A Cultural-Historical Study of Scientific Concept Formation Possibilities for Preschool Children in Everyday Environments

Jui Judith Gomes

Master of Education, Science Education (by Research)

Melbourne Graduate School of Education

The University of Melbourne, Australia

M Ed, B Ed (Science, Mathematics and Technology Education)

Institute of Education & Research

University of Dhaka, Bangladesh

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Abstract

Although research in science education has a long history, it has not been many years since attention began to be paid to early childhood science education, where preschool children's scientific concept formation is an area of interest for researchers. Most of the long-standing studies researching concept formation are traditionally influenced by the constructivist approach. These studies discuss children's science as an end product and do not discuss the process of concept development situated in the child's everyday context. This cultural-historically (Vygotsky, 1987) framed study fills this gap in the literature and explores the scientific concept formation possibilities for preschool children. This PhD study (Ethics No. CF12/3871 - 2012001777) was conducted in the context of a larger project funded by the Australian Research Council Discovery Grant (Ethics No. CF11/3199 – 2011001746) lead by my supervisor, Professor Marilyn Fleer. The broader ARC study explores relations between cognition and emotion in learning science for preschool children. The overarching aim for this PhD study is to gain a better understanding of the science learning possibilities in preschool children's everyday life, so as to explore children's scientific concept formation process from a cultural-historical wholeness approach (Hedegaard & Fleer, 2008).

Home and preschools were identified as the possible rich science learning contexts in children's everyday life. Two focus children, their parents, three teachers and the centre director from a preschool participated in this study. Video observations and photographic data were collected as part of the ARC project at the preschool and video and photographic data for the PhD study were collected at the family home contexts. As part of the PhD project, the parents and teachers were also provided with an open-ended questionnaire and interviewed to gain an understanding of their perceptions about

science, play and children's everyday science learning experiences at home and in preschool. In depth data were collected at the preschool for a total period of four weeks. Home visits were made during and after the project for follow up data gathering.

Based on Vygotsky's (1987) cultural-historical concept of everyday concepts and scientific concepts, a theoretical working model was developed to explain the dialectical relationship between these two concepts. A science walk method (Fleer, Gomes, & March, 2014) used to gain deeper understanding of teachers' conceptualisation of the science learning possibilities in the everyday environment that can provide content for their teaching practice. The science walk method was further employed and analysed using the concept of social situation of development (Vygotsky, 1994b) to understand how teachers in the same preschool conceptualise science-learning possibilities in the everyday environment. The findings show that a teacher with a *conceptually oriented science attitude* is aware of identifying the science learning possibilities in the environment at a conceptual level rather than leaving science learning at an everyday level. The study finds that parents have different perspectives regarding learning science for their children in the family home context. However, through parents' active involvement with their children, the simple everyday moments can help children develop a motive orientation for science learning at home. Children's everyday play-based practices at home and preschool were observed to explore the dialectical relationships between everyday and scientific concept formation. The findings show that there is a reciprocal relationship between the science learning experiences in children's everyday life between home and preschool. This finding is theorised as a *scientific motive*. Finally, analysis of the children's participation in the everyday play-based environment in the preschool and home contexts reveals an analytical concept of *scientific perezhivanie,* which explains the relationship between emotions and everyday and scientific concepts. All these study findings are presented in this thesis from Chapters 5 to 9.

It is argued that teacher awareness about the everyday environment gives a new understanding about science pedagogy for children in the early years of education. The relationships between home and preschool practices give further understanding about everyday moments that can create possibilities for developing motives for learning science from the early years. Overall the findings shed light on the cultural-historical relationship between the child's everyday institutions in the science learning process. The findings on teachers' and parents' perceptions about science, the environment and observing children in their everyday social institutions provide new understandings about the possibilities available for science learning and child development in everyday conditions in a child's life. This cultural-historical study contributes in the broader science education research by informing the home and preschool relationships in scientific concept formation for preschool children. Further research avenues are identified for more early years science studies in the home and preschool contexts.

Publications During Enrolment

Refereed Journal Articles

1. **Gomes, J.,** & Fleer, M. (2018). Is science really everywhere? Teachers' perspectives about science learning possibilities in the preschool environment. *Research in Science Education*. doi:10.1007/s11165-018-9760-5
2. **Gomes, J.,** Fleer, M. (2017). The development of a scientific play motive: How preschool science and home play reciprocally contribute to science learning. *Research in Science Education.* doi:10.1007/s11165-017-9631-5
3. Fleer, M., **Gomes, J.,** & March, S. (2014). Science learning affordances in preschool environments. *Australasian Journal of Early Childhood, 39*(1), 38-48.

Conference Papers

1. **Gomes, J.** (2017, 28 August – 1 September). Science learning in play of preschool children: Introducing the concept of scientific perezhivanie. Paper presented in symposium: Children's conceptual learning in imaginative play across educational settings: A cultural historical analysis of science learning at the 5th International Society for Cultural-Historical Activity Research (ISCAR), Quebec, Canada.
2. **Gomes. J.** (2016, 27 June – 1 July). Preschool teachers conceptualising science in the preschool environment: Concepts or activities? Paper presented at the 47th Annual ASERA Conference of the Australasian Science Education Research Association, QT Hotel, Canberra, Australia.
3. **Gomes, J.** (2014, 30 September – 3 October). *Crossing boundaries between home and preschool to support early years science concept formation.* Paper presented in symposium: Transformative Research: Science concepts formation in everyday life at the 4th International Society for Cultural-Historical Activity Research (ISCAR), Sydney, Australia.
4. **Gomes, J.** (2014, 30 September – 3 October). *Crossing boundaries between home and preschool: Changing the nature of play in early years.* Poster presented at the 4th International Society for Cultural-Historical Activity Research (ISCAR), Sydney, Australia.
5. **Gomes, J.** (2014, 2 July – 4 July). *The relations between everyday and scientific concepts across institutions: Changing the nature of play in early years.* Paper presented at the 45th Annual ASERA Conference of the Australasian Science Education Research Association, Melbourne, Australia.
6. **Gomes. J.** (2012, July 6). *Teachers' and parents' views on science concept development for preschool children in play.* Presented at the Monash Education Research Community (MERC) Annual Conference, Monash University, Melbourne, Australia.
7. Fleer, M., **Gomes, J.**, March, S. (2012, 27 June –30 June). *A cultural-historical reading of scientific concept formation: Affordances for science learning in*

preschools. Paper presented at the 43rd Annual ASERA Conference of the Australasian Science Education Research Association, University of the Sunshine Coast, Queensland, Australia.

Thesis including published works declaration

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

This thesis includes *four* original papers published in peer-reviewed journals and one submitted publication. The core theme of the thesis is scientific concept formation possibilities of preschool children in everyday environments. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, the student, working within the faculty of Education under the supervision of Professor Marilyn Fleer.

The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research.

In the case of Chapter 6, 7 and 8 my contribution to the work involved the following:

Thesis Chapter	**Publication Title**	**Status** *(published, in press, accepted or returned for revision, submitted)*	**Nature and % of student contribution**	**Co-author name(s) Nature and % of Co-author's contribution***	**Co-author(s), Monash staff Y/N***
Chapter 6	**Is science really everywhere? Teachers'**	Available as Online First	***Judith Gomes:*** *75%* *Data gathering, Conceptualisin*	***Marilyn Fleer:*** *25%* *Conceptualising, write up, key ideas*	Y

	perspectives about science learning possibilities in the preschool environment		*g, write up, key ideas, data analysis*		
Chapter 7	**A parent's views on science learning in everyday family life: Developing a motive orientation in science for preschool children**	Submitted to *Early Child Developm ent and Care*	***Judith Gomes:*** *100%* Single Author		
Chapter 8	**The development of a *scientific motive*: How preschool science and home play reciprocally contribute to science learning**	Available as Online First	***Judith Gomes:*** *85%* *Conceptualisin g, write up, key ideas, data analysis*	***Marilyn Fleer:*** *15%* *Conceptual guidance*	

I have not renumbered sections of submitted or published papers in order to generate a consistent presentation within the thesis.

Student signature: [redacted] Date: 29 September 2018

The undersigned hereby certify that the above declaration correctly reflects the nature and extent of the student's and co-authors' contributions to this work. In instances where I am not the responsible author I have consulted with the responsible author to agree on the respective contributions of the authors.

Main Supervisor signature: [redacted] **Date:** 29 September 2018

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Studying for a PhD is a journey—it’s common knowledge. But every PhD journey is different. This journey not only served historical development for me, but it was also built on my personal history. I was born into a large family and grew up with my seven siblings in the capital city of Dhaka in Bangladesh, located in South Asia. Mine was a middle-class family, my father being a banker in the Australia NewZealand Bank (ANZ) situated in Bangladesh and my mother a housewife who devoted her life to raising this big family with the goals of providing us with the best possible education options. I believe I had a lovely childhood with an inspiration for working towards a PhD at some stage of my life. I completed my Bachelor degree in Science Education and Masters degree in Science, Mathematics and Technology Education from the Institute of Education and Research in Dhaka University in Bangladesh. Later, my school teaching and work experience in schools in Bangladesh and South Africa continued my interest to pursue further research in science education.

After a few years of working in education settings my dream of studying in an international university came true. I received a full international scholarship (MIPRS and MIFRS) for a Master of Education at The University of Melbourne in Australia. I was supervised by Dr. Pamela Mulhall, one of the former students of the famous science education guru, Emeritus Professor Richard Gunstone. During my masters I was excited to find the line of threads that internationally concerns the science education community. During the same period of time in the first decade of 2000, research findings highlighted that one of the reasons that students feel disengaged in science is because of academic science not being relevant to student’s everyday life. I was

motivated by this issue and felt impelled to know more about this problem. After completion of my Masters degree, the golden opportunity came to fulfil the long awaited dream of my life to do a PhD, when I received another full International Scholarship [MGS and MIPRS, later rolled into Australian Postgraduate Award (APA) after I became a local student] for studying a PhD at Monash University Australia. I met the Early Childhood Education guru, Professor Marilyn Fleer. We discussed my research interests over coffee and Professor Fleer decided that I could work under her supervision for my PhD study. The tale of the journey began a new chapter at that moment.

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During my PhD I gave birth to my first child, Alfie, and am currently pregnant with my second baby. Marilyn was always compassionate about my child and suggested strategies to balance between work and family life. I am so proud to have been Marilyn's student and I certainly believe my PhD journey experience could have been completely different without her. My words are limited to saying 'Thank you', Marilyn, but I certainly believe you know how deeply I feel these words, and that they acknowledge your wonderful contribution to my life.

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CHAPTER 1
Introduction to the Research

1.1 Introduction

The research reported in this thesis aims at examining the science learning possibilities available in the everyday natural activity settings for preschool children's scientific concept formation. Observing children in their everyday home and preschool environments reveals possible science learning moments that include interaction with adults and the everyday environment. Observation also supports an understanding of the scientific concept formation possibilities as part of the process in children's cultural development. The findings are reported as a series of research papers. This introductory chapter begins with my personal motivation for the study, followed by the research context and an overview of the theoretical framework guiding the study. This is followed by the research questions of the study. The chapter concludes with an overview of the remaining chapters, including the abstracts for the papers.

1.2 Personal Orientation to the Research Problem

After having a conversation on PhD topic over coffee with my supervisor while I started to think about my PhD research problem area, I began to take myself back to my childhood play memories. My earliest memory about science related play was about looking for metal particles in the sand that had been left in front of our house for some building construction purpose. It was one of my most favourite plays with my brother when I was five. I remember that I loved to collect rectangular magnet pieces from my broken pencil cases and used them to catch metal particles from sand. I loved to show this to others as I imagined I was performing ‘magic’! I used to think the metal particles in sand were magnets and that this was one of the properties of sand. After many years I realised the metal particles were actually the microscopic particles of iron due to sand and iron rods being carried together in lorries to the construction site.

At the same period of time, my preschool placed greater focus on literacy and numeracy with some music, art and craft work activities, but teaching had no connection with science. At home, my mother introduced me with some everyday science. For example, I was taught that pouring hot water in a glass-drinking cup might crack the cup. However, if I put a metal spoon in it before pouring hot water, it would help the glass resist cracking. Many times I witnessed this phenomenon. I came to know the scientific explanation of this phenomenon when I read about heat conduction in my secondary science book. The science is as follows: due to the imbalance of temperature of the glass material inside and outside, the cup can easily break. Since glass is a poor heat conductor, the temperature outside the cup is cooler than inside. Putting a metal spoon prevents the cup from cracking because the metal spoon conducts heat faster than glass. These early memories about science orientations in everyday life prompted me to think more about the early development of science concepts as the focus of my PhD topic.

As a science teacher and an education researcher, I experienced that my students at primary and secondary levels found science subjects difficult as teachers heavily emphasised rote learning and struggled to relate scientific concepts to their everyday life. I started thinking about how my students were oriented with scientific concepts in their preschool years. I found that although research interest was growing in the early childhood area, very few studies had focused on children’s scientific concept development in relation to everyday life. Studies on preschool science from family home contexts are particularly scarce, indicating a significant gap in this area. As a former science education student, science teacher and science education researcher I was curious about researching these issues. My supervisor Professor Fleer introduced me to Vygotsky's work on 'Thinking and Speech' (Vygotsky, 1987). I was inspired learn more about how Vygotsky viewed everyday concepts and scientific concepts, adult interaction for concept formation, and relations between instruction and learning, the cultural construction of knowledge and many more revolutionary ideas. I became familiar with Vygotsky's theories and concepts, including play and development, higher mental functions, and the social situation of development (1966, 1994a, 1994b, 1997a, 1998). I wanted to understand more about the complex relationships between the child and their surroundings.

I realised that science is everywhere in a child's everyday life but at the same time I started questioning why students found formal science irrelevant to their everyday life. Questions still remain unanswered regarding what science we can teach to our young children and what science looks like at home and preschool. What do adults think about science in children's everyday life? How can we increase our understanding about the holistic process of concept formation? I aimed to explore what views early year teachers and parents possess about science in the everyday life of children that could broaden our understanding of the process of children's science learning including the social and cultural practices, with the hope of contributing to research in science education.

1.3 The Research Context

This research is about preschool children aged 3-5years old, their parents and teachers who are included in the children's formal preschool and home context. In regard to the formal context, the *Early Year Learning Framework* is the first Australian early years curriculum which focuses on not only processes, but also concepts. The document describes the elements of early years learning and development for preschool children (birth to five years). This document is significant because it is the first framework to explicitly list conceptual outcomes for Australian preschool children. For instance, the second learning outcome – "children are connected to and contribute to their world" (Department of Education Employment and Workplace [DEEWR], 2009, p. 29) and the fourth outcome – "children are confident and involved learners" (p. 34), provide scope for educators to consider the everyday concepts of children and at the same time create the learning conditions to support science learning for preschool children.

However, the various curriculum reform efforts and philosophical beliefs about child development at different times have influenced early childhood science education (discussed in Chapter 2). Although the reform efforts began to emphasise conceptual understanding of science, researchers observed a worldwide concern regarding decreasing enrolment in post-secondary science that included physics, chemistry and biology (Kennedy, Lyons, & Quinn, 2014). Scholars described the trend of declining enrolment as an alarming situation and outlined the problem as a mismatch between science as delivered in the classroom and students' everyday life experiences (Goodrum, Hackling, & Rennie, 2001; Lindahl, 2003; Lyons, 2006a, 2006b; J. Osborne, Simon, & Collins, 2003; Tytler, 2007). In this context of global concern about declining science enrolment, Fensham (1991) emphasised that early years science education need more attention. A recent emphasis on STEM education may also be viewed as a call for reimagining science education from the early years to upper levels.

In a global context increased attention is directed to encouraging academic science to link with everyday science to prepare more capable future science-literate citizens. At the local preschool context curricular importance is placed on learning concepts for children. Given these global and local trends, while young children's social, cultural and emotional development is still much emphasised, increasing attention is being given to including science in preschool teaching. However, in practice, the problems associated with teaching science in formal contexts are documented in teacher education studies pointing out that early years teachers often lack the confidence to teach science and struggle to teach the science content. Another long standing problem identified in science education research is the traditional Piagetian Constructivist view that heavily influenced the early years curriculum during the 1960s. This orientation meant that research in science education focusing on concept development has historically been dominated by a constructivist approach. Piaget's cognitive theory took a maturational point of view of child development from, explaining that children can learn certain concepts at certain ages (Piaget, 1929/1951). This view of development failed to consider the social and cultural environment, situating the child as an individual (Fleer & Robbins, 2003a). The large body of science education literature generally omitted the study of children's social and cultural contexts, and therefore a holistic understanding of the process of scientific conceptual development is missing in this area as will be discussed further below.

Since the early 1990s the socio-cultural approach started to become popular for teaching and learning (Lim & Genishi, 2010). Research papers originating from socio-cultural and cultural-historical perspectives started to emerge in early childhood science education area. This new philosophy was based on the theory of child development of the Russian psychologist, Vygotsky, which viewed the inseparable relationship between development and the child's social and cultural environment. Vygotsky's ideas led to the inclusion of various dimensions in preschool education, for example, play, socio-cultural contexts, adult-child relationships, the use of cultural tools and the concept of zone of proximal development (ZPD). The vast richness in studying children in their context points to a basic contrast between Vygotsky's cultural-historical theory and Piagetian constructivist theory in regard to the relationship between learning and development. According to Vygotsky, learning leads development whereas Piaget argues that development leads learning (Howe, 1996). This shift of view in child development started to open up more inclusive studies, for example, those including families and other social institutions and informal contexts in early childhood science education research.

Alongside the preschool, this study includes children's informal family home context. It is argued that at the family home children experience ample everyday science experiences. Adults, particularly parents, play an important role for children in noticing the everyday phenomena, but these interactions have not been fully captured in studies yet. My four-year-old son asks questions like ' Where does the rainbow come from on the wall every morning when I am brushing my teeth? What is inside my skin? How can we see us in the mirror? How can we see things?' During the shower he experiences hot and cold water. He watches hail and rain or warm sunny weather that make him curious. Noticing or responding to these questions to a four year old could lay the foundation for interacting with the environment with a scientific lens. However the conversation has to start. Studies are growing in this area suggesting children need opportunities to have rich experience, and they need opportunities to engage with these experiences in scientifically meaningful ways (Hao, 2016; Sikder, 2015a). For this reason it is argued that teachers and parents play a significant role in providing meaningful experiences and explanations to children in everyday contexts.

Preschool aged children love to play and interact in playful environments in their daily life. They play at home, and in preschool. Sometimes they play alone, other times they play with peers or adults. I observed these everyday involvements in a preschool child's life and I am interested to know how the adults give meaning or not to the science moments available to children's everyday social context and the possibilities that are laid by adults for children's concept formation both in preschool and home contexts. These relationships in a child's everyday life are not fully known yet. Vygotsky discussed the dialectical relationship between everyday concepts and scientific concepts that gives structural support for concept formation. Both formal and informal contexts contribute to the process of concept formation that can be realized in a child's daily life as will be discussed in Chapters 7, 8 and 9.

To investigate the research problem, this thesis draws on the following theoretical concepts: the links between everyday and scientific concepts; cultural-historical concepts of play; motives; the social situation of development with an extended link to perezhivanie. A summary of the main theoretical ideas follows, with detail found in Chapter 3.

1.4 Theoretical Framework: Cultural-Historical Theory

In light of the aforementioned research context, this study embraces Vygotsky's cultural-historical theory of child development. Vygotsky's theory establishes the unique nature of the relationships in a child's environment through dialectical logic.

Vygotsky's (1987, 1997a, 1998) theory introduces a system of concepts. It is important to note that more than one concept is needed at a time to discuss concept development, because child development is not linear but a complex revolutionary process. This is a different conceptual framework to constructivism, because in a cultural-historical study, the social and cultural processes are foregrounded, rather than the individual's construction of concepts. Important to this study is how cultural-historical theory also illuminates how everyday practices and scientific conceptions are dialectically related (Chapters 5–9).

