________　　　　Date_____________________

Elaine J Blake

Research supervisor: Dr Christine Howitt PH: 92662328 HREC Approval number: HR69/2008
Researcher: Mrs Elaine Blake 94444912

Curtin
University of Technology

TEACHER SURVEY AND CONSENT

What does young children's curiosity in science look like and how can early childhood educators take advantage of this?

By completing and returning this form you are giving consent:

- For the information you provide to be used for the purposes of research

Please sign below to acknowledge that:

- You have read and understood the procedures of this study
- You have been provided with an information booklet
- You understand that results of the research may not benefit you
- Your participation is voluntary and you may withdraw at any time without problem.
- All information provided is confidential and will not be published in any manner that allows you, your school or your students to be identified.
- You have an opportunity to ask questions about the research

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Signature of Teacher ______________________________

Signature of Witness ______________________________

Name of Teacher ______________________________

Name of Witness ______________________________

Date__________________________

Date____________________________

Elaine J Blake

Research supervisor: Dr Christine Howitt PH: 92662328 HREC Approval number: HR69/2008
Researcher: Mrs Elaine Blake 94444912

APPENDIX B

Principal's information

Elaine J Blake

Research supervisor: Dr Christine Howitt PH: 92662328 HREC Approval number: HR69/2008
Researcher: Mrs Elaine Blake 94444912

APPENDIX B

Science and Mathematics Education Centre
Curtin University of Technology

Principal Participant Information Sheet

What does young children's curiosity in science look like and how can early childhood educators take advantage of this?

To the Principal,

______________________________Early Learning Centre

My name is Elaine Blake. I am a postgraduate student of Curtin's Science and Mathematics Education Centre and I am currently investigating the development and pursuit of science education for children under the age of five years.

As an educator with more than 20 years' experience teaching young children, I am passionate about the importance of childhood wonder, curiosity, investigation and reporting in relation to real science experiences. Integrated with other basic skill development, I believe scientific skills should be encouraged as a priority in early childhood centres.

As part of this research I will be collecting information from both teachers and children who wish to participate. Teachers will be asked questions relating to their science teaching experience and confidence with teaching science. These questions will relate to science professional development opportunities and experience afforded to teachers and young children in their care, where they obtain their science teaching ideas, the types of science resources used, and how they cope when science questions get 'too hard'. The interviews will be audio-taped and should take no longer than 45 minutes. The interviews will be arranged at a day and time convenient for the teacher.

Before collecting any information on the children, I plan to spend considerable time with them to allow them to become familiar with my presence. I will observe two children while they engage in science related activities. Conversations with these children will be collected as data. These conversations will be audio recorded. Written notes relating to conversations will also be made. As young children can be unpredictable with responses, and prefer a range of activities to develop their answers, extensive data including singing, drawing, playing or constructed results, may be gathered as evidence of engagement in science activities

Information gathered for this research will have no identifying information on it and where necessary pseudonyms will be used. This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee with approval number HR69/2008

Should you allow your school to participate, a summary of results of data collected from classroom and students will be made available to you, and school community members associated with this study.

If you think you would be interested in participating in this research, please contact me on either 9444 4912 or eblake@postgrad.curtin.edu.au to arrange a meeting where I can provide more detailed information. This meeting should take no more than 30 minutes of your time. The attached Participation Information Booklet provides additional information.

Yours sincerely

Elaine J Blake

Research Supervisor: Dr Christine Howitt, Science and Mathematics Education Centre, Curtin University of Technology, Phone: 9266 2328, Email: c.howitt@curtin.edu.au

APPENDIX C

LIST OF ACRONYM

AAAS	American Association for the Advancement of Science
ACARA	Australian Curriculum, Assessment and Reporting Authority
ACECQA	Australian Children's Education & Care Quality Association
EA	Education Assistant
ECE	Early Childhood Education
ELC	Early Learning Centre
EYLF	Early Years Learning Framework
COAG	Council of Australian Governments
DEEWR	Department of Education Employment and Workplace Relations
DET(WA)	Department of Education and Training Western Australia
MCEECDYA	Ministerial Council for Education, Early Childhood Development and Youth Affairs
NOS	Nature of Science
NQF	National Quality Framework
NQS	National Quality Standards
NHMRC	National Statement on Ethical Conduct in Human Research
OECDL	Office of Early Childhood Development and Learning, Department of Education, Western Australia
RE	Reggio Emilia
SCALTELC	Socio Cultural Approach to Learning and Teaching in Early Learning Centres
SCALTEC-S	Socio-Cultural Approach to Learning and Teaching in Early Learning Centres - Science
WA	Western Australia
ZPD	Zone of Proximal Development