This cultural-historical study draws upon the system of concepts that frame the study, including: everyday and scientific concept formation (Vygotsky, 1987), play (Vygotsky, 1966), motives (Hedegaard, 2002), perezhivanie (Vygotsky, 1994b) and social situation of development (Vygotsky, 1994b). Using the system of concepts the reciprocal relationships in a child's life that support concept formation can be captured. These concepts shed light on the complexities in the dynamic and evolving process of scientific concept development in young children as they participate in everyday home and preschool learning contexts. Detailed discussions of these concepts are presented in Chapter 3.

1.5 Research Questions

This study examines the everyday concepts and contexts of preschool aged (3–5years) children with the view to understanding their potential for contributing to children's scientific conceptual development. As such, both the home and preschool contexts are included in this study. Teachers' and parents' perceptions about science are considered important in this aspect, assuming that their perceptions further contribute to children's scientific concept development in their everyday contexts.

The main research question in this thesis is:

- What are the scientific concept formation possibilities in preschool children's everyday life?

Subsidiary questions were formed to respond to the main research question and for in-depth data analysis. The subsidiary questions include:

1. How does teachers' knowledge about science contribute to children's learning in science in play-based settings?

1a. How do the teachers conceptualise early childhood science education?

1b. What are preschool teachers' perceptions about learning through play?

1c. What science experiences are afforded in the preschool?

2. How does parents' knowledge about science contribute to children's learning in science in play-based settings?

2a. What parents' believe are the science learning opportunities in their children's everyday life at home?

2b. What are parents' perceptions about learning science through play?

2c. What science experiences are afforded at home?

Table 1.1 illustrates how the specific questions formulated in each paper included in this thesis are associated with the subsidiary research questions outlined above.

Table 1.1 Research questions and the subsidiary questions as reported in the publications

Research questions answered in ***Publication Two - Chapter 6*** 1. How does teachers' knowledge about science contribute to children's learning in science in play-based settings? 1a. How do the teachers conceptualise early childhood science education? 1b. What are preschool teachers' perceptions about learning science through play? 1c. What science experiences are afforded in the preschool?	Sub question formulated for ***Publication Two - Chapter 6*** How do teachers in the same preschool setting interpret their environment for science learning possibilities?
Research questions answered in ***Publication Three – Chapter 7*** 2. How does parents' knowledge about science contribute to children's learning in science in play based settings? 2a. What parents' believe are the science learning opportunities in their children's everyday life at home? 2b. What are parents' perceptions about learning science through play? 2c. What science experiences are afforded at home?	Sub question formulated for ***Publication Three – Chapter7*** • How does parents' knowledge about science contribute to children's learning in science in play-based settings? • What do parents think is science in the everyday life of their children? • What are parents' perceptions about learning science through play? • What science learning opportunities are available at home for preschool children?

Research questions answered in ***Publication Four – Chapter 8***	Sub question formulated for ***Publication Four – Chapter 8***
1c. What science experiences are afforded in the preschool? 2a. What parents believe are the science learning opportunities in their children's everyday life at home? 2b. What are parent's perceptions about learning science through paly? 2c. What science experiences are afforded at home?	What are the opportunities for children's scientific concept development during everyday experiences at home and in the preschool environment?

1.5.1 Publication One - Chapter 5

This chapter includes publication one that gives a methodological background for paper Two included in Chapter 6. I co-authored with my supervisor Professor Fleer and colleague Dr. Sue March for Professor's Fleer's ARC study (Project No. DP110103013) where I collected data along with other research assistants and analysed part of the data as a contributing author. As part of my PhD journey I also drew upon Vygotsky's (1987) everyday and scientific concepts to show the relationship in a working model to support the conceptual work in the paper and in the thesis. A new data gathering method of science walk was developed in this paper as part of the ARC project.

1.5.2 Publication Two - Chapter 6

This paper follows publication One and relates to the second research question using the science walk methodology mentioned in publication One. Two preschool teachers from the same preschool were interviewed. Using the cultural-historical concept of social situation of development (Vygotsky, 1994b) and the everyday and scientific concept (Vygotsky, 1987) it was possible to answer research questions 1 and 1a, 1b, 1c to capture the perspectives teachers had on the science learning affordances in a preschool environment.

1.5.3 Publication Three – Chapter 7

This paper uses Hedegaard's (2002) concept of motive orientation and stimulating motive and reports on the second focus child's everyday home science experiences and the mother's perceptions on everyday science learning for her child. This chapter directly addresses research question 2 and the sub-questions 2a, 2b and 2c.

1.5.4 Publication Four – Chapter 8

This paper uses the cultural historical concept of motives (Hedegaard, 2002) and extends this concept by introducing a new concept 'scientific motive'. The new concept captures the reciprocal relationship between home and preschool science experiences in a child's everyday life. This paper also reports on the mother's perceptions about everyday science in her child's life. This paper responds to the sub-research questions 1c and 2a, 2b, 2c using analysed data from the first focus child's everyday home and preschool experiences.

1.6 Significance of the Study

This cultural-historical study explores the relationships in a child's everyday environment that show the possibilities affording scientific concept formation. New understandings regarding the science content available in a child's surroundings can be gained by knowing how the significant adults perceive the relationships between science and the environment in the child's everyday context. By understanding the relationships in a child's everyday play-based context and science related activities at preschool and home, we can better understand the complex process of concept development in the early years.

The present research is situated solely in the context of early years learning for young children (age 3-5 years). According to Rogoff (2003) a child's individual development can be perceived as a process where the child contributes to and the concepts are constructed by the social interactions. Therefore, studying the child alone cannot give a complete picture of development. This study involves preschool teachers' and parents' views to gain an understanding of the cultural practices that support children's scientific concept development. Therefore, studying the participating children through their interactions at home and in the preschool contexts gives a holistic view of the scientific concept development of young children. Findings of this research contribute to better and more nuanced understandings of preschool science pedagogy in formal and informal contexts.

1.7 Outline of the Thesis

This thesis comprises ten chapters. Followed by this introductory chapter, a literature review is presented in Chapter 2 providing a brief history of science education and the early years science education research trend, research on children's ideas about science, cultural-historical research in science education and studies on early year teachers. These studies include formal preschool and informal family home contexts for early years science learning. Chapter 3 discusses the theoretical concepts within the cultural-historical theoretical tradition that have informed this study. Chapter 4 frames the methodology and methods section. Chapter 5-8 present the publications. Over the course of the PhD study, findings (Chapters 5-8) drew attention to the emotional aspects of science learning (Chapter 9) which was the main focus of the broader ARC study, and which became increasingly important to this PhD thesis also. Chapter 10 concludes the thesis with a brief discussion of the overall findings and provides the implications for practice, the limitations and directions for future research.

Abstracts for each paper are presented below.

Chapter 5: Paper One

Science learning affordances in preschool environments *Published in Australasian Journal of Early Childhood. 39* (1), 2014. Available at http://search.informit.com.au/documentSummary;dn=192562941588104;res=IELHSS

Marilyn Fleer

Judith Gomes

Sue March

Abstract

This paper presents the findings of a study into the perceived everyday science practices occurring within an early childhood centre in a southern part of Australia. In drawing upon cultural-historical theory, the study maps the possibilities for everyday science learning through photographic documentation (n = 223) and through undertaking a science walk with an early childhood teacher in order to establish how the environment was perceived for creating opportunities for science learning (planned or otherwise). The results foreground: science within the constant traditional areas within the preschool, building science infrastructure into the centre, and using science in everyday life in the centre. The findings show the importance of a sciencing attitude on the part of the teacher for affording meaningful science learning for preschool children.

Chapter 6: Paper Two

Is science really everywhere? Teachers' perspectives about science learning possibilities in the preschool environment Available as Online First in *Research in Science Education* http://link.springer.com/article/10.1007/s11165-018-9760-5 and https://rdcu.be/7GT5 (Please copy-paste any of the URL on your browser)

Judith Gomes

Marilyn Fleer

Abstract

There is increasing interest in early childhood science education and a corresponding increase in research in this area. Studies have shown that in some countries the teaching of science in the early years remains low. These studies show that science pedagogy in the early years needs attention, despite the myriad opportunities afforded for the informal teaching of science concepts. What is not known is how teachers interpret the opportunities for science moments in these play-based environments. Drawing upon Vygotsky's cultural-historical theory this paper examines how preschool teachers engage with their environment to promote the teaching of science concepts. Two preschool teachers were involved in this one site preschool case study. Both teachers participated in an indoor and outdoor science walk. Hedegaard's (2008c) three-step analysis procedure and Tu's (2006) sciencing categories were used to analyse the data. Findings show that teachers in the same preschool setting have different levels of science awareness for the possibilities of informally teaching science. Specifically, an activity oriented sciencing attitude, and a conceptually oriented sciencing attitude emerged. The complexity of teacher engagement in science teaching in play-based

settings and their conceptualisation of science affordances in the environment, point to new understandings and ways of conceptualising pedagogy for early year science education.

Chapter 7: Paper Three

A parent's views on science learning in everyday family life: Developing a motive orientation in science for preschool children. (Paper submitted to *Early Child Development and Care)*

Judith Gomes

Abstract

What do families think is science for preschool children? Do parents believe children learn science in everyday life? What are parents' beliefs about the relations between play and science learning? Drawing upon cultural-historical concepts of everyday and scientific concepts (Vygotsky, 1987) and motive orientation (Hedegaard, 2002), this one-child case study examines a parent's understandings on science learning possibilities in everyday life and the family home conditions for the preschool child's development of a motive orientation in science. This study is part of a larger study exploring science-learning possibilities in preschool children's home and preschool environments. The larger study gathered data at home and preschool for two children including their parents and teachers. This paper reports video data from a home visit with Alisa (aged 4), field notes and parent interviews and questionnaire responses. The findings suggest that parents can use everyday moments to act as a stimulating motive (Hedegaard, 2002) and contribute towards a motive orientation for children's scientific concept formation. The study broadens our understanding of early years science

learning and the process of concept formation in an everyday informal family home context.

Chapter 8: Paper Four

The development of a *scientific motive*: How preschool science and home play reciprocally contribute to science learning. Available as Online First in *Research in Science Education* http://link.springer.com/article/10.1007/s11165-017-9631-5 and http://rdcu.be/uxNx (Please copy-paste any of the URL on your browser).

Judith Gomes

Marilyn Fleer

Abstract

There are a growing number of studies that have examined science learning for preschool children. Some research has looked into children's home experiences and some has focused on transition, practices, routines and traditions in preschool contexts. However, little attention has been directed to the relationship between children's learning experiences at preschool and at home, and how this relationship can assist in the development of science concepts relevant to everyday life. In drawing upon Hedegaard's (2002) cultural historical conception of motives and Vygotsky's (1987) theory of everyday and scientific concept formation, the study reported in this paper examines one child, Jimmy (4.2 years), and his learning experiences at home and at preschool. Data gathering featured the video recording of four weeks of Jimmy's learning in play at home and at preschool (38.5 hours), parent questionnaire and interviews, and researcher and family gathered video observations of home play with his parents (3.5 hours). Findings show how a scientific motive develops through playful everyday learning moments at home and at preschool when scientific play narratives

and resources are aligned. The study contributes to a more nuanced understanding of the science learning of young children and a conception of pedagogy that takes into account the reciprocity of home and school contexts for learning science.

In the given context of this thesis the next chapter will discuss the relevant literature and the gaps that situates the study in the broader area of early childhood development and science education.

CHAPTER 2
Literature Review

2.1 Introduction

This chapter presents a review of the literature on early childhood science education. The structure of this thesis with publications means that the included publications have already included major studies in this area. The purpose of this chapter is to avoid repetition of the already reviewed literature but to give a comprehensive overview of the studies in general and situate the study by identifying the gaps within the broader research context.

This chapter firstly presents a brief history of science education followed by an account of orientations and trends in science education research. Later, the empirical research is discussed, showing how it is grounded in two major philosophical contexts in science education – constructivism and cultural-historical research. This covers both preschool and home contexts. Teacher education studies are drawn upon for further understanding of teacher beliefs and practice in early childhood science education.

2.2 Brief Historical Context of Science Education

The present study includes both the formal preschool context and the informal home context in early childhood science education. Reviewing the history of formal science education reforms provides insights into the overall societal value placed on science education at different times and the emergence of a science education era for preschool children.

In science education, arguments have historically centred on how students' capacity could be enhanced to apply science knowledge in their everyday life—either at a personal or social level (Lederman, 2006). In USA, there were two visionaries named David and Frances Hawkins who were very passionate about early years science teaching. In his work “Messing About in Science ” Hawkins (1965), discussed his teaching philosophy and the importance of including science for young children. Key aspects of David and Frances’ emphasis for science teaching were- start with nature, seize the moment, become a researcher alongside children, become a researcher alongside adults, think of your classroom as a laboratory. David and Frances’ work inspired teachers to incorporate intentional science teaching and undertake inquiry investigations grounded in children’s everyday life.

Apart from the noble work the Hawkins’ were doing, school science curriculum in the 1960s widely aimed at developing intellectual knowledge and producing future scientists, which (Aikenhead, 2006) called a *pipeline ideology*. Fensham (1981, p. 53) notes that school science at that time was solely aimed at “head” science where “intellectual processes and discovery were separated from activities and inventions.” Emphasis was given to content and pedagogy. Everyday science was merely absent in teaching practice.

In the 1970s, a reform movement named Science, Technology and Society (STS) aimed at increasing collaboration between science and technology and society so that a link could be made between school science and everyday life experience. Fensham (1981) argued that though the reform gave science more “heart” and made science more enjoyable for students, it ignored the “hand” skills needed to make science knowledge practically applicable. Eventually, Fensham (1985) called for a new curriculum movement *Science for All* that was committed to delivering science education to both the future science careerist and non-science-career students. However, during 2000, a worldwide concern about declining enrolments in science at post-secondary level was noticed. For many children, science was not found engaging and not seen as relevant to their everyday experiences. This situation was alarming. Attention was paid to science education from the early years (Fensham, 1991). Everyday science learning was emphasised globally for developing scientifically literate citizens. Given the background it is understood that early childhood science education is a relatively new area and much research in this space is needed.

2.3 A Brief History of Science Education at Primary and Early Childhood Level

Although science education research has a long-standing history, it was not until 1984 that new areas in research arose in primary science education (Appleton & Symington, 1996). In 1984, with the agenda of improving the state of primary science education, a symposium was organised by some chief primary science education researchers. Appleton and Symington (1996) analysed the symposium papers and publications since 1984 from *Research in Science Education* Journal to observe improvements in this field. Science process skills were identified as the dominant theme in the primary science curriculum, and were criticised as being limited in contributing to much broader scientific understanding in children. Therefore, contextual learning was emphasised so that children could relate science to their practices in society. Teacher competence and confidence were also identified as a major problem in teaching science. Teacher education studies attained greater attention after 1994 in Australia (Appleton & Symington, 1996).

The history of early years science education is not as old as the history of science education discussed in Section 2.2 above. It was not until the late 1990s that early childhood science education (Birth to Eight Years) started attracting increased attention globally. As a result some curriculum advancements like *ScienceStart!* in the USA began to emphasise early years science activities (Conezio & French, 2002) and new research publications started to appear (e.g., Fleer, 1991, 1995, 1999; Ravanis & Bagakis, 1998). International journals like *Research in Science Education* (2003) and the *Early Childhood Research Quarterly* (2004) issued the earliest special editions on early years science (including maths for the latter journal) and research publications appeared (Fleer & Robbins, 2003a; Greenfiled et al., 2009). Government initiatives also started emphasising science and technology education for early years in Australia and New Zealand (Fleer & Robbins, 2003b).

Until the year 2000, research in this area— especially for children aged less than 8 years— remained scarce. Fleer and Robbins (2003b) identified some major reasons for the lack of early childhood science education research. They suggest that there was a major methodological problem researching young children under age 8. A method like the *interview about instances* was not very effective for researching children younger than 8 years old. Alongside the methodological problem, early childhood teachers' confidence and content knowledge in science were also identified as barriers for teaching science in preschools (Conezio & French, 2002; Garbett, 2003). To overcome the problems in research and teaching, a shift from the constructivist approach towards sociocultural approaches was emphasised by researchers for science education in the early years (Fleer, 1991; Fleer & Robbins, 2003b; O'Loughlin, 1992; Robbins, 2003).

2.4 Research Publication Trends in Science Education

In continuation of the research reform efforts it is noted that research on concept development in science education is mostly concentrated on primary and secondary school contexts (e.g., R. Osborne & Freyberg, 1985). In their study Lin, Lin, and Tsai (2014) analysed publications from science education in some high ranked science education journals, namely *International Journal of Science Education, The Journal of Research in Science Teaching* and *Science Education*. Their study found that during the years from 2008 to 2012, Australian researchers were among the top publishing authors in these journals. Although the analysis did not give any separate data on early childhood science education research, overall the data showed that Australia has a strong research group in science education. Analysing the trend on the research topics, Lin et al. (2014) claim that during a period of 15 years (1998–2012) researchers tended to focus on the context of students' learning, science teaching and learners' conceptions on various science topics. The authors anticipated that issues relating to science teaching and conceptual change would continue to be foregrounded, given they had been the focus of a long-standing research trend in science education.

As is reflected in the above review and curriculum context, early years science education has become a growing concern, I undertook a historical book search on Google Ngram [1]viewer on 'early childhood science education' (since the year 1960-2018). The search result revealed that publications in this area had only begun in late 1980 and during the early 2000s had experienced a significant rise but fell during 2005. Figure 2.1 shows the search result.

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[1] The graph result appears until 2008 only.

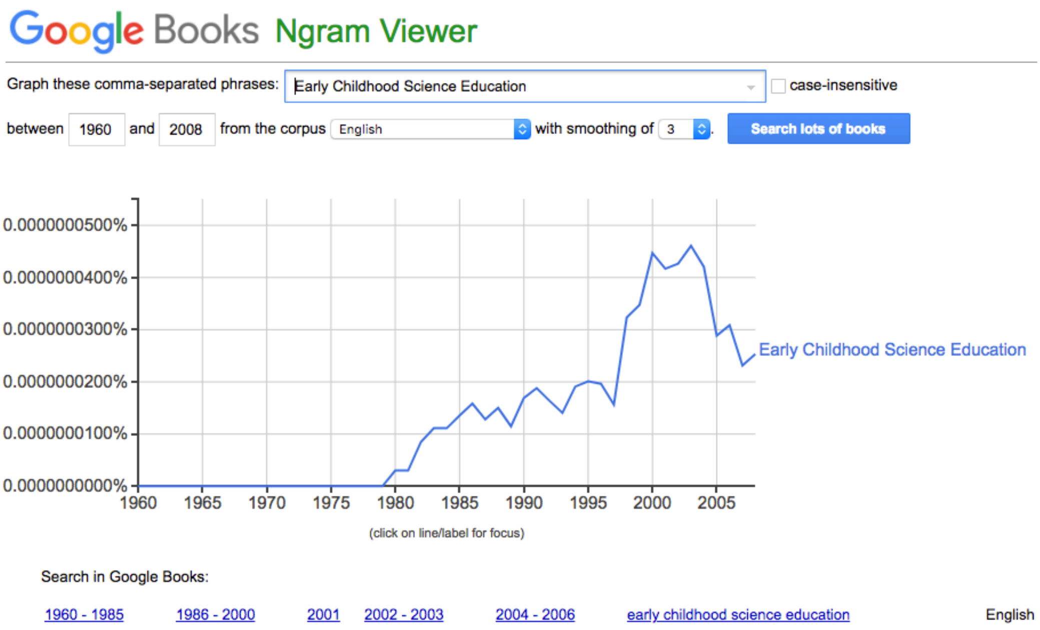


Figure 2.1. Literature search on 'early childhood science education' (1960-2018). Reproduced from Google Books Ngram Viewer , retrieved from: https://books.google.com/ngrams/graph?content=Early+Childhood+Science+Education&year_start=1960&year_end=2008&corpus=15&smoothing=3&share=&direct_url=t1%3B%2CEarly%20Childhood%20Science%20Education%3B%2Cc0

2.5 Empirical Studies on State of Early Years Science Learning

From the brief history of science education at different levels and the snapshot from the research trends it is now clear that science education in the early years has been influenced by two major child development philosophical views—constructivism and cultural-historical theory. In this section I discuss some empirical literature on preschool science literature from constructivist and cultural-historical perspectives, the state of science in preschools, studies from family home contexts and teacher education studies in early years settings. These dimensions of literature will provide an overall understanding about the science education scenario in the early years and the need for researching the problem addressed in this current thesis.

2.5.1 Constructivist and Social Constructivist Approach Studies

This body of literature has a long-standing history in science education (discussed in Chapter 8, paper 4). Constructivist literature was theorised based on Piaget's age-based cognitive development theory (Johnston, 2005; Lind, 2005; Metz, 1995, 2004, 2008, 2011). According to Watts (1995, p. 51), "constructivist learning is always an interpretative process involving the individual's constructions of meaning relating to specific occurrences and phenomena." Therefore a major focus of this approach is to identify the numerous conceptions pupils hold about various aspects of science content and identify the teaching–learning approaches for these various science topics and process skills they develop (Fensham, Gunstone, & White, 1995). Consequently a vast body of literature accumulated in this area on children's ideas about many different science topics. For example, studies on children's ideas focussed variously on light and shadow (Chen, 2009; Segal & Cosgrove, 1993), the state of matter (Stavy, 1990); floating and sinking (Havu-Nuutinen, 2005); space science concepts including the shape of the earth (e.g., Kallery, 2011; Samarapungaven, Vosniadou, & Brewer, 1996); phase changes (Bar & Travis, 1991). The contribution of these studies to identifying children's ideas about various science content cannot be ignored. However, methodologically, these studies do not go far in understanding children's science learning in a natural context. Studies on children below eight years was also very limited since the existing methods such as surveys, use of picture cards or interviews for studying children could not gain a deeper understanding of the complexity of processes that occur as children learn science. Constructivist researchers discuss children's understanding of particular science concepts as an end product (e.g., Driver, 1983;

Silfverberg, 2006) rather than as the process of scientific concept development (Fleer & Pramling, 2015).

Some later research projects in this area were inspired by social constructivism studying conceptual change. Since the advent of the new millennium there have been studies on the concept of light and shadow (Dedes & Ravanis, 2008; Ntalakoura & Ravanis, 2014; Ravanis, Christidou, & Hatzinikita, 2013); evaporation and condensation (Tytler, 2000; Tytler & Peterson, 2004; Tytler, Prain, & Peterson, 2007); seasons (e.g., Tao, Oliver, & Venville, 2012); dissolution of solids into liquids (Panagiotaki & Ravanis, 2014); light and shadow (Herakleioti & Pantidos, 2015); children's ecological concepts of food chain (Allen, 2017); natural science concepts (Ravanis & Bagakis, 1998); children's literature and science concepts (Sackes, Trundle, & Flevares, 2009); categories of children's explanations about structure and properties of materials (Christidou, Hattzinikitas, & Dimoudi, 2005); emotions and conceptual change (Broughton, Sinatra, & Nussbaum, 2013); progression of children's concept development (Allen & Kambouri-Danos, 2017); play and science learning in preschool context with a focus on use of scientific language, process skills development (Campbell & Jobling, 2012; Gross, 2012; Henniger, 1987; Johnston, 2003; McFall & Macro, 2000); children's conceptions and misconceptions on science topics like matter, magnetism, density and air (Smolleck & Hershberger, 2011); children's fragmented knowledge on astronomy and teaching the astronomy topics from an early age (Hannust & Kikas, 2007).

These studies included approaches like intervention, inquiry-based, problem-based activities, grounded theory, approaching play and science learning from a developmental perspective, studying representation of children's mental models, quantitative experimental design, interviews, mixed-methods and descriptive analysis using statistical methods. Findings from these studies suggest children's conceptual change can be explored through studying children in their regular classroom context, social interaction, and use of representation models like drawings. These studies have named children's science concepts as 'alternative concepts'. However, these studies mirrors the broader literature at that time, and still fail to holistically study the science learning process of children of three to five years of age.

A cultural-historical perspective in early childhood science education research started to emerge after the mid 1990s and is discussed in the next section.

2.5.2 Cultural-Historical and Socio-Cultural Studies

In this section I present studies that directly draw upon Vygotsky's cultural-historical theory. I also mention some other studies that include a socio-cultural approach. The point of departure for these studies from the constructivist approaches stands precisely on the arguments that young children are capable of learning complex science concepts and the process of children's science learning is "dynamic and fluid" (Fleer & Robbins, 2003a). This means children's biological, social and cultural conditions interplay as learning happens through interaction in their everyday life (a detailed discussion on cultural-historical theory is presented in Chapter 3). Hence it is argued that interpretations of children's thinking may not give the authentic picture of children's science understandings unless the socio-cultural contextual aspects for the development are considered (Hadzigeorgiuo, 2015; Murphy, 2015; Wells, 2008). In addition to the account of the theoretical orientations of studies in early years science education I now present empirical studies that discuss science activities in formal preschool settings followed by studies including children and families at home or other informal contexts.

2.5.2.1 Science in formal preschool contexts

How science could be included in preschools has been a concern for researchers for many years. Among some very early studies on preschool science activities Neuman (1971) used the concept of ‘sciencing’ for including science in preschools. By sciencing he mainly means some science-related activities that children can actively participate in with possibilities of developing specific science process skills. He introduced the concept of sciencing, mentioning,

> Children who are actively involved with sciencing methods and materials are given a unique opportunity to develop a number of valuable skills, understandings, and attitudes. Independence, a more positive self-concept, development of specific motor skills, and improved reading readiness are some of the potential benefits that can accrue from these activities (Neuman, 1971, p. 297).

Feng (n.d.) discussed sciencing from a teacher attitude perspective that sees the teacher as taking an active role in children’s learning process skills. In a later study in Amsterdam, Schijndel, Singer, van der Mass, and Raijmakers (2010) conducted a quantitative experimental study in an everyday context in preschools. Their study included a sciencing programme for young children aged 2 to 3 years. The study focused mainly on observing children’s process skills development in sorting, forming sets, and observing slope and speed during free play. Their study found that a sciencing programme guided by adults improves children’s exploratory play. McNairy (1985) discussed sciencing as a useful framework in early years science learning, integrating process skills through an inquiry approach where sciencing could be integrated by the teachers to include the social, physical and logico-mathematical knowledge earlier theorised by Kamii and DeVries (1978). In an early study Perry and Rivkin (1992) emphasised the urgency of including the child's perspective for teaching science in preschools. The authors suggest using a sciencing approach for preschool educators and children to explore the preschool environment and some everyday phenomenon. In their study, early childhood educators and children used a sciencing approach in an everyday environment to measure shadows at different times of a day, and to observe plants, leaf patterns, ant hills, etc.

These studies show that the concept of sciencing has been used only in relation to some particular science activities in preschools for particular process skills development. Later Tu (2006) discussed sciencing from a researcher perspective and drew upon formal, informal and incidental sciencing to examine everyday preschool materials that could be used for science learning . No studies are available using the concept in relation to teachers' sciencing perspectives for exploring teacher attitudes about the relationships that can be made between learning and making everyday science available for children within the natural preschool environment.

As discussed in Section 2.5.1, historically, preschool activities have been based on a constructivist or a developmentally appropriate approach that encourage a domain-based perspective. Hence a major emphasis on preschool activities in early years was based on literacy and numeracy skills development. Meanwhile in many preschools, science-learning activities centred only on developing science vocabulary skills. Awareness about the relevance of science in children's everyday world did not get much attention in teaching practices in most countries where research was conducted. Process skills development was also an increased area of attention during that time. Conezio and French (2002, p. 16) pointed to this problem, mentioning that language and literacy learning *must be about something*. As the authors of the *ScienceStart!*

curriculum, they suggested emphasising children’s wonder and curiosity as well as developing science process skills for developing science understandings about everyday phenomena. Similarly, Dreyer and Bryte (1990) suggested that learning science vocabulary is not very important but children should be posed questions and given opportunities for exploring science in everyday moments such as swings and their pendulum motion, or learning about gravity while playing with balls. Shaji and Indoshi (2008) investigated some preschool environments in Kenya for the available science learning conditions for a possible implementation of a science curriculum. Watts (1997) emphasised including science in the curriculum, arguing that children’s theorisation about everyday phenomena provides evidence for possibilities of science learning at an early age.

Studies began to appear that included the everyday natural environment for teaching science. For example, in their study Deans, Brown, and Dilkes (2005) explored the ‘sound’ concept in children’s everyday natural environment in an inner city context with preschool children of four to five years old. Teachers, music experts and children together explored sound in their everyday environment through a *sound walk* using a digital recording method. They recorded sounds of birds, water flow in the nearby river, traffic, leaves blowing, people talking, etc. in the environment. The sound experiences were reproduced through children’s reflective drawings and reproducing the river sounds in a water trolley full of stones in the preschool. The exploration focused mainly on increasing children’s environmental awareness and sensory skills development. Mihaljevic (2005) explored play activities and science process skills development through setting up some formal play/games activities for Year 2 and 3 children. Plevkyak and Carr (2011) broadly outline some areas for science learning possibilities, for example, language arts, mathematics, social studies, music, heath science, physical education. Anne Wigg's (1995) study explored preschool science learning on increasing pre-schooler's knowledge and skills through hands-on activities. Children in her study prepared a lot of science equipment like a weather gauge, bird feeder and barometer at preschool and visited farms, the beach, nature centres, local parks, and a museum to learn about science concepts to do with dinosaurs, weather change, seasons, etc.. Parents were also involved in the study. Wigg also mentioned that creating a learning environment that discusses concepts relating to children's everyday life could improve teacher confidence, since the teacher, children and often parents can work together in such an approach.

Alexander and Russo (2010) suggest that to make science relevant to children's everyday context, children's interest in science could begin from a backyard environment. For example, their study involved an inquiry unit on observing magpies and other birds in the everyday environment to collect naturalistic data that developed children's observation skills about birds. Anastasiou, Kostaras, Kyritsis, and Kostaras (2015) suggested two kinds of science experiences significant for concept development—activities using moving objects (e.g., rolling a ball on a ramp) and storytelling supportive of scientific concept development for preschool children. These studies included the everyday environment in formal and informal contexts for children's science concept development. However, the studies mostly remained focused on some particular skills development perspective or generally finding out the many ways science could be investigated in everyday nature. Adult-child interactions in science learning were not yet fully captured in these studies.

In the 1990s researchers initiated a call for science oriented curriculum and activities in preschools. Although some of the above studies started to include the everyday environment, the focus still continued to come from a developmentally appropriate and skills development perspective concentrating on learning science vocabulary, science content or process skills. Arguments continued on what early childhood science might look like in preschools (Eshach & Fried, 2005). A few studies began to include children's science concepts and contextual learning in an innovative way, including the socio-cultural context (e.g.,Fleer, 1997; Robbins, 2005). Scholars like Murphy (2015) and (Eshach, 2006) argued that it is important to discuss the significance of science learning in a context rather than knowing the factual science content. These authors also noted that although developing science skills like observation and problem solving is important for developing increased competency in science, mastering these skills particularly does not provide a full picture of children's conceptual understandings of science concepts.

Some more studies have been included in this review that saw science as a social and cultural activity from a deeper theoretical orientation. Children learn from their everyday experiences though interacting with the social and material world. It is, however, likely that without adult support, children's science learning may be at risk of resulting in alternative or naïve concepts. Many of the studies conducted in formal preschool contexts have increased emphasis on the adult support imperative for learning abstract science concepts. Investigating this matter researchers have come up with some important findings—for example, Fleer (1991) discussed the process of introducing science concepts on electricity to preschool children. The study findings show that young children were able to learn about electric circuits. The study emphasised that the teacher's intentional role and teacher-child interaction for teaching science to young children can support learning abstract concepts. In another study Fleer (1995) studied the teacher-child interaction in an early years (5-7years) science-teaching lesson on electricity and time, focusing on learning technology aspects. Investigating the different teacher-child interaction styles, the study identified that a procedural and conceptually oriented approach for teaching and interacting with children makes a difference in children's abstract science learning. In particular, a social framework of interaction between the children and teacher focusing on a conceptual change approach showed that significant conceptual discussion and learning could occur for young children. Further studies on teachers' interaction styles were suggested. Situating children in their natural context, Segal and Cosgrove (1993) studied the fluidity and complexities of children's intuitive concepts of light and shadow. Their study used a conversation approach that is different from interviewing children.

Robbins's (2003) study on children's ideas on the everyday phenomena of day and night showed that children's learning is situated within their social and cultural contexts. This finding is important in its variance from the former understandings that children's science perceptions do not vary across cultures (Driver, Asoko, Leach, Mortimer, & Scott, 1998). Some other studies are also available that take into account the cultural context for science learning and which have increased our understandings on contextual learning in the context of Western and Australian Aboriginal science (e.g., Fleer, 1996a, 1997, 1999). These studies critique the narrow view of generalising children's science understandings based on Western science. The study suggests a broader view that acknowledging the varying cultural knowledge and practices held by different communities should be included in the early years curriculum. Kirch (2007) also emphasises the value of drawing for learning on cultural practices and interactions in everyday social situations beyond formal group settings.

Studies on play in science learning have gained increased attention in the past several years. Some examples include a focus on play, everyday and scientific concept formation (e.g., Fleer, 2009b; Fleer, 2010); and play, imagination and creativity (e.g., Fleer, 2011a, 2011b; Lindqvist, 2010). More of these studies are discussed in Chapters 8 and 9. Unfortunately in science education research not many studies are found that use the cultural-historical concept of everyday and scientific concepts. Fleer (2009b) suggests that in early childhood settings, educators need to be aware the relationships between everyday and science concepts so that the children can have opportunities to develop an informed attitude towards science. Findings from her study suggest that teachers should explicitly relate the play materials in their teaching to scientific concepts, because children may easily relate the materials to their everyday concepts without having developing the scientific concepts. This also suggests that a pedagogy needs to be developed in order for the early childhood teachers to incorporate science concept development through play activities. Data from an urban preschool centre in this study show that the teacher as a mediator in play can help children interlace everyday concepts with scientific concepts.

In Sweden, Larsson (2013) explored everyday phenomenon of friction in a preschool context using video observations. The study found that often there are moments in play or in everyday situations such as eating time or outdoor play with sledges where children encounter friction, yet teachers viewed such moments from an institutional value and practice need to keep the use of the materials within the norm and hence missed the opportunities to elaborate on the science concept. The everyday science experience is overlooked in such an instance. Murphy (2015) discussed Vygotsky's four super cultural-historical *golden key* school curriculum concepts – space, time, substance and reflection in science teaching context. The author emphasises that close observation to the science phenomena, generating explanations, attention to the context could bring much deeper understandings on science concepts for children and teachers could use such approach more deliberately for developing children's conceptual knowledge. In a study with a 3year old preschool aged child, Pramling and Samuelsson (2001) also found that young children could start developing an interest in everyday science concepts when they are given opportunities to interact with materials in a scientific way with the help of their educators. The authors argued it is not likely that children will learn the complex science concepts completely at that early age but we need to create science-learning possibilities for them to interact and to create the awareness to begin thinking scientifically.

It is agreed that children have immense curiosity regarding their surrounding environment. There are studies that have emphasised children's wonder, curiosity and everyday science experiences for science learning (Hadzigeorgiuo, 2001; Rule, 2007; Siry & Kremer, 2011). Evidence shows that preschool educators can play a significant role to help the children notice the changes in the seasons, feelings of warm or cold, plant growth and many other everyday phenomena (Eshach, 2011; Eshach & Fried, 2005; Siry & Kremer, 2011; Siry, Ziegler, & Max, 2012). Siry and Kremer (2011) studied 5 and 6 year old children's explanations about the rainbow, which is an abstract natural science phenomenon. Drawing upon sociocultural theory, the study findings highlight the importance of teaching science in early years of education. The study showed that children make meaning of their world and natural phenomena through complex interaction between books, media, imagination and through interaction with educators. The findings suggest that children together with the teachers can contribute in developing science curriculum where children's wonder about everyday natural phenomena can play a significant role. Therefore, teacher initiatives for creating science-learning opportunities within a sociocultural context that connects the everyday and scientific concepts relevant to children's everyday life strongly support young children developing competency in science (Howitt, Upson, & Lewis, 2011). Siry et al. (2012) explored teacher-child collaborative practices that give directions on the process of children's scientific knowledge construction. The study found that when children's discourse-in-interaction interactions are analysed including their gestures and actions, this reveals deeper understandings of the process of children's science learning. These findings could be drawn on for science teaching in preschools.

Children's curiosity and understanding develops through building a relationship to their environment. Blake and Howitt (2012) found that science activities are often a one-off activity in preschools. The authors recommend that children's wonder and curiosity should be continued through organising multiple experiences. Brooks (2009) and Wee (2012) discussed the importance of children's understanding of everyday science using drawing. (Wee, 2012) studied children's drawings on the concept of environment. The qualitative study sought samples from China, USA and Singapore. Using these children's drawing on the concept of environment, the study found that children's everyday concept of environment varied according their everyday context of living. The findings are relevant for science teaching that values children's everyday socio-cultural context for science concept formation. A study by Nadelson et al. (2009) showed that young children can demonstrate their learning of the concept of evolution—for example, bone structure of forelimbs or other anatomical features, similarities and differences— through modelling and drawing. These findings suggest young children are able to learn in their everyday context and a lot more could be revealed about children's concept formation if pedagogical attention is paid to their context.

In their quantitative experimental study Martins and Veiga (2001) emphasised the importance of learning everyday science concepts from the yearly years. The study included primary teachers and children from 90 classrooms. In an experimental design study they included everyday objects to explore science concept development on dissolving and floating and sinking concepts for children. They found that children are able to learn the science concepts when related to everyday experiences using objects and materials from everyday life. Klaar and Ohman (2014) further discussed the importance of the everyday environment in science learning through their investigation in a Swedish nature-based preschool activity. The authors mentioned the benefits of outdoor science activities for preschool children: 1) personal development and well-being; 2) care for nature; and 3) creation of knowledge about natural phenomena and processes. The authors discussed how when children had the opportunity to explore the outdoor natural environment in play-based preschool settings, there was the possibility to "create experience-based content knowledge" (p. 241). For example, during free play activities children may often explore the different forms of water (ice and liquid) in the natural environment due to the weather conditions, but this scientific phenomena of different forms of water is not often verbalised within a scientific conversation between the educator and the child and therefore left at an everyday level of understanding on the side of the child. The authors argue that not only with verbalised actions, but also through bodily cultural activities, the scientific phenomena could be introduced to children and therefore children's outdoor experiences could be richer with enhanced knowledge about the surrounding environment.

Concluding Remarks: In summary, the studies show that there is a growing body of literature emphasising contextual learning in preschool science. The content focused practices derived from constructivist literature are limited in capturing the process and possibilities for developing science concepts through the wide range of everyday experiences that children bring during interaction with peers and educators. The cultural-historical and socio-cultural studies bring a new perspective in studying science learning, exploring as they do adult-child interaction, children's cultural contexts, children's wonder and curiosity which were missing in the earlier body of literature. However, we also need to know about children's science learning environment in informal contexts in addition to preschool. What science learning conditions are available at home for preschool children? Do parents get involved with their children for science learning in everyday home environment, or is this not the case? I explore these questions in the next section.

2.5.2.2 Science including family home and informal contexts

Apparently very few studies are available that discuss parental involvement and family pedagogy for children's learning (Cumming, 2003). Studies that involve the family home in science education are included in Chapter 7 in this thesis. These studies generally suggest including science learning in everyday informal environments (e.g., Alexander & Russo, 2010; Awbrey, 1989; Dreyer & Bryte, 1990; Galvin, 1994; Wigg, 1995; Zhai, 2012). Chapter 7 also presents a review of studies from socio-cultural and cultural-historical perspectives that emphasise adult-child interaction for scientific concept formation (e.g., Blake & Howitt, 2012; Coeiw & Ortel-Cass, 2011; Crowley et al., 2001; Fleer, 1996b, 2009b; Fleer & Robbins, 2003a; Gomes & Fleer, 2017; Hao & Fleer, 2016a, 2016b, 2017; Robbins, 2005). In an early study Fleer (1996b) discussed home-preschool relationships for children's science concept formation. The study found that when parents are involved at home in exploring science experiences with their children, such experiences could extend preschool science learning for their children. Cumming (2003) also suggests similar findings from the study where she investigated children's thinking during informal family home conversations and experiences with parents about food growth and origin. The study found that children feel curious about the many everyday science concepts regarding food. This suggests that the everyday knowledge children bring from the informal family home context could inform educators in better framing of preschool science lessons. Zimmerman and McClain (2014) and Zimmerman, McClain, and Crowl (2013) studied family involvement in an informal nature centre public science programme. Zimmerman et al. (2013) studied families' uses of magnifying glasses during a nature walk program. In their study they gave the families a range of exploration tools, for example, field guides, compass, binoculars, lenses etc. during a nature walk to understand how the families use these tools or not. Their study increased knowledge on the scientific and non-scientific use of the magnifying glass by families as a science investigation tool. Katz (2011) studied how a child can use a digital science photo book for capturing scientific aspects in everyday life and how this develops a scientists' perspective for investigations in everyday life.

Fleer and Rillero (1999) reviewed studies on parent-child involvement with various formal home-school programme activities for science learning. They suggest there is a gap in knowing how parents' knowledge about science influences children's science learning. Also the review of studies broadly covers school science programmes but does not focus on preschool-home parent child involvement in everyday natural settings. We do not know about what the parents think about science learning for their preschool age children in the everyday family home context. We do not know how they interact in everyday contexts that could help preschool children (ages 3–5) learn everyday science. There is also a large vacuum in knowing how preschool and home environments could support children's science learning. These need to be further investigated in children's everyday natural activity settings.

Few studies are available on pedagogy in the home context. Children's ages vary from infants up to nine years old in the studies that have been done. A few of these studies focus on science learning. For example, (Sikder, 2015b); (Sikder & Fleer, 2015) and (Sikder & Fleer, 2018) studied infant-toddlers scientific concept formation in everyday family practices. These study samples were drawn from Bangladeshi families from Australia and Singapore. In their study Sikder and Fleer (2015) found that infant-toddlers could develop *small science* concepts (e.g., push, pull, press etc.) through everyday family practices. Parents' intentional involvement with children in the everyday cultural practices can help infant-toddlers in the process of developing small science concepts (Sikder, 2015b). A few studies investigated parent-child interaction during play moments where particular examples were drawn from science. For instance, Hao and Fleer (2016b) presented findings on children's scientific learning through pretend signs in everyday family imaginary play practice. The study findings show that in collective family play parents' roles are significant. Parents can foster scientific learning through giving meaning to the child's imaginary play when they play together.

In another study (Hao & Fleer, 2017) discussed Chinese children's learning motive development through imaginary play with parents in the family home. The study found that parents who value a learning motive related to various concepts—for example, counting; earth's rotation, etc.—participate in role-play or imaginary play with their children and create conditions for a learning motive. Their study concluded that the parent's role is important for creating a learning motive for their children during imaginary role play but did not elaborate particularly on science learning motives.

Some contemporary studies researched parent-child interaction in the family home learning environment but not necessarily from a science learning perspective. For example, in a longitudinal study in the UK, Siraj-Blathford and Sylva (2004) found that the cultural context at home and parents' interaction with their children support a sustained-shared thinking that can promote a home based pedagogy in the everyday context. Recently more studies have been conducted that investigated family pedagogy and children's' learning from various cultural contexts; most of these studies focused on imaginary play. In China, Hao (2017) studied play pedagogy at home in the form of a naturally created play-world and discussed the relations between ideal and real forms of children's concept formation on some social rules like 'sharing' with use of story telling. Fleer (2014) studied imaginary role-play practices in two Australian families. The study found that only one of the families creates imaginary role-play conditions and these conditions are created by adult-child interaction. This study focuses on the overall different kinds of family play practice. Devi (2016) studied Indian migrant preschool children in Australia. The study focused on parent's position in children's imaginary play at home. The study found that parents take different pedagogical positions (above/equal/under) during play with children that can help children learn measurement concepts. One study (Wong & Fleer, 2012) was found that included the everyday family practices extensively for observing the family pedagogy on developing learning motive. Wong and Fleer's (2012) study of an immigrant Hong-Kong Chinese family in Australia found that a learning motive can be fostered when a child's perspectives are taken into account by parents within the strict family values and everyday practices. The study findings particularly focused on motive development for learning playing guitar for a 9-year-old boy. These studies particularly focuses on informal family home pedagocial practices for studying child development and learning but does not include formal institutions.

There are some other studies that discuss parent-preschool partnerships. According to Lawrence, Gallagher, and Team (2015, p. 3) "the value of working with parent's pedagogy is that it includes what the children learn within their home and within their culture." Their study included parents and practitioners and analysed videos for adult-child interaction with children from birth to five years of age. Their study on relational pedagogy found that acknowledging the child's presence and using body/touch are some pedagogical strategies adults use in families with children under three. The adults use these strategies and are aware of their own pedagogical strategies for interacting with their children. The authors' claim that acknowledging the child's presence relates to inter-subjectivity that constructs a sense of identity in the child hence it is so important. The study suggests creating opportunities for early childhood practitioners to become informed about family pedagogy and values. In a quantitative study Sage and Baldwin (2012) investigated parental cues in natural pedagogy during free play. The authors argue that during informal parent-child interactions pedagogy is more likely to arise spontaneously. Although performed in a natural setting, the experimental study design findings were based on Western cultural background families and found that most of the parents used pointing, gaze shifts, referential speech, suggestions, observational statements and knowledge questions as cues during play with their children. Studies from Sweden (Sandberg & Vourinen, 2008; Vourinen, 2018) interviewed teachers and parents and discussed the many forms of co-operation between home and preschool on current practices. Macpherson (1993) explored partnerships between parents and preschool professionals. These studies contribute in highlighting the importance of understanding parents' interaction with their children in the family home environment, parent-professionals relationships and parent-child relationships during play, but do not particularly focus on the science learning environment at home or parental involvement during science learning.

The studies discussed in this section use varieties of data gathering methods such as video, photographs, use of artefacts, cultural tools, and in-depth interviews employing qualitative case study approaches. A main feature of these studies that distinguishes them from other studies is that they are conducted in the naturalistic cultural contexts of the everyday life of children. This is a very a different approach from earlier case studies that employed a constructivist approach. The natural context allows researchers to take into account the interaction between the participants and social situations of the child's development. The cultural tools, materials, and conditions give meaning to the researcher in the search for an understanding of the child's everyday life practices. For analysis these studies use approaches like discourse/conversation analysis, multimodal analysis, Rogoff's three lenses (2003), and document analysis. A few studies use cultural-historical concepts like everyday and scientific concepts, play, imagination, motives, ideal and real forms, the social situation of development and creativity. Use of the theoretical concepts in these cultural-historical studies allows authentic analysis to go deeper into understanding children's learning and development.

2.5.3 Empirical studies on early childhood teachers

In this section I include studies on both in-service and pre-service teachers that discuss teachers' beliefs, self-efficacy, confidence, competence and perceptions on science teaching. Some of the studies in this area have been reviewed in Chapters 5 and 6. This section mainly includes that are not discussed in the chapters.

Generally, lack of teacher confidence and competence for teaching science is a common concern at all levels of science education (Goodrum, Cousins, & Kinnear, 1992). Early childhood teachers are not excluded from this concern. Lack of teacher confidence to teach science (Appleton, 2006; Blake & Howitt, 2009; Garbett, 2003; Watts & Walsh, 1997) and what science looks like for young children with concern regarding how to teach science in early years have been common problems in the field for many years (Eshach & Fried, 2005; Howitt et al., 2012; Siry, 2014; Wigg, 1995). There is ample evidence that how teachers teach science depends on their perspectives on children, science, previous experiences of how they were taught science and their views of teaching science (Areljung, 2018; Yoon & Onchwari, 2006). Considering all the reasons, together with an increased emphasis on early childhood science education Peter Fensham (1991) drew attention to the need for building a community of teachers that recognise the importance of science in early childhood. The debate is how do we teach the young children the abstract science content embedded in everyday life? How can the teachers be empowered with the confidence to teach science? The concerns indicate that teaching science in the early years is a complex area. Although it is commonly perceived that science is everywhere in daily life (Eshach & Fried, 2005;

Roychoudhury, 2014), the concern is how to teach science for young learners to permit the science conversations and thinking to have a stronger basis and to view science as part of their everyday life.

Research has found that there are many opportunities for science learning in everyday life, particularly in preschool environments but teachers do not promote science learning (Tu, 2006). In a study by Blake and Howitt (2009), preschool teachers mentioned that the teachers did not feel confident to teach science; literacy and numeracy skills development were regarded as more required than science in the early years. Similar findings were also available from a quantitative study by Sackes, Trundle, Bell, and O'Connell (2011). Their study concluded that early science intervention does not impact on concept development in later years. The reasons identified are teachers' lack of confidence to teach science at preschool level and science not being perceived as a priority area since literacy and numeracy are more emphasised at this level. The authors suggest supporting early years pre-service and in-service teachers with innovative science teaching methods for increased confidence and competence to teach science. In the same year, Howitt (2011) developed an early years science teaching resource called *Planting the seeds of science* that early childhood educators could easily implement. This collaborative project involved academics from early childhood and engineering, pre-service and in-service teachers. Children's wonder, curiosity, adult interaction and contextual learning were emphasised in this study. The resource included an identification of everyday science concepts in the environment to help teach science to young children.

Studies available on pre-service teachers have explored a number of aspects in the area of preschool science teaching. A study on pre-service teachers by Beverley, Fleer, and

Gipps (2007) found that teacher interaction can move young children's perceptions from the traditional view of scientists towards an understanding that children can be scientists in their everyday life. In Spain, Oliveras and Oliveras (2014) study on pre-service kindergarten teachers' perceptions about science, mathematics and play, it was found that the student teachers thought play could develop scientific and mathematics thinking in children. However, this finding is very general as there were no in-depth discussions; data were presented from a questionnaire using quantitative interpretations. Bayrakter (2011) found that Turkish teacher education programs contribute positively to pre-service final year students' self-efficacy beliefs in teaching science. Final year students also had a more positive attitude towards teaching science. Fleer and Robbins (2007) studied about pre-service teachers' theoretical paradigm shifts from a developmental-constructivist perspective towards a cultural-historical perspective. The study findings show that although it was difficult for the student-teachers to bring new lenses for documenting observations in traditional constructivist-practice environments, the new cultural-historical lenses brought deeper understanding about children's interactions and development that were missing in the existing preschool science teaching practice. The new socio-cultural—personal, interpersonal and contextual—lens for observing children in their natural cultural context suggested by Barbara Rogoff (2003) was found powerful by the pre-service teachers for understanding the cultural relationships in a child's immediate context of scientific interaction.

Some studies, such as that of (e.g., Spektor-Levy, Bauch, & Mevarech, 2011), researched in-service teachers' perceptions on the curiosity of preschool children and teaching science in preschools . Their study found that the teachers think curious children wonder and ask questions about the natural science phenomenon. The study suggests that although most teachers have a positive view towards introducing science from the preschool age, they do not feel confident about planning science lessons through their fear of inadequate science knowledge. Yoon and Onchwari (2006) suggested three key points for teaching science in early years. They advise it is important that early childhood teachers have increased knowledge on child development, acknowledge differences in individual children and recognise the role of socio-cultural contexts in child development. The authors emphasise inquiry-based learning and recommend that teachers give importance to encouraging children to ask questions about the everyday environment.

Further studies are available on innovative strategies for the professional development of in-service teachers. For instance, Watters, Deizmann, Grieshaber, and Davis (2001) discussed professional development workshops for early childhood teachers. The workshops were designed to provide teachers with experiences relevant to science teaching strategies. Their study found that early childhood teachers need more support on pedagogical strategies for explaining abstract scientific concepts to young children. Tsitouridou (1999) emphasises the need to include strategies for science pedagogy in early childhood professional development units as well. Traianou (2007) critiques the constructivist methods, finding them inadequate for assessing a teacher's conceptual knowledge since the practical problem solving abilities in teachers may not be adequately measured by the artificially created situations during teacher interviews. From a sociocultural perspective the study argues that teachers apply their conceptual knowledge in a community of practice that varies in every single experience. Teacher's expertise and knowledge develops in practice. Therefore, the complexities in everyday situations need to be studied carefully for assessing teacher's knowledge. In Irish context Murphy, Mullaghy, and D'Arcy (2016) signals lack of teacher confidence for less contextual science teaching. The authors also emphasised on taking into account of the children's perspectives during science teaching for making science concepts more meaningful in children's life. It appeared from their study that the team teaching programmes like 'science-in-a box' as an innovative initiative for delivering a unique science curriculum could enhance teacher confidence because of its collaborative and context-based nature. The programme made links between industry and academia by including scientists, primary school teachers, science experts, artists and musicians. Siry and Lang (2010) reported on a field based pre-service teacher education unit that also included in-service teachers and an expert teacher educator. The study analysed teacher-child cogenerated dialogues that could create scope for creating children's agency in the classroom and inform the teachers about children's personal science experiences. The findings are twofold: firstly, they provide important directions for teacher education studies for learning how children theorise their experiences and secondly, they improve teacher confidence to develop science lessons based on children's experience. In a recent study Areljung (2018) discussed introducing some 'verb ideas'—for example, rolling, melting—to preschool teachers for teaching science. The author argues that rather than viewing science as compartmentalised content areas, the verbs and actions related to everyday physical and chemical science experiences could help teachers build closer relationships to children's science learning. The authors also argue that doing traditional science experiments makes teachers feel more challenged in science content areas as they are based on specific canonical concepts. However, using the verb idea gives teachers more freedom and increased confidence to think about science beyond 'boxes' and do science with children using everyday situations.

(Siry, 2014, p. 302) suggests that in contrast to

> asking ourselves (for decades!) questions relating to levels of primary school teachers content knowledge in science, we instead embrace notions of science as a communal practice—one that is lived and generated in the practices—teachers do not need to be necessarily ‘‘experts’’ in a content area such as science. Rather, through such epistemological perspectives on science as a communal practice, teachers would need to have theoretical assumptions of the inherent complexities of teaching and learning science, in order to be able to support their students (and themselves) in exploring phenomena and learning together about concepts, processes, and products of science.

The author emphasises that drawing upon a multidimensional approach, for example, looking into the process, content, histories, emotions and experiences, we can come to a more nuanced understanding of what science is for preschool children and how they could learn and could be taught science.

2.6 Conclusion

Collectively, the studies emerging from cultural-historical theory suggest that children below eight years are able to learn abstract science concepts. The findings conclude that studying children in a collective environment can give better understandings about their learning than studying children alone. Researching and applying play theories can be helpful with the many new dimensions featured in this genre of studies. Not a lot is known about children’s play-based everyday contexts to inform newer understandings for exploring science-learning possibilities. Very few studies are available from family home contexts or from a combination of preschool and home contexts involving parents. Studies from family home contexts reveal that parent-child interaction and play can support concept formation. But we do not know what parents particularly think about preschool children's play and scientific concept formation in everyday life. We do not know what preschool and family home affordances create opportunities for children's motive orientation for science learning. Few of the studies reviewed in this chapter use cultural-historical theoretical concepts. More studies are needed using Vygotsky's theoretical concepts for understanding children's science learning in an everyday context. This gap is addressed in Chapters 7,8 and 9.

From teacher education studies and studies on preschool activities it is revealed that more is to known on how teachers can use the everyday environment and interact with children for teaching science in everyday contexts. More needs to be known about how the everyday environment could be used for science teaching in preschools. Concepts like sciencing still have the potential to be explored in relation to the everyday environment. The studies suggest that teachers have an important role in promoting interest in science for young children. This could begin from the everyday surrounding natural environment for teaching science. Unfortunately we do not know much about how teachers could bring the everyday environment into preschool science teaching and learning.

From the empirical and theoretical literature presented in this chapter it is concluded that much needs to be known across diverse activity settings to develop a clearer understanding of the various complex relationships that exist in a child's everyday functioning environment and activity settings that can create possibilities for scientific concept formation. In particular, from the history of primary and early childhood science education it is also clear that this area needs increased research in science education focusing on contextual learning for furthering children's scientific understanding from an early age. Alongside various curriculum reforms and emphasis on content, process and conceptual learning from an early age, we do not want to teach heavy abstract science content to our young children; rather, we want our teachers empowered with conceptual knowledge on the everyday and scientific relationships of the science concepts existing in a child's surroundings. A cultural-historical approach can provide a strong basis for better understanding of children's scientific concept development possibilities. In the next chapter I discuss the cultural-historical theoretical concepts employed in this study.

CHAPTER 3
Theoretical Concepts Guiding the Study

3.1 Introduction

The theorisation of children's cognitive development has been critically examined over the years. In studying the process of children's scientific concept formation, it is important to conceptualise what view of development is informing the research. This thesis is framed within a cultural-historical conceptualisation (Vygotsky, 1998) of child development to understand the process of children's scientific concept formation. The research problem in this study demands a strong theoretical base that will take into account the social and cultural relationships within the existing practice in the formal and informal contexts in a child's everyday life. Because of its holistic focus on child development within their social, cultural and historical contexts, cultural-historical theory is deemed appropriate in this regard. In this chapter I discuss the basic cultural-historical theoretical understanding of child development and the theory of concept formation. I also present theoretical understandings of everyday and scientific concepts and include a brief orientation to the other concepts used in this thesis in Chapters 5, 6,7,8, and 9. These concepts provided the theoretical skeleton to frame the study and data analysis.

3.2 Lev Vygotsky and Cultural-Historical Theory

Lev Vygotsky (1896-1934), known as the "Mozart of psychology" established the cultural-historical theory that occupies an exceptional place in modern psychology. He rejected the former classical psychology based on reflexology and he further started investigating his explanations of the social cultural relationship of *consciousness* in a more naturalistic scientific way (Veresov, 1999). Vygotsky was immensely interested in arts and drama and he studied literature at the university. He was originally not a psychologist. After his graduation his early orientation to Marxist philosophy greatly influenced him, but rather than seeing humans as a product in the Marxist sense, he started to think about child development in a completely unique way that centered on interactions between a person and the surrounding cultural tools (Levitin, 1982). His work, *The psychology of art* (1971), was remarkable, leading him to the discussions in psychology that made him popular for the originality of his ideas and explanations, all of which developed into the cultural-historical theory.

Vygotsky's theoretical work has been developed through three phases as his thinking developed over time during the period of 1925 – 1934. During the first phase he worked on the book Psychology of Art (1915-1922) and finished writing it in 1925 although it was never published during his life time (Smagorinsky, 2011). The book gave a foundation for all his work in his later life. Gradually from first to second phase the emphasis of his theoretical framework on human psychological development moved from social interaction and cognition to sign mediation. During the second phase between 1928 and 1931 his theoretical work emphasised on higher mental functions, sign mediation. Vygotsky's theoretical search on the genetic roots of thinking and speech (Chapter 4 of Thinking and Speech) was key between the second and third phases (Minick, 1987). Eventually his critique on Piaget's work (1932, Chapter 2 Thinking and Speech) played a vital role on expansion of his novel work on understanding mental development. During third phase he extended the explanatory framework to some unique concepts like social relationships, perezhivanie, imagination, social situation. His work during the third phase (1932/33 – 1934) appeared significant, as it started to “develop a system of psychological constructs that would facilitate the analysis of psychological processes in connection with the individual’s concrete actions and interactions” (Minick, 1987, p. 18). During 1931 Vygotsky and his colleague Sakharov studied on concept formation (Chapter 5, Thinking and Speech) and later during 1934 before his death Vygotsky and Shif were working on scientific concept formation (Chapter 6, Thinking and Speech). In his work on scientific concept formation (Chapter 6, Thinking and Speech). Vygotsky noted the emergence of a new type of meaning and function of a word or a concept in a child’s understanding of the word meaning that he theorised as a “scientific” or “true” concept (Minick, 1987, p. 27). However it took until the 1950s for his work to become widely known in Russia and after 1962 in the USA (Levitin, 1982). The period of 1990 – 2010 is marked as the worldwide renaissance of Vygotsky’s work (Veresov, 2012).

3.3 Cultural-Historical Developmental Characteristics at Preschool Age

Bodrova and Leong (2003) discussed preschool age and cultural-historical characteristics of children in this age group as posited by Vygotsky. The authors mention that in Russia during Vygotsky’s time, preschool age used to refer to the children prior to the age of entering school. The lower boundary of preschool age was 3years and the upper boundary of this age group was ages 7 or 8. The current study includes 3 to 5 year-old preschool children within Vygotsky’s preschool age bracket. He referred to children younger than this boundary of preschool age as infants and toddlers or children of early age. Vygotsky perceived children of any age group as being possibly beyond their biological age because of the unique relationships he theorised between the child and his or her surroundings.

According to Vygotsky, preschool age (3-7 years) is a crisis period and he discussed several themes or characteristics to describe development at this age period. Speech and social interaction were identified as the underlying foundation of child development process and was the main focus in Vygotsky's work during 1926 and 1930 (Minick, 1987). This emphasis of his work was named as "higher mental functions, functions such as voluntary attention, voluntary memory, and rational, volitional, goal-directed thought" (Minick 1987, p. 20). While discussing Vygotsky's Bodrova and Leong (2003) suggests, firstly, dynamic higher mental functions such as attention, memory and imagination begin to emerge at preschool age, while the lower mental functions begin to change from the previous toddler period. Language plays an important role at this stage, and is key in beginning to transform their imagination and thinking. Secondly, since at this stage children begin to use language in a more voluntary manner they not only use language for communicating with others but they also use it for communicating with themselves that is called private speech. At this age language plays a vital role in making children capable of more independence and they begin to become involved in private speech and imaginary play. Vygotsky noted the process of using language as a cultural tool and acquisition it internally in the form of private speech that he later used in his theorisation for children's thinking and development while explaining interpsychological and intrapsychological functions (Bodrova & Leong, 2003). Vygotsky saw a unity between emotion and cognition, which he described as a third aspect at this age but he could not complete his theorisation of this because of his early death (Bodrova & Leong, 2003). His fourth theme is the social situation of development – a central theme Vygotsky described to explain child development.

3.4 Cultural-Historical Understanding of Child Development – Linear or Dynamic?

Previous theories of development described child development based on external and visible changes in life – as evolving milestones linked with a particular age. For instance, the Piagetian model of child development focused on how child development occurs through stages. However, his theory appeared limited, describing only the influence of social interactions and contexts for development but not discussing the complex dynamic process of development. Moreover, these earlier naturalistic theories situated the child as separate from society and considered development as taking place along a linear developmental path. This made the discussion of development problematic because "linear approaches use formal logic to describe surface appearances of psychological development but do not reveal its internal essence—the process of motion, change, and development" (Mahn, 2003, p. 121) .

Vygotsky's analysis focused on the relationships between an individual's growth and the socio-cultural interactions that are part of their everyday life. For the first time this relationship in terms of development was described as 'dialectical' from a cultural-historical point of view by Vygotsky when he discussed the stable (lytic) period and crisis periods in a child's life. He notes that, during a stable age, a whole lot of "molecular" changes occur in a child's life that become visible "only as a conclusion of long-term processes of latent development" (Vygotsky, 1998, p. 190) at the 'crisis' age level. According to him, this change is revolutionary for the child. However, the whole internal process of development, particularly during the 'crisis' age stage was pointed out by Vygotsky as being an under-researched area that could uncover the process of child development. Firstly, in the child's personality, rapid development takes place in a relatively short time during these crisis periods. Such characteristics indicate the presence of the crisis age. Secondly, a conflict arises between the internal interest and regular activities for example, inattentiveness in schoolwork. However, not all children may explicitly show these disruptive characteristics, though they may become relatively difficult to handle at this crisis age. Thirdly, a temporary negative progress is observed in regular activities or interests. Transition from infancy to early childhood (towards age three) is considered to be a crisis age. Bozhovich (2009, p. 64) explains:

> During the transition from one age to another, not only separate mental functions grow and qualitatively change, but their relationships to one another and structure change as well…the different mental functions do not grow and develop at an even pace. They each have their own period of optimal development, and during this period all of the other functions operate as if within this function, through it. This accounts for the distinctiveness of the structure of the child's consciousness at each developmental stage.

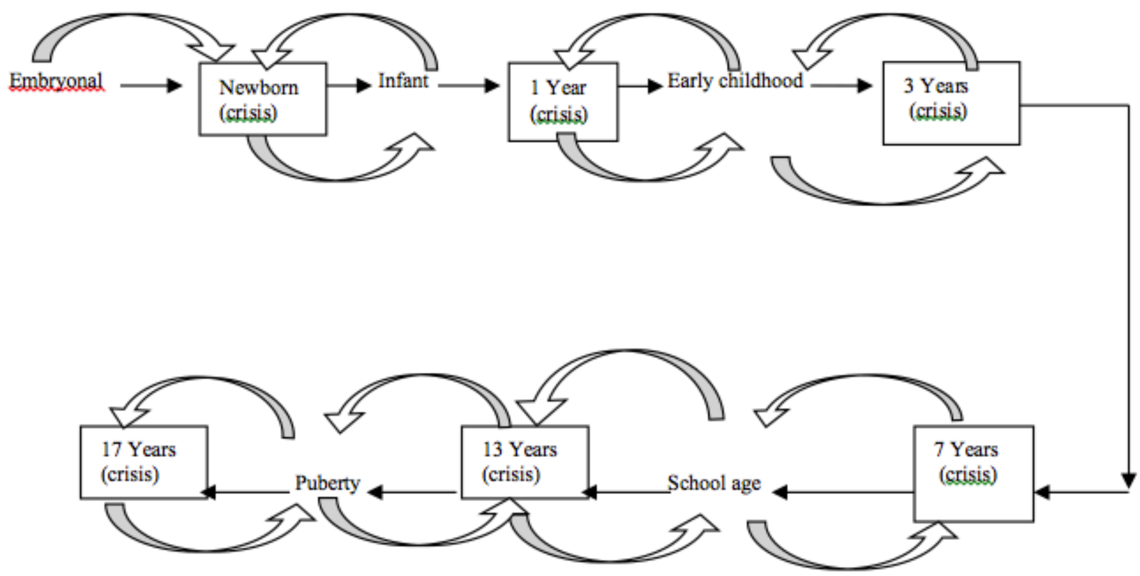


Figure 3.1. Dialectical relationship between crisis and lytic periods. Figure developed based on discussion from Vygotsky (1998)

This means that the beginning of a stable period is related to the end of the previous crisis period. In a crisis period, the child acquires self-awareness of particular features of him/herself and their environment. However, this self-awareness also changes during the development in stable periods. Vygotsky (1998) argued that in a given period the child's self-awareness and the child's relationship to their environment profoundly affects development. This internal and external relationship is determined by the new formations in their personality. New formations therefore give the psychological structure of the personality. The psychological structures are for example, language, verbal thinking and conceptual thinking. The new formations become the driving force behind the transition form one age level to the next and determines the characteristic of the new age level (Mahn, 2003, p. 123). A new formation in each stable period assimilates the new formation of the crisis period. This happens at the beginning of a stable period with adult communication. Finally, the status of this new formation changes and this is called a leading activity when it is included in real life at the end of this stable period. According to Kravtsova (2005), "transition from one age stage to another is related to the change of leading activities (p.1)." Therefore the child's development and the leading activity are strongly related to each other (Kravtsova, 2005; Veresov, 2006). The crisis and stable periods can be understood in a dialectic relationship (Figure 3.1) with each of its transition ages. The new formation of the stable period builds the foundation of a leading activity. This is when a child masters the activity on his/her own, without the help of adults. Appropriate pedagogy during these crisis levels has been very little developed (Vygotsky, 1998).

3.4.1 Genesis of higher mental functions

Vygotsky suggests that to understand child development, the natural and the cultural lines of development of the child need to be studied closely (Vygotsky, 1994a). If we do not think about the cultural development of a child, s/he cannot learn and develop through using the cultural tools invented by that community. Vygotsky (1994a) clearly distinguishes development along two different lines—the natural line of development and the cultural line of development. The reason he argues for the two lines is explained by an example of a child's memorisation process. For example, a child may simply remember things according to his/her biological growth of age. The other reason for memorizing could be the process of how the child remembers, for example, using cultural signs and tools such as language or maps. Vygotsky argues that the process of the qualitative change in a child's development can be studied through analysis that explains the nature of development and recognizes the cultural tools, materials and cultural aspects in a child's environment.

The process of development is therefore better understood as a *relationship* between the natural and cultural environment. At his point Vygotsky (1997a, p. 105) further explains the dialectical relationship between the person and environment, stating:

> Culture…does not produce anything new apart from that which is given by nature. But it transforms nature to suit the ends of men. This same transformation occurs in the cultural development of behaviour. It also consists of inner changes in that which was given by nature in the course of the natural development of behaviour.

This suggests that a complex transformation process occurs between the natural biological and the cultural lines of development. He explains:

> Every higher mental function was external because it was social before it became an internal, strictly mental function; it was formerly a social relation of two people. The means of acting on oneself is initially a means of action of others on the individual. (Vygotsky, 1997a, p. 105)

This general genetic law of development theorises the social in connection with the psychological. Vygotsky explains we can formulate general genetic law of cultural development as follows:

> every function in the cultural development of the child appears on the stage twice, in two planes, first, the social, then the psychological, first between people as an interpsychological category, then within the child as a intrapsychological category. This pertains equally to voluntary attention, to logical memory, to the formation of concepts, and to the development of will. (Vygotsky, 1997a, p. 106)

In contrast to Piaget's theories and other psychological methods, cultural-historical studies researching individual development of behaviour explains it as a social act. This process of development should be first understood and analysed by observing how an individual reaction proceeds from the forms of social life. Development proceeds not toward socialisation, but toward converting social relations into mental functions (Vygotsky, 1997a, p. 106). In Vygotsky's words such a process of development is "not evolutionary but revolutionary" (Vygotsky, 1997a, p. 110). He states that higher mental functions are central in this revolutionary process of cultural development. While discussing the genesis of higher mental function, Vygotsky points out:

> Scientific consciousness, on the other hand, considers revolution and evolution as two mutually connected and closely interrelated forms of development. Scientific consciousness considers the leap itself that is made in the development of the child during such changes at a certain point in the entire line of development as a whole. (Vygotsky, 1997a, p. 99)

Cultural development therefore explains the child's developmental process from a holistic perspective that explains the relationship between the child and the environment.

3.4.3 System of concepts

To explain the dynamic process of development, Vygotsky introduced a system of concepts, since only studying the stimulus-response pattern discussed in classical psychology is rather narrow in describing the complex human process of development. During 1930 in a lecture Vygotsky mentioned analytical units that he called psychological systems (Minick, 1987). The main point of his argument states that psychological studies on human development should not focus only on individual mental developmental functions but "on the development of new relationships between mental functions, in the development of psychological systems that incorporate two or more distinct functions" (Minick, 1987, p. 18). Although the stimulus-response laws of development influenced his earlier work, in his later work Vygotsky developed an integrated conceptual framework that discussed development in terms of unit of analysis and human social interaction in which an individual takes part in his/her everyday life.

In this integrated system Vygotsky rejected the traditional psychological trend of the body/mind split. His theory integrated the consciousness and behavioural actions as a unified process. Vygotsky's work started to introduce some new psychological constructs as part of a system of concepts that could help us discuss and analyse the complex psychological process of an individual's development, as it evolves through social actions and interactions.

Learning science is an important part of the cultural development of a child. Studying the child through their interactions in their natural settings illuminates a more holistic view of a child's development of scientific concepts. A dialectical conception of child development allows for a study design that pays attention to how the significant adults in the child's world give meaning to their everyday life and interactions, and how these same adults give scientific meaning (or not) to events in a child's everyday life at home and in the preschool. The cultural-historical revolutionary process of development needs to be explained through a set of inter-connected concepts. The main cultural-historical concept in this thesis is the everyday and scientific concept that I have used in conjunction with the concepts of play, motives, and social situation of development to understand the complex cultural-historical process of scientific concept formation possibilities. These concepts are only briefly discussed below to avoid repetition from the publications.

3.5 Cultural-Historical Understanding of Concept Formation: Everyday Concepts and Scientific Concepts

Vygotsky's 1932 work *Thinking and speech*, which mainly discussed scientific concepts, emerged during the transition between the first and second phase of his theoretical development and provided a strong basis for the emergence of the third phase of his work, which remained unfinished because of his untimely death.

Vygotsky's (1987) discussion on the development of scientific concepts is based on the experimental study of his student, Shiff, along with Tolstoy's analysis of the relations between word meaning and concepts and Piaget's theory on concept formation. In the *Collected works of Vygotsky* Volume One, Chapters 5 and 6, Vygotsky (1987) discussed concept formation. Chapter 5, written in 1930, was based on Vygotsky and his student Sakharov's work, which discussed concept formation in a three layer process, progressing from 'unorganised heaps' to 'complexes' to 'concepts' in an individual's mind. This explanation mainly reflected the intrapsychological functions of concept formation (Daniels, 2005). Chapter 6 was written in 1934 and provided explanations on concept formation in relation to teacher-child interaction in institutional contexts and activities. The discussion centred on the interpsychological process of concept formation (Daniels, 2005). In Chapter 6, Vygotsky discussed four major research agenda of his work in relation to understanding concept development. These areas are: understanding concept development regarding the everyday and scientific concept; the relationship between instruction and development; conscious awareness of concept development; and the zone of proximal development in regard to concept development.

In cultural-historical theory instruction occupies an important space for development. Scientific concepts have their origin in instruction. Vygotsky contends that "development has a different tempo than instruction" (Vygotsky, 1987, p. 207). He explains:

> If the course of development coincides completely with that of instruction, every point in the instructional process would have equal significance for development. The curves that represent instruction and development would co-inside. Every point in the curve representing instruction would have a mirror image in the curve representing development." (Vygotsky, 1987, p. 207)

But this does not happen as he continues pointing towards the significant moments of learning saying, "in both instruction and development there are critical moments. …these points of transition on the two curves do not coincide but display complex interrelationships." Through his strong argument on instruction and development Vygotsky unveils the significance of formal instruction for developing scientific concepts that may otherwise remain at an everyday level. His experiment on children's responses and the use of 'because' and 'although' as an everyday and scientific understanding of sentence construction provided the foundation for developing the understanding of the relationship between instruction and development. The study found that through instruction children were able to use these phrases in an increasingly scientific fashion, combining both everyday and scientific reasoning. The reasoning was based on a more concrete everyday experience but received a structural foundation through understanding the scientific relationship that was possible through teacher instruction.

Vygotsky (1987) further suggests that concepts develop through a complex process that is not possible to develop through mere memorisation. Vygotsky cites Tolstoy saying "the word is almost always ready when the concept is ready" (Vygotsky, 1987, p. 171). This suggests, "when the child first learns the meaning of a new word, the process of development has not been completed but has only begun" (p. 172). Similarly, when the child expereinces scientific phenomena in everyday life or receives instruction on scientific concepts in formal education, the process of developing the final form of the abstract concept just begins. Both of these concepts have to undergo some organisation and reorganisation process through links running back and forth between each other. In this process, any direct instruction of concepts is discouraged by Tolstoy and this is supported by Vygotsky as well. They both agree that direct instruction is fruitless. For this reason, “the formation of scientific concepts is not completed but only begun at the moment when the child learns the first meanings and terms” (Vygotsky, 1987, p. 176).

The major argument that distinguishes Vygotsky’s explanation of concept formation from previous other theories is the dialectical logic. Vygotsky (1987) critiques Piaget’s ideas of concept development from a cultural-historical point of view, arguing that in former studies on concept development, the nature of scientific concept development and everyday concept development remained undifferentiated. He highlights the flaws in Piaget’s ideas of cognitive development, which see such development as occurring through a process of replacing old ideas with new ideas as the child grows. Vygotsky argues that scientific concepts are nonspontaneous concepts that are the accumulated thoughts of a child’s experiences at a given stage of development; these thoughts are not suddenly developed. In Vygotsky’s words “scientific concepts are not simply acquired or memorised by the child and assimilated by his memory but arise and are formed through an extraordinary thought of his [sic] own thought” (Vygotsky, 1987, p. 176). This explains how everyday concepts develop outside any formal setting—for example in the family home or in other informal settings—but formal school instruction gives a systematic structure to the everyday understanding. Therefore, both concepts are related to each other.

From a cultural-historical point of view, concept formation is described at two levels—firstly everyday and secondly, scientific. Scientific concept formation is a higher psychological function of which the process is socially embedded. For any higher mental function the process occurs at two levels as discussed earlier-—social and personal. It is a dialectical process. Through this process the complete transformation occurs not only in one's actions but also in the whole mental process. This brings a qualitative change that includes both actions and consciousness in an integrated system that was first ever described by Vygotsky as a dialectical relationship. This implies when children can use the scientific concept deliberately in a conscious way, they actually combine the everyday concept with the scientific reasoning (Van Der Veer, 2007). As such, his work clarifies the significant aspect where 'consciousness' is essential for higher order thinking and concept formation. Conscious awareness is a state of the core foundation of one's development. In Vygotsky's words,

> Because of the foundation which is common to all the higher mental functions, the development of voluntary attention and logical memory, of abstract thinking and scientific imagination, occurs as a complex unified process. The common foundation of all the higher mental functions is conscious awareness and mastery. The development of this foundation is the primary new formation of school age. (Vygotsky, 1987, p. 208)

For example, knowing that pouring hot water may break a glass and putting a metal spoon into the glass may prevent the glass from breaking is an everyday concept. However, the scientific concept of heat conduction is important here to allow the person to transfer the everyday concepts to any other context. An everyday level of intuitive understanding is a result of the way of interacting with the social and material world.

This example explains Vygotsky's argument that both everyday and scientific concepts are foundational for concept formation. It shows how in Vygotsky's term, the 'everyday and scientific concept', represents the dialectical process of the essential interaction of the everyday concept with the developing scientific concept (through application of the grammar of scientific thinking and consciously provided timely input that links to the everyday). The one is within the other, each transforming the other as the concept develops.

Based on Howe (1996) and Minick's (1987) discussion, the basic differences between Piaget's constructivist theory and Vygotsky's cultural-historical theory are outlined in Table 3.1.

Table 3.1 Differences between Constructivist and Cultural-historical Theory

Constructivist Theory	Cultural-Historical Theory
Piaget as an epistemologist seeking the origin of knowing (Howe, 1996, p37)	Vygotsky as a psychologist, seeking the origin of consciousness that includes the phylogenetic, historical and ontogenetic development (Howe, 1996, Minick, 1987)
Biological growth determines learning and development isolating the individual from their context	Historically developed socio cultural learning is the origin of development.
Learning and development are independent processes; Instruction waits for development. Therefore, development explains learning	Instruction and learning lead development. Instruction creates a Zone of Proximal Development (ZPD)

This paradigm is based on stimulus-response conditional behaviour for explaining learning and development	Speech and other historically developed sign systems provide humans with a unique form of stimuli. Signs and mediation are foundational for development in cultural-historical theory
Subjective study of human development analysing the mental psychological functions and omitting socio cultural conditions for development	A system of psychological constructs facilitates an understanding of the process of development and includes the actions and interactions in human life that give meaning to the objective world

The argument based on the notion of dialectical relationships continues as Vygotsky states that scientific concepts are closely intertwined with everyday concepts. Basic everyday concepts lay the foundation for higher order thinking. Everyday concepts are experienced in children's day-to-day practice. "It [everyday concepts] tends to move upwards toward abstraction and generalisation"; on the other hand, scientific concepts start with verbal definition and descend to the concrete (Vygotsky, 1987, p. 168). My understanding of this dialectical relationship is captured in Figure 3.2 below (published in Fleer, Gomes & March, 2014: Chapter 5 in this thesis).

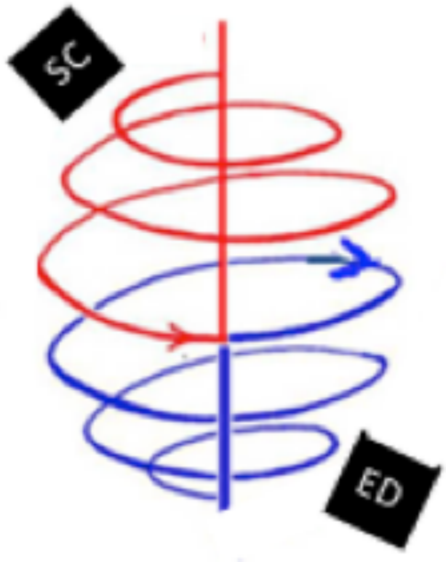


Figure 3.2. Everyday concepts and scientific concepts are dialectically related (Model developed based on discussions from Vygotsky (1987)

This essential understanding provides a strong foundation for researching the dynamic process of children's concept formation in this thesis. According to, Fleer (2009b, p. 282)

> studying the dynamic process as opposed to the child's definitions of a particular concept ('end product'), offers a new direction for science education research, and is particularly pertinent for researchers interested in how very young children pay attention to, and extend their understandings of scientific concepts.

Scientific concepts strengthen the everyday concepts supporting the structural formation of concepts. Everyday or spontaneous concepts lay the foundation for scientific concepts. The strength of the scientific concept lies in the child's capacity to use it in a voluntary manner. Children's thinking and practice can therefore be transformed when everyday and scientific concepts are interlaced together. It was found that in formal educational contexts when educators simultaneously use both concepts in their teaching–learning practice, they interact with the environment from a position that Hedegaard and Chaiklin (2005) characterise as a double move. Teachers' perceptual recognition about the surroundings and their active role in conceptual science teaching are therefore very important.

Vygotsky's (1987) emphasis on the influence of conscious instruction for the process of concept formation that propels learning is discussed above. The tacit knowledge children develop from their everyday experiences is not always consciously understood from a point of scientific explanation (Vygotsky, 1987). Adult interaction is therefore significant for deliberately making the concepts conscious for children. 'Intentional teaching' is a relevant term in this respect. The national curriculum document–Early Years Learning Framework for Australia—defines "intentional teaching" as "deliberate, thoughtful and purposeful" (Department of Education Employment and Workplace [DEEWR], 2009, p. 15). Educators that engage in intentional teaching are aware that learning should occur in a social context. However, what views they draw upon for science teaching and children's concept formation are not completely known yet.

The everyday and scientific concept provides a strong theoretical basis for the content and process of formal instruction (Karpov, 2003). Fleer and Hoban (2012) discussed intentional teaching in a technology teaching context that draws on the everyday and scientific concept. The authors emphasise that scientific concepts are explanations of everyday phenomena and therefore "their genesis does not arise in everyday situations without explanation or conscious exploration" (Fleer & Hoban, 2012, p. 62). In an empirical study Fleer (2009b) has shown that children's' play materials are often not framed conceptually and children's' learning is hence left at an everyday level because of the lack of enough interaction with their educators. Hence children create their own imaginary play to give meaning to the materials, and this may prevent the possibility of scientific play. If the scientific concepts (in the science domain for this study) learned in school are de-contextualised, there is the danger that learning is not qualitatively transformed, but relearning happens for every new context for similar experiences (Fleer, 2007). Children's thinking and practice can therefore be transformed when everyday and scientific concepts are interlaced together. Howe (1996) discussed the significance of cultural-historical theory, particularly the everyday and scientific concept, for studying children's concept development in science education. The author mentions, "a Vygotskian perspective…shifts the focus from the child as a solitary thinker to the child in a social context, where everyday concepts are integrated into a system of relational concepts through interaction, negotiation and sharing" (Howe, 1996, p. 48). Howe further emphasises: "It would seem to be productive to shift from close examination of a specific concept such as heat/temperature or the trajectory of a falling object to studying growth in understanding of relationships within a system of concepts" (Howe, 1996, p. 48). In Rogoff's words (1998, p. 682), Central to Vygotsky's theory is the idea that children's participation in cultural activities with the guidance of others allows children to "internalize" their communities' tools for thinking." Therefore it is important what social and cultural roots and relationships adults draw on or not in the available situations to the young learners to direct them towards concept formation.

The theoretical understanding of the everyday and scientific concept and the findings from empirical studies constitute a rich foundation to draw upon in this thesis for analysing data on science learning for children in their everyday functional context. Nevertheless, the varied social conditions in these functional contexts have still remained unexplored. Thus, the dialectical relationship between everyday and scientific concepts is used in this study to help understand the relationship between home and preschool practices in children's scientific concept formation and to analyse the teachers' and parents' meaning making regarding the science possibilities in the everyday life of children.

3.6 Environment and Person: Cultural-Historical Relationship

A major emphasis in Vygotsky's theory is the context that shapes the personality, characteristics and socio-culturally and historically developed form of human interactions. As discussed in the previous section, studying only human brain functions can present only a partial picture of development that fails to represent the holistic picture of child development. Therefore Vygotsky's interpretation of environment in relation to child development gives some unique understanding in this respect.

During 1933/1934 in his lecture at the Moscow Medical Institute Vygotsky discussed the relationship between environment and person (Bozhovich, 2009; Van Der Veer, 2007). In this work Vygotsky (1994b) introduced the concept of *social situation of development* to discuss the interdependence of the environment in a child's development. Vygotsky mentioned this interdependence as a process that unites the mental and material aspects, a process that unites the person and the social aspects. Introducing this relationship between person and environment is a valuable contribution by Vygotsky (Bozhovich, 2009). A cultural-historical meaning of environment holds a greater meaning for development, drawing on the complexities of person-environment interactions as a source of development rather than viewing the environment as a mere factor for development. This means the environment does not have a simple, one-way impact on the person but there is a reciprocal relationship between the person and the environment. Vygotsky (1994b) elaborated the relationship between the environment and the individual through several examples, one of which mentioned the scenario of three abused children in the same social situation with a drunken mother's disruptive behaviour. Although each child was at a different biological age, they related to the same situation differently because of their different cultural age. At this point while discussing the decisive relationship between the person and environment, Vygotsky identified 'perezhivanie' (emotional experience) as a unit of analysis to explain this complex relationship (discussed in Chapter 9). A person's "experience is like a node where the varied influences of different external and internal circumstances come together" (Bozhovich, 2009, p. 69) Vygotsky aimed to identify the dynamic mental process that explains the experiences, at the same time pointing out how a circumstance is experienced by the person.

Basically, it is understood that the relationship between person and environment is unique at each age. For example, the environment in a child's surroundings may remain the same since they are born but both the relationship with the environment and the child change as the child grows up. For example, the cultural tools, language, and artifacts in a child's surrounding environment may remain the same as s/he grows, however, the meaning changes as the interaction pattern changes with the person. In other words the complexity between these relationships grows because the cultural beliefs, practices and activities present a different relationship between the child and the environment at different moments in their development. As such, the environment is not an absolute yardstick (Vygotsky, 1994b). The environment has to be always discussed in relation to organisms that mutually shape each other in a spiral relationship of growth (Van Der Veer, 2007).

The significance of the concept of social situation of development is in its power for interpreting and analysing the relationship between person and environment. This theoretical concept has been least explored until now regarding its implications in preschool studies. In preschool play-based teaching contexts different educators can perceive the same physical environment differently. In relation to teaching science, their personal beliefs about the relationship between the child and the everyday environment could therefore bring a very new understanding that has not yet been discussed in the early childhood literature. For example, children can perceive the same playground or the play materials in their everyday life in preschools in some particular way. The scientific meaning for children might be in their sole interaction with the environment. In relation to developing scientific concepts, adult interaction and instruction plays a very important role as discussed in the above section. The scientific meaning adults bring to children's everyday conceptualisation of the environment, therefore, could bring much significance in a child's life for interacting at a conceptual level. The social and material relationship to the objectivity of the everyday environment could change how the children would interpret the environment at a scientific conceptual level. This little explored cultural-historical relationship is drawn on in this thesis in Chapter 6 to discuss teacher conceptualisation of the everyday environment for children's scientific concept formation.

3.7 Cultural-Historical Concept of Play

Vygotsky's interest in the complexities of play originated from his work on the psychology of art and his critical thinking on sign mediation (Elkonin, 2005a). It was reported in 1933 at the Herzen Institute when Vygotsky presented a series of lectures on psychology of children that included play (Elkonin, 2005a). Vygotsky positioned the potential of play to provide a rich context for explaining (and developing) preschool age children's higher mental functions. As Bodrova and Leong (2003, p. 158) mention,

> During preschool years, important changes take place in the very structures of mental processes. Whereas most behaviors are still governed by "natural" or "lower" mental functions, the first signs of future higher mental functions emerge – first in play and later on other contexts.

Historically the word 'play' has been defined in a number of ways. El'konin (2005b) discusses some early definitions of play by Russian, Italian, Dutch and some other authors. El'konin suggests that play is not a scientific or technical term that could be defined universally. Rather, play is based more on human activity, has cultural components—art, history—all integrated in it. Therefore, it becomes problematic defining play because play is so diverse in nature. In Australia, the Early Years Learning Framework mentions that "play provides opportunities for children to learn as they discover, create, improvise and imagine" (Department of Education Employment and Workplace [DEEWR], 2009, p. 15).

Also there are many theories of play. Johnson, Christie, and Yawkey (1987) categorised the theories as classical and modern theories of play based on the time period these appeared in. The authors mention that classical theories originated in the nineteenth and early twentieth century. The classical theories (e.g., surplus energy, recreation, recapitulation and practice theory) are heavily based on philosophical reflection and are non-experimental. The theories generated after 1920 were classified as modern theories of play. These modern theories view play from a developmental perspective. Piaget's, Bateson's and Sutton-Smith's theories mainly discuss aspects of cognitive development in play. A lot is known about play from scholars (e.g., Göncü, Jain, & Tuermer, 2007; Pellegrini, 2009; Roopnarine, 2015) from developmental or socio-cultural perspectives. Vygotsky's theory on play can be particularly distinguished from the classical theorists' perspectives (Kravtsov & Kravtsova, 2010). According to Göncü and Gaskins (2011) Vygotsky's cultural-historical theory of play draws upon children's past experience and takes it a step further to discuss future development.

The consideration of the cultural-historical dialectical relationship between the child and his/her everyday experiences is continued in Vygotsky's theory of play. As such, a cultural-historical theory of play extends our understanding about the relationship between "the child's psychological functioning and the social and material conditions afforded in the child's environment" (Fleer, 2014, p. 2). According to Vygotsky (1966), in play, children consciously act out everyday concepts and rules. For example, if children play as sisters, they consciously realize the rules of being sisters, where in real life, they do not consciously think of these rules. This means 'play' creates a learning space where a dialectical relationship is established between everyday and scientific concepts (Fleer, 2009a). During play children move between the imaginary and real worlds. This is a unique psychological state. In sum, cultural-historical theory defines play for preschool children when they place themselves in an imaginary situation (actually copying the real world), changing meaning of play objects with rules and behaviours acted out from their everyday experiences.

3.7.1 Concept formation and play

Vygotsky's definition of play mainly includes children's imaginary play also known as make-believe play. In children's play, an act of imagination is visible when they give meaning to an object. According to Vygotsky, play provides a space for the conscious realisation of concepts. Vygotsky's (2004) cultural historical theory provides a strong premise for explaining imagination in preschool children's play. Imagination acts as a bridge between play and learning. Fleer (2011a) argues that imagination, from a cultural historical perspective, includes the social and cultural aspects apart from the internal and biological aspects of imagination and thus supports bridging the gap for concept development. For example, preschool children play at baking cakes in a sandpit; they bring this everyday experience into their play context. They give meaning to sand chunks as the cakes. They imagine fire and heat to cook the food. They say "it's very hot, you can't eat it now". The scientific concept of heat is imagined in this pretend play. As such, play provides a "conceptual space for the dialectical relations between everyday concept formation and scientific concept formation" (Fleer, 2009a, p. 5).

Concept formation is a complex process. Words may carry meaning to a child though the concept is not developed (Vygotsky, 1966). According to Vygotsky, concept development occurs gradually. Coming across a new word, the child only has a vague understanding of the concept. As s/he encounters it in further interaction and gains scope for using it, a further development occurs in his/her understanding. Imagination and play are rigorously connected in this process. For example, during play, children give meaning to objects. Imagination as a construct, used to be thought to be personally oriented. However, from a cultural-historical perspective, imagination can be viewed as a “conscious and social act” (Fleer, 2011a, p. 226). “Imagination as a new psychological formation occurs through play because play is a leading activity at that time” (Fleer, 2010, p. 136). In children’s play, imagination plays a major role and in play children consciously give meaning to objects (Vygotsky, 1966). Therefore, in play, children move to an imaginary situation that comes out of the real world but is beyond it. In play, children also develop rules and they consciously develop these rules. As such, a dialectical relationship is observed between reality and imagination. In such way, “through the object-meaning inversion, imagination becomes a conscious act by the child” (Fleer, 2011a, p. 227). Figure 3.3 shows this relationship.

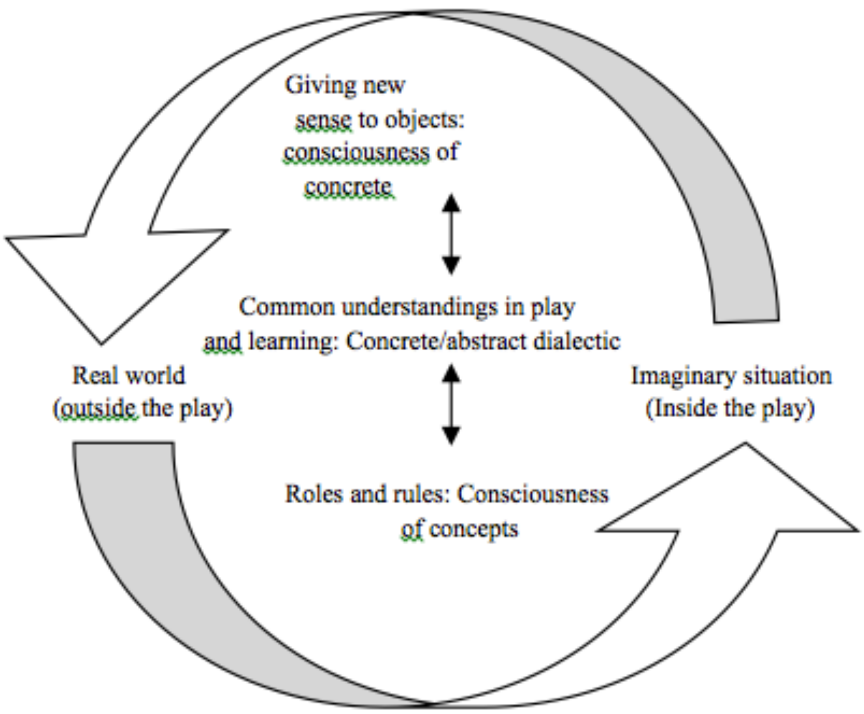


Figure 3.3. Imagination as the bridge between play and learning (Adapted from Fleer, 2011a, p. 232)

Through conscious mental representation with materials, it is possible to build theoretical knowledge and thinking in a child (Fleer, 2011a). As such, play provides psychological attunement for a child for learning in school and this is possible to develop through adult-child communication (Kravtsov & Kravtsova, 2010). According to Kravtsov and Kravtsova, with adult mediation and consciously conceptualising key actions with objects, children's play as a leading activity develop into learning activity.

Fleer (2010) presents an empirical example in a child's preschool context where investigation of nature and creating a location map for food habitats for the insects typically shows how imagination contributes to conceptual development in a play environment. This example also portrays how teachers or adults in this process can bring together the historical knowledge traditions that are valued by the society for the theoretical and conceptual development of the child. Fleer's study theorises imagination as a significant element for concept formation. This theoretical concept of play illustrates that imagination helps children "to rise above reality, to engage with reality and to play with reality" (Fleer, 2010, p. 150). This suggests imaginary play spaces can support teachers to develop play activities into learning activities (Fleer, 2010). Separating the meaning from an object and giving a new scientific meaning to the object therefore explains the social relations a child builds with the everyday play materials in a science learning context. The present study analyses preschool children's imaginary play (Chapter 8) from this cultural-historical point of view to develop further understandings of the process of concept formation.

3.8 Cultural-Historical Concept of Motives

Hedegaard (2002, p. 55) defines the cultural-historical concept of motives as the central dynamic factor that characterises a person's actions in different settings over a long period of time. Hedegaard clearly emphasises that for human beings, motives are not biologically developed but are culturally and historically determined and mediated by cultural tools and materials. The different cultural practices in a child's participating social institutions and the child's contributing actions in those settings can form a dialectic relationship that describes motives in the process of the child's development (Hedegaard, 2002, 2012b). A preschool child's back and forth movement between home and preschool therefore brings them into a new situation where these different activity settings place different demands on the child, which further creates conflicts and leads learning and development in the dynamic developmental process. The different social situations in different activity settings therefore contribute in constructing and deconstructing earlier motives and therefore the motive orientations lead learning and development (Hedegaard, 2014).

At preschool age, children pass through a complex period. At this age they enter into preschool, which is a formal structured environment completely different from the informal home environment. At this age the process of concept formation occupies a major space in their mental development as they continuously move between formal and informal environments. Before preschool age, informal everyday concepts dominate whereas at preschool age the formal structured abstract concepts give meaning to the formerly developed everyday concepts. This process ultimately raises conscious awareness in the child of the need to scientifically interact across any settings – that is they develop a new competency (Hedegaard, 2007). New relations such as perception, logical memory, intentional attention, abstract thinking and scientific imagination develop within the broadening periphery of their world (Vygotsky, 1987). Vygotsky therefore emphasises continuing research into preschool children's concept formation in everyday activity settings, including both formal and informal environments. The concept of motives has excellent potential for uncovering the relationships supporting concept formation. According to Hedegaard (2007, pp. 254-255):

> how children's personal conceptual competencies from home and community life will be related to academic knowledge and work knowledge depends how the situational conditions encourage him or her to develop motives for using conceptual competencies in these new situations.

The concept of motives has been used for studying transition moments for: children at different age groups (Hedegaard, 2014); children experiencing different social situation in the same activity settings (Hedegaard, 2012a). Hedegaard (2002) discusses three kinds of motives—dominant motives, meaning-giving motives and stimulating motives. These three kinds of motives have been discussed and drawn on in Chapter 8 of this thesis to study the reciprocal relationship between formal preschool and informal home experiences in a preschool child's everyday life and to theorise the findings. The concepts of stimulating motive and motive orientation are drawn on in particular in Chapter 7 to studying a preschool child's everyday home science learning experiences.

3.9 Conclusion

From the theoretical discussion presented in this chapter it is concluded that the cultural-historical concepts position the child in the social system where the various concepts collectively can explain the dynamic process of child development. These concepts can explain the complexities in a child's environment. The relationships are complex but related to each other. The unique characteristics at preschool age, the dialectical relationships between everyday and scientific concepts, the relationship between the person and environment and motives development together represent the social and cultural dynamism in a child's life. A cultural-historical research approach with the unique theoretical concepts is therefore powerful in discussing children's scientific concept development process. Although there are many other cultural-historical concepts available that could have been integrated in this study, it was not realistic to combine all of them in this small scale PhD study. This study therefore uses the concepts discussed in this section for a firm framing of the thesis.

CHAPTER 4
Methodology

4.1 Introduction

Although Vygotsky lived a very short life, his cultural-historical theory is still contemporary in current educational research. His theoretical orientation and the research tradition following his theory have much potential and a lot still remains undiscovered in researching child development. This chapter presents the rationale for employing the cultural-historical methodology and the methods used in the study based on Vygotsky's cultural-historical theoretical lens. The cultural-historical dialectical-interactive methodology is illustrated in regard to how it helped respond to the research questions in this study. Video observation, photographs, interviews, a questionnaire and field notes were used as the methods of data collection for this study. These methods are appropriate for this cultural-historical study where data were gathered between home and preschools (Hedegaard & Fleer, 2008) to capture the dynamic interaction and possibilities of children's scientific concept formation across the children's participating institutions.

4.2 Epistemological knowledge in a cultural-historical dialectical-interactive approach

The *Collective works of Vygotsky,* Vol. 4, gives us a historical account of the genesis of the rationale of Vygotsky's arguments for introducing completely new psychological methods for studying human development. According to Vygotsky, "finding a method is one of the most important tasks of the researcher…the problem of method is the beginning and foundation, the alpha and omega of the whole history of the cultural development of the child" (Vygotsky, 1997b, p. 27).

(Vygotsky, 1997b) argues that there is a contrast between the objective versus the subjective psychological trends of studying human development. He felt that the traditional stimulus-response experimental methods are not directly applicable for studying subjective situations. Opposed to studying the mental process, Vygotsky's cultural-historical research method proposes studying the dynamic, activity and experience-based naturalistic genetic conditions for development. According to Vygotsky, "most important is the study of these connections and relations as whole formations and processes or structures that must be understood specifically as wholes that determine the role and significance of the parts" (Vygotsky, 1997b, p. 37). The main focus of cultural-historical methodology therefore is to study the complex relationships between person and the environment in human development. Understanding this complexity helps explain higher form of development.

Methodologically, a paradoxical relationship exists between studying cultural-historical development and biological development. In Binet's studies during the early 1900s, speech was used as a stimulus tool but research still adhered to the basic methodological principle of the stimulus-response approach and speech was considered as a sensory stimulus. Additionally, these later traditions did not take into account the role of instruction on the response of the subjects. Consequently, speech as a stimulus was not differentiated from other sensory stimuli and was in effect considered as a motor skill. For the first time, Vygotsky pointed out that speech and other sensory stimuli were used for analysing lower mental functions –biological functions/ biological development. Viewing speech in this way could not facilitate analysis of the higher mental functions and cultural development. Vygotsky explained the gap in the old traditional psychology and presented a methodology for analysing qualitative development. Based on Hegel's logic, Vygotsky explained that there is a ‘dialectic leap’ between the process of stimulus-response and development. Increasing the complexity in the stimulus-response methods cannot simply explain this complex historical process of thinking in human development. This is a key point of cultural-historical methodology (see Vygotsky, 1997b, p. 39). Vygotsky emphasizes that the everyday phenomenon occupies a vast space in our life that had never been taken into account in research. The everyday moments were seen as obvious with no special role in human development. In contrast, Vygotsky argued that the rudimentary forms of development actually exist in these everyday phenomena that later provide scope for development. Vygotsky (1997b, p. 41) indicates these everyday moments as being “insignificant [but] at the same time deeply significant phenomena”. Rudimentary forms in everyday life are the links to the higher forms of cultural development.

“To study something historically means to study it in motion. Precisely this is the basic requirement of the dialectical method” (Vygotsky, 1997b, p. 43). In other words, the rudimentary forms indicate the possibilities of development. Rudimentary forms are significant as mentioned by Vygotsky because each one “fits the problem of higher processes like a key in a lock” (p.43). He also mentions, “before studying development, we must explain what is developing” (p.44). The key gaps he (Vygotsky, 1997b) identified in studying child development are-

- Methodological gap of everyday experiences
- Cultural devices (artificial stimuli)- knots, writing methods
- Dialectic relationship
- Motives
- Higher mental functions- abstract scientific concepts
- External/internal- interpersonal/intrapersonal- tools/signs

Indicating the gaps in traditional psychology research Vygotsky presents an example of ‘knots’ to explain a cultural stimulus to memory. This stimulus is artificially created but is a cultural stimulus. For example in Bangladeshi-Indian culture a knot could be used as a cultural device to tie a key at the outer end part of a women’s traditional attire called a saree. For some cultural reasons a key tied with a knot in the woman’s saree could represent a high status, especially for the eldest female with the power of controlling the rules in a large joint family. Generally the women with such status would be the mother-in-law in the family or the wife of the eldest son in absence of the mother-in-law. Having the important bunch of keys of the household tied in a knot in the attire symbolises status and power in the family in such a culture. However, the origin of the knot was originally created as a cultural memory device to be not forgetful about the key, so that it would not be lost somewhere by mistake. A knot is an artificial tool for memory in some other cultures, yet it takes on a different meaning when tied in a woman’s saree. Therefore, according to Vygotsky, “…society must, in the first place, be considered as a determining factor of human behavior. This is the whole idea of cultural development of child (p.59).”

(Vygotsky, 1997b, p. 69) outlines the relationship between tools and signs, saying:

> The tool serves for conveying man's activity to the object of his activity, it is directed outward, it must result in one change or another in the object, it is the means for man's external activity directed toward subjugating nature. The sign changes nothing in the object of the psychological operation, it is a means of psychological action on behavior, one's own or another's, a means of internal activity directed toward mastering man himself; the sign is directed inward.

He adds,

> The use of auxiliary devices, the transition to mediated activity radically reconstructs the whole mental operation (memory/concept development) just as the use of a tool (knots/sticks) modifies the natural activity of the organs (naturally something that man would not remember/stick modified activity of hand), and it broadens immeasurably the system of activity of mental functions (concept development/ concrete towards abstract/ applying the concept in a different situation/the change in man's activity of being mindful of the knots representing to remember something- as a result of the mediating tool or remembering to use a stick next time). We designate both taken together by the term *higher mental function* (Vygotsky, 1997a, p. 63).

These arguments lead us to the need for generating knowledge on the methodology and methods for studying the artificial stimulus/creating conditions in everyday life so that we can better understand the dialectical process involved in developing the higher mental functions. The present study is situated in the natural everyday context, exploring these natural conditions created in preschool or home environments through everyday activities in the family or preschool to see how they promote scientific concept formation of preschool age children.

4.3 Dialectic-Interactive Methodology

The cultural-historical theoretical discussion in Chapter 3 and the above discussion in this chapter make it clear that developmental psychology needs to consider a combination of both social and personal characteristics in a child's environment. Child development is a unique process that cannot be understood by studying the child apart from the social relations they develop at various developmental stages, which include the social institutions with which a child regularly interacts. Hedegaard (2008a) suggests a child's developmental trajectories or pathways could be studied more closely when the focus is not just on particular age-based criteria, but includes the child as contributing to his/her own development. This could certainly be understood by examining the social relations they develop in everyday experiences. Therefore considering the dialectical relationship between the individual psychological aspects and the social/cultural aspects is very important since this will inform the researcher about the new relations children develop with their environment. In this way, development as moving forward from one stage to the next stage could be much more deeply understood. Vygotsky's (1998) concept of the dialectical logic in the relations between cultural and biological lines of development explains the structural relationships between the child's personality and consciousness. This logic suggests how functions develop thinking as the child develops new relations. The complex process of genesis of higher mental functions therefore could be studied in a child's real context through this method of the dialectic-interactive approach.

Having a methodology consistently related to the theory guiding the study is necessary to permit relevant understandings on dialectical-interactive relationships between the person and the environment in the child's process of development. The traditional psychological understanding of child development has had a long-standing influence on educational research. In particular, the constructivist research approach continued that legacy in studying concept development in science education research. However, such traditional psychology-inspired science education studies have failed to capture the complex process of child development and concept formation. Incorporating the distinctive conceptualisation of child development introduced by Vygotsky permitted insight into the rich dynamic process of concept formation, and this marked the beginning of a new research genre in science education research since the mid 1990s (Discussed in Chapter 2 & 3).

This thesis embraces a cultural-historical research approach. It is therefore important to look at the basic differences between the traditional research traditions for a firm rationale for cultural-historical conceptualisations as a basis for researching concept formation in the area of early childhood development. The differences between the traditional experimental approach and the cultural-historical dialectical-interactive approach are outlined in Table 4.1 below.

Table 4.1 Differences Between Traditional Descriptive Research and Dialectical-Interactive Research Approach (Reproduced from Hedegaard, 2008b, p. 35).

Research method	Research principles	Knowledge form	Knowledge content
Hypothesis testing/Descriptive methods			
Laboratory experiment	Control groups Blindtest design	Empirical	General laws of children's psychic functioning
Observation	'Fly on the wall' One-way screen	Empirical/narrative	Description of children in actual, local situations
Interview	Non-leading questions/clinical interview	Narrative	Description of children's perspective

Dialectical – Interactive methods			
Experiment as intervention into everyday practice	Theoretical planned interventions into local practice	Dialectical-theoretical	General conditions for children's activity in local situations
Interaction-based observation	Participation in shared activities Activity partners	Dialectical-theoretical	Diversity in conditions for children's activity in local situations
Interview as experiment	Leading and provoking questions Communication partners	Dialectical-theoretical	Relations between conditions and children's perspective

A research method embracing a dialectical-interactive approach focuses directly on the conditions in natural settings at a local level that include the child's everyday activity settings and the child's actions and interactions in them. For a dialective-interactive study the research methods should be theory-guided and the researcher needs to take an active role in the research context. It is argued that (see Chapter 2) the earlier science education research that employed interview or dialogue methods for delving into the psychic functioning of young children are not fruitful and do not capture the authentic understandings of a child's conceptualisation process in relation to everyday phenomenon. In contrast the dialective-interactive approach offers an extensive approach that includes both researcher and the participant (even the child participant) on the same communication plane through active involvement in the research context. The researcher is not an external communicator but participates in a shared communicator perspective that integrates participant perspectives (Hedegaard, 2008b).

Table 4.1 also shows that the traditional observational methods only pay attention to the details of the child's participation. Contextual information is interpreted as factors of development in social-constructivist studies. The two-way perspective of interpreting the observation content that includes the researcher's theory-guided perspective and the child's perspective is absent in the traditional studies. A dialectical-interactive research methodology guided by theoretical-dialectical knowledge allows the researcher to take into account these contextual relationships and extends knowledge on child development, integrating the societal conditions embedded in everyday practice, culture and traditions. It is important to note that the focus on culture in cultural-historical research does not mean studying the ethnicity or race but studying the social and material relationships in a person's life—looking into the cultural practices of the community through play, everyday practices, interactions, media, virtual life, etc. Dialectical methodology therefore is the process of learning about the development by documenting the movement, understanding the essence to capture the process, dynamics, conflicts, moments of tension, and transitions. As (Vygotsky, 1997b, p. 75) puts it, "It is not fossilized or post mortem research".

According to Hedegaard and Chaiklin (2005), a major aspect in cultural-historical theory of human development is concept development. From both philosophical and psychological perspectives there are conflicts on how to define what a concept is. Hedegaard (2008b, p. 37) draws on Iljenkov (1977), Davydov (1990) and Schutz's (2005) theory of knowledge and suggests that together with the activity and practice traditions, a theory of knowledge on concepts should take into account the perspective one takes into practice. This can be a particular societal perspective or institutional perspective or an individual person's perspective in a practice tradition. These perspectives are discussed below.

4.3.1 Societal, institutional and individual perspectives

Societal perspective is a macro perspective integrating institutional and individual perspectives (Hedegaard, 2008a). Vygotsky discusses the social situation of development, which is an important concept for understanding the relationship between the child and the environment. "Social situation of development indicates that the child's personality and social environment at each age level are in a dynamic relationship" (Hedegaard, 2008a, p. 13). The relationship between a child and the social reality at a given age of the child is called the social relation of development. According to Roth, "if we want to understand what and how others know and learn, we do not need to find devices that allow us to get into their mind. All we need to do is study social relations between people" (Roth, 2012, p. 196). Dominant institutional practices at different age levels influence the social relation of development. Children's activity across social institutions varies because of the varying practices across the institutions (e.g., practices at home and in school differ). That is, learning and development conditions for children also vary across institutions. Also, institutional culture sets the values and norms of the traditional practices in them in such the way that is found in any culture (Göncü, 1999). This study seeks to identify the possible everyday moments for development of scientific concepts for children drawing on Hedegaard's (2008a, p. 17) argument that "development should be viewed as a process that integrates a person's development of competencies with values". Hedegaard (2008b), therefore, strongly suggests a child's period of development needs to be understood across the institutional norms and values that the child participates in.

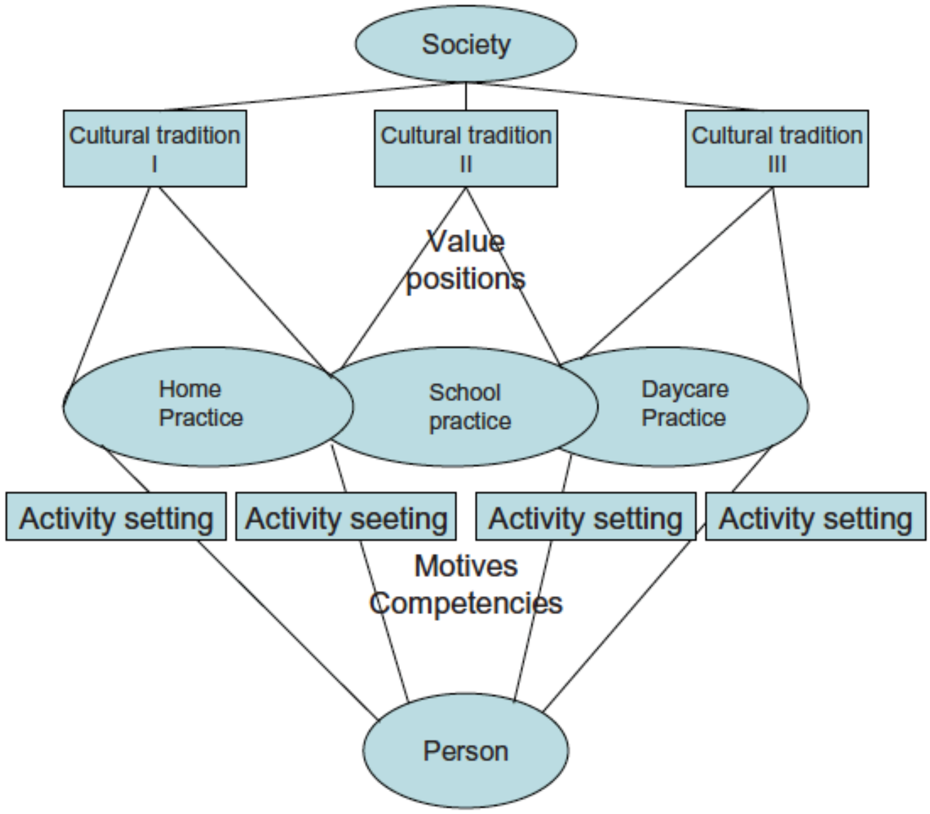


Figure 4.1. A model of children's activity settings in different institutions (Adapted from Hedegaard, 2012a, p. 130)

Hedegaard (2008a) (see also Figure 4.1) explains that understanding children's learning and development through participation in institutional practices give sufficient strength to study this dialectical relationship: "A cultural-historical wholeness approach for understanding children's development has to research the child's social situation in the activity settings that the child participates in" (Hedegaard, 2012a, p. 135). Learning about he child's everyday experiences between preschool and home helps the researcher develop a broader understanding regarding the dialectical relationship between everyday and scientific concept formation. It is important to study the societal, institutional and individual perspectives to reveal children's concept formation from this theoretical stance (Hedegaard, 2008a). Given that the developmental pathway is a combination of these three perspectives in relation to child development (Hedegaard, 2008a) in this current study, children were observed in a natural setting in a preschool and in their home.

4.4 Role of the researcher: Participant observer and researcher as a scientist

According to Goodwin and Goodwin (1996), "in early childhood research…observation is often an appropriate and helpful technique" (p.131). The authors cited Adler and Adler (1994, p.377), mentioning, "as long as people have been interested in studying the social and natural world around them, observation has served as the bedrock source of human knowledge". However, the observation style can vary upon the researcher role in the context. Glense and Peshkin (1992) represent general observer and participant observer roles along a continuum (Figure 4.2).

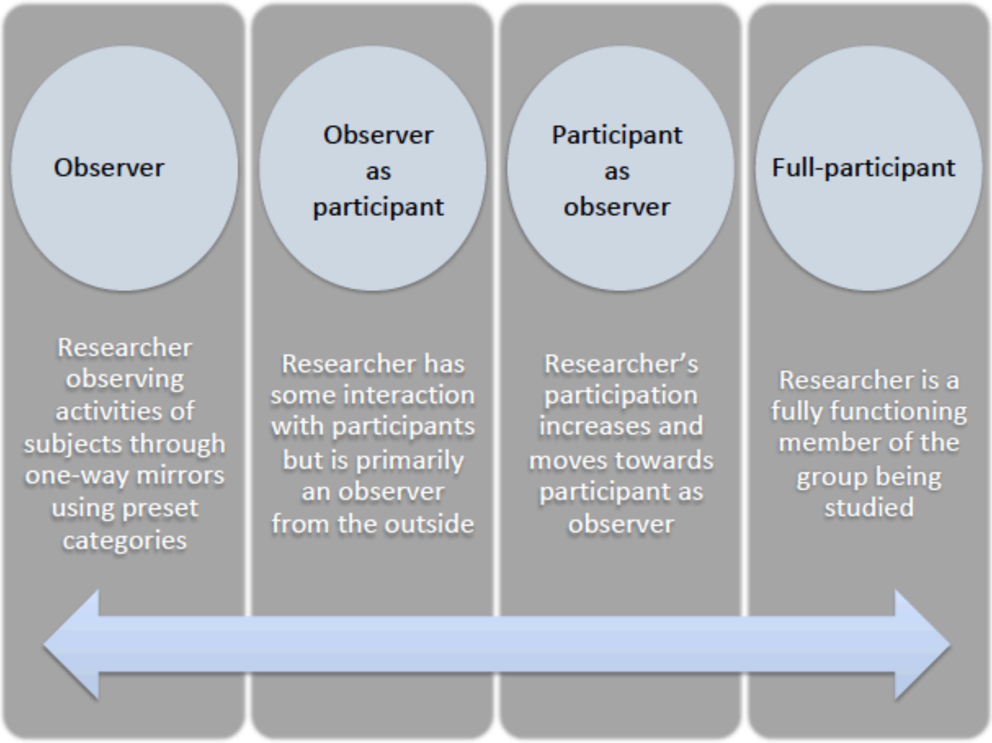


Figure 4.2 Participant observation (Figure developed based on ideas from Glense & Peshkin, 1992).

According to Hedegaard (2008d), in a cultural-historical approach, the role of the researcher is defined as a social scientist with dual roles. Hedegaard explains that the researcher "enters into a social situation with other persons where she has to understand what is going on as a participant in everyday practice. But she is also entering the activity setting as a researcher researching the activities" (Hedegaard, 2008d, p. 202). In this naturalistic cultural-historical dialectical-interactive study design I acted as an active participant observer and an active researcher. As a participant observer, I was familiar with the language of the participants. My previous training as a research assistant in Professor Fleer's ARC project made me confident and competent for taking an active role in observing, listening and taking field notes carefully regarding the activities and situations happening in the research site. I participated in the activities in the everyday settings, paying attention to the research participants' needs and motives. At the same time, my role as a researcher was to keep conceptualising my own participation motives clearly in my mind to keep aligned with the research aim.

4.5 Research Design Context

The PhD study was directly linked through ethics to a larger study funded through Australian Research Council Discovery Scheme (grant Number DP110103013) and Monash University Human Research Ethics Committee (MUHREC No. CF11/3199 – 2011001746) and led by my supervisor Professor Marilyn Fleer. I acted as a research assistant on this project. My PhD study [Monash University Human Research Ethics Committee (MUHREC) Ethics No. CF12/3871 – 2012001777] was undertaken at one of the four sites of the larger ARC project, where I acted as a research assistant as reported in Chapter 6. In addition, I collected data for my PhD study at the same preschool site in a southeastern suburb of a major city in Australia. Participating children and families for my PhD study were recruited separately from the larger study to research the problem of exploring children's scientific concept formation possibilities at home and in the preschool context. Video data were gathered over four weeks in the preschool. However, a non-filming week due to staff sickness stretched the total duration of the project into five weeks.

After gaining ethical approval, a month before beginning data collection, the ARC Field Leader, Dr. Sue March, and I went to visit the preschool. We met the educational staff and the Centre Director. We clearly explained the aims of the research and gave them the written details of the projects. I familiarised myself with the regular program and routine of the preschool. In a cultural-historical approach, it is important that the adult participants must not feel that the researcher is "taking over their roles or responsibilities" (Hedegaard, 2008d, p. 203). For this, we scheduled two professional development sessions as part of the ARC project for the staff so that they could have the opportunity to gain a clear understanding about the research projects. In the professional development session for the educators I discussed the cultural-historical concepts—everyday and scientific concepts and scientific concept formation—as a focus of my study. For the parents who consented to being focus families, I initially met them during morning drop-off or pick-up time in the preschool as these were times convenient to them. I gave them a clear idea about my study and answered any questions they had. This way a rapport was built between the researcher, the preschool staff and the focus families.

4.5.1 The preschool

The preschool was run under an established university. Children from the university staff and student families as well as the local community were eligible to attend the preschool. Children from diverse cultural backgrounds for example, Vietnam, India, Canada, Australia and China, came to the preschool. Pseudonyms are used for all the participants of this study.

4.5.2 Focus children family participants

At the beginning of the project a consent letter collection box was left at the preschool entrance. Parents and educators left their consent forms in the box. 30 children participated in both the ARC and PhD studies in the preschool centre. The age range for the children in the preschool room was 3.3 to 5.3 years. The average age was 4.2 and median was 4.1 years.

Focus Children: Three children, Jimmy, Alisa, Lala and their families consented to participate as focus families. Jimmy was a 4.2 year old boy during the time of data collection in the preschool. Both of Jimmy's parents are from Australia and speak English at home. His mother was an academic at a university and father worked in industry. Both parents had tertiary degrees from university. He had a younger sister. Jimmy attended the preschool three days a week. Other days he stayed at home with his mother. One of these days he attended outdoor activities with his mother, for example *playgroup,* that specially focused on activities for his toddler sibling.

Alisa was a 4.1year old girl during the data collection period in the preschool. Her father was Australian and mother was of Canadian background. They speak English at home. Their family used to live in Canada and in the year of the project they had moved to Australia from Canada for her mother's job at a university. Alisa's mother was specialised in health science. Alisa had a toddler brother who also attended the same preschool but in a different room.

Lala was a 4.4-year-old girl during the data collection period at preschool. Lala's parents had migrated to Australia five years earlier from the southern part of India. In the middle of data collection Lala's family went overseas and did not continue participating in the study. To fill this gap, a follow-up interview was arranged with Lala's mother at a later time. Finally, it was not possible to include Lala's family data in this study.

All family home and preschool data presented in this study therefore include focus children Jimmy and Alisa.

Teachers: One preschool teacher, Tamara, two educators—Riana and Dan—and the Centre director, Rekha, voluntarily participated in this study. There was only one preschool age (3-5years) children's room in the centre. Tamara, Riana and Dan, were all working in the same room with the same group of preschool age children. In the Australian context the term educator is commonly used for all preschool staff, irrespective of their educational qualification. However, the staff working with the preschool aged children (3-5years), had a combination of qualifications, and worked together in a team that included one early childhood teacher with a bachelor degree and the two others who had certificate and diploma qualifications. In the present study I used the term educator when people with mixed qualifications (Bachelor and Certificate/Diploma qualifications) were working in a pair or team (e.g., Chapter 6).

Tamara is a Caucasian Australian and Riana comes from an Indian cultural background. Tamara has a Bachelor of Early Childhood Education. She is an early childhood teacher and holds the Educational Leader position in the centre. Altogether she had been teaching in the centre for five years, with three of these years teaching preschool children. According to Rekha, Teacher Tamara's responsibilities included focusing on the programs and educational aspects, mentoring peers and continuing good research practices to guide overall development of the programs. Riana has an early childhood qualification and during the project she was studying towards a Diploma. She had been working in the centre for one year. Her role was to work collaboratively with Tamara. Teacher Dan had a Diploma in Children's Services. He had been working in the centre for approximately six years. He had worked with toddlers and preschool age children during his earlier years in the centre.

4.5.3 Video observation at preschool

As mentioned previously, the current PhD study is linked through Ethics with my supervisor Professor Fleer's ARC project. I worked as a research assistant for Professor Fleer's broader ARC project, and specifically for the science walk conducted at this preschool site (Chapter 6). For beginning researchers it is often challenging to know where to point the camera and what to capture in a child's environment where a lot of dynamic interactions are happening. As a research assistant for my supervisor's ARC study (Project No.DP110103013) I was trained on appropriate holding of the video camera at a child's eye level so the camera is not intimidating for them. Overall 2 to 4 cameras were used for data gathering in the preschool site. Generally, two cameras were dedicated to capturing data for the ARC project with one held by a research assistant and one set up on a tripod to capture the maximum view of the setting in the safest corner of the room. An additional camera was operated by me to capture data for my PhD study. I followed the PhD study focus children participants in the everyday preschool social situation in both indoor and outdoor environments during the period of the ARC study. A total of 74 hours of ARC data were collected. For the PhD study 26 hours of data involving Jimmy and Alisa in the preschool centre were selected for the papers presented in this thesis.

The focus children were followed closely in the preschool. A regular day for the kindergarten children could be described as beginning with a morning circle to register attendance, followed by morning tea, free play (indoor/outdoor according children's choice), story time, lunch time, sleep time, afternoon tea, and free play. Every day the kindergarten children participate in activities, such as physical, fine-motor skill play activities, artwork, and other activities associated with the *Early Years Learning*

Framework (Department of Education Employment and Workplace [DEEWR], 2009). A total of 16 sessions were filmed in the preschool, of which 12 were morning sessions and 4 were afternoon sessions. Data gathered for each focus child in the preschool are presented in the table below. In the beginning week of the project some children were very curious about the video cameras. They came close to me to look at what was captured on camera, how the screen showed the images of the moving people and so on. I let the children play with the camera and look through while I was holding it. They giggled, waved and were happy to see each other on the camera screen. Later it became familiar for them to see me coming to the centre with the camera; it became an everyday thing for them and they could focus on what they were doing while I was videoing them. This situation is found in much video methodology research with children (e.g., Pramling & Samuelsson, 2001), where children become used to the cameras and they act normally in their regular activities.

Table 4.2 Total Data for Each Focus Child in Preschool

Focus Child	Total data for each focus child in preschool	Preschool centre data included in the PhD study
Jimmy	35 Hours	18 hours
Alisa	20 Hours	8 hours
Total focus children data	55 Hours	26 Hours

4.5.4 Video observation at home

Home visits were made for focus children Jimmy and Alisa during and after the project. Video data were gathered about the children's play interests, play practices and some everyday moments relevant to everyday science such as preparing meals. Each home visit lasted for 1.5 to 2 hours. Three visits were made to Jimmy's house and 2 visits to Alisa's house. Due to moving to another continent, further home visits were not possible at Alisa's house. During home visits the video cameras were held rolling from the moment of entering the house. Each of the children was visited at home by me with an assistant holding the camera in a so that the camera could be rolling while I as researcher was interacting with the participants. Home visits were recorded (by me) in field notes as well. A camera was left with the participant families to capture some play moments that parents thought supported science affordances. Table 4.2 below gives the detail regarding home data.

Table 4.3 Focus Children's Data at Home

Focus Children	No. Of home visits	Total Duration of home visit	Total PhD data for each focus child at home
Jimmy	3	5h	3.5h
Alisa	2	4h	4h

4.5.5 Questionnaire

According to Bang and Hedegaard (2008), in addition to video observation and interviews a questionnaire can be another source for gathering information about the lives of children. "A questionnaire is useful for researchers who want to study practices in which practitioners work with planned activities as well as planned goals for groups of children" (Bang & Hedegaard, 2008, p. 157). A questionnaire is a useful tool for a setting where a group of children interact as well as for institutions like the family, where this tool can be used for studying different family practices that can contribute in providing developmental conditions for young children (Bang & Hedegaard, 2008). The authors also suggest that a cultural-historically constructed questionnaire can be used to study the institutional practices and a child's social situation of development, where the child is a member of a group of children who share the developmental conditions. According to Bang and Hedegaard (2008, p. 163), "construction of a cultural-historical questionnaire should reflect: how an individual child participates in institutionally valued activities; the relations between the child and other children; and the relations between the child and significant others (teachers, parents etc.)".

With the cultural-historical construction of a questionnaire in mind, an open-ended questionnaire with some closed questions (Cohen, Maninon, & Morrison, 2007) was used for teacher and parent participants in this study. The purpose of the study was to seek the science learning possibilities in children's everyday life. The questionnaire was aligned with the societal, institutional and individual perspectives and related to the research questions to collect data collection at the centre and at home. Therefore, teachers' and parents' thinking about science and play from a societal perspective and about children's play practices within the everyday institutional practices were mainly sought through the questionnaire (see Appendix 1 for the teacher questionnaire and Appendix 2 for parents' questionnaire). For example, in the Australian Early Years Learning Framework (EYLF) (Department of Education Employment and Workplace

[DEEWR], 2009) play has been defined as a major component of child development. Science learning is also encouraged in Outcomes 2 and 4 in the document. In line with these societal values, the questionnaire included questions on: teachers' perspectives on definitions of play (Q. 2); theoretical views that inform perceptions on play (Q. 3); and teachers' understandings on science (Q. 5). The institutional practices regarding play and science were sought through the questions on: examples of some common play themes of children in the preschool (Q. 1); science experiences in children's everyday life (Q. 6); and different kinds of formal, informal or incidental science (Tu, 2006) activities in preschool (Q. 8 – Q. 10). Teacher-child interactions were sought through the question on the educator's role during children's play (Q. 4). In the parent's questionnaire the societal value of science was reflected through the questions on parents' understandings on science (Q. 3). The values at home about play and science learning were sought through questions on: common play activities the children engage in at home (Q. 1, 2); children's experiences of science in everyday life (Q. 4); children learning science concepts through play at home (Q. 5); science related play activities at home (Q. 6); and examples of intentionally explaining science concepts to the child (Q. 7). Parent's understandings of their child's perspective were sought through examples on science related questions the children asked about everyday activities or phenomena (Q. 8).

Teachers and focus family parents were invited to respond to the questionnaire at a convenient time after the initial visits to the centre and home. The questionnaire responses were used to stimulate further interview discussion. Responses were supported by the video data in investigating the home environment and everyday practices and possibilities for scientific concept development for the children. All three teachers and the mothers of the focus children responded to the questionnaire.

4.5.6 Interview and Science Walk

The purpose of an interview is to investigate the non-observable ideas/views of the interviewee (Patton, 2002). The interviewee's thoughts, values, prejudices, perceptions, views, feelings and perspectives can be sampled through interview (Patton, 2002; Wellington, 2000). Video cameras have some limitation in this sense since they are capable of capturing only a certain radius of the context while human eyes are capable of seeing 180 degrees or more (Fleer, 2008). In this cultural-historical study, as a researcher on site I was in close interaction with the social situation of the focus children. The video data were therefore reintroduced to the parents/family members and the teachers in a semi-structured interview to seek detailed perspectives of the interactions with the child. The stimulated recall interview (Hedegaard, 2008) with video data was helpful to understand the social conditions and demands, values perspectives and traditions of the two institutions. As mentioned before, the questionnaire responses were also drawn upon to stimulate the conversations at interview. These interviews were video recorded or audio taped with the permission of the participants. Parent interviews were mostly informal and conducted at home during the home visits (Appendix 3- Parent interview questions). In this study semi-structured interviews and an unstructured informal science walk method were used for interviewing the educators in situ. They are discussed below.

4.5.6.1 Teacher Interview

Each educator was interviewed separately at his or her convenience in the preschool. The interviews were semi-structured and unstructured. The interviews were conducted at different times during the second, third and fourth weeks of the study in accordance with teacher convenience, and there were follow-up interviews with Tamara and Dan. Tamara was interviewed a total of four times, while Riana was interviewed once and Dan three times. No follow-up interviews were possible with Riana since she left the centre after the project ended. The teacher interview questions drew upon their questionnaire responses for further clarification and also covered areas such as educational background and teaching experience, regular science teaching programs in the preschool, views about science in the everyday life of preschool children, children's home science experiences and any matters related to science activities in the preschool (see Appendix 4).

Table 4.4 Teacher Interviews

Educator	No. Of Interviews	PhD Interview Duration	ARC Science Walk/ Interview Duration	Total
Tamara	4	52 minutes (Video and voice recorded)	10 minutes (Science walk) 14 minutes (interview)	76 minutes

Riana	1	22 minutes (Video recorded)	36 minutes (Science walk)	58 minutes
Dan	3	54min (Video and voice recorded)	-	54 minutes

4.5.6.2 Science Walk

As a research assistant I was trained to conduct science walk interviews (Fleer, Gomes & March, 2014) for Professor Marilyn Fleer's ARC study (Project No.DP110103013). Later, in the present study I conducted the science walk interview with two participating educators (Paper 6). Teacher Tamara and Educator Riana voluntarily participated in a science walk for the current study. Teacher Dan did not wish to participate in the science walk so he was not included in this interview method. The science walks were conducted during the second, third and fourth week of the study at the educators' convenience. Science Walk is a resourceful informal unstructured interview method for gathering data, given that in a science walk the educator is literally taking a tour around the preschool indoor and outdoor environment to explain all the science affordances he/she could think about. In a science walk, the researcher follows the participant educators and captures their live detailing of the science affordances through video recordings and photographs.

4.6 Video Data Analysis and Interpretation

The main aim of my research is to study the process of concept formation for preschool age children as part of their early childhood development. The research context is situated in natural everyday settings at the home and preschool of two focus children.

Informed by cultural-historical theory of child development and using the dialectical-interpretive methodological approach along with Hedegaard's (2008) rationale of using the activity settings and considering the three levels of perspectives, I have followed a cultural-historical method of data analysis and interpretation. Videoing was the main method of data collection. According to Fleer, (2008, p.106) "using digital video technology it is possible to capture the dynamics of a child's participation in several institutional settings and recording what possibilities this holds for the child's development".

4.6.1 Logging digital video files

The first thing necessary after gathering video data is to organise the data in a systematic way. As an ARC research assistant, I was also trained in this process, which includes data logging, filing and coding. During my PhD data gathering period, after each day of data collection I downloaded the digital files into an external hard drive using the iMovie software program installed in my computer and labelled each folder containing the video files according to date and the camera number that I used. The folders were then described in an Excel logbook that contained more details about each folder. For example, the folder downloaded in the hard drive had the same folder name in the Excel log book and corresponding columns indicated the name of the folder, date, total number of clips in each folder, duration of each folder, time of data collection, content of the files and a brief set of details about the video in the files. These data were also arranged in clusters in the logbook according to the place of data collection—e.g., home or preschool— and according to the focus children's names. Colour codes were also used as necessary to indicate the place of data collection or to signal focus children's presence across different files and to further indicate the theme of analysis; for example, there were clips containing everyday concepts and scientific concepts.

Once the initial log was ready, it was then easy to work on my computer across the iMovie files, moving back and forth across activity settings between focus child's participating institutions for further analysis. For example, I switched between the file 'Jimmy's planting experience in the preschool with teacher Dan' and 'Jimmy's first home visit- Lego beanstalk'. In this way it was much faster to work across the data set, as the files could be viewed very easily and there was no need to make written observations (Fleer, 2008). At the end of analysis, using iMovie software, it was possible to make small video clips of 1-3 minutes duration on particular data excerpts that I wished to transcribe in detail for journal article writing or conference presentation.

4.6.2 Conceptual interpretation of data

Once data are gathered, the researcher has to conceptually interpret what has been captured to give meaning to the electronic data that must speak about the reality (Fleer, 2008). As a cultural-historical researcher, I worked from a dialectical perspective during the data analysis process (Fleer, 2008). For example, data on reality about children's everyday activities and experiences were collected digitally, then the digital reality was interpreted by also looking back into contextual reality to give the meaning of the child's actions, institutional practice traditions, concept formation, motive development from a higher analytical point of view. In this way I was engaged in different levels of analysis using the cultural-historical theoretical concepts. Figure 4.3 shows the relationship between digital reality and contextual reality of interpretation.

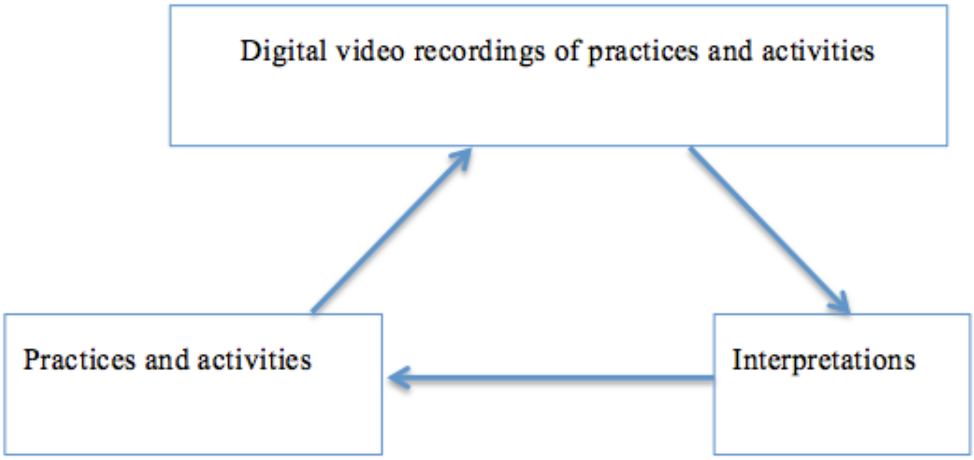


Figure 4.3. The relations between practices and activities, video recordings and interpretations (Adapted from Fleer, 2008, p. 113)

For example, to analyse the cultural-historical dialectical relationships to respond to the research questions, the digital video data were further interpreted using Hedegaard's (2008) three levels of interpretation, the common sense, situated practice and thematic levels, as discussed in the different publications in (Chapter 6-9) included in this thesis. Codes and categories were used for the analysis of data from the child's participating institutions as he/she was in the process of concept formation; these included categories such as: everyday concepts and scientific concepts, child-object interactions, child-adult interactions, and institutional practice. Examples of the interpretation are presented in tables in Chapters 6,8, and 9.

4.6.3 Validity and Reliability

The validity and reliability of dialectical-interactive research lies in a clear conception of the research problem and the distinguished perspectives between the researcher and participants (Hedegaard, 2008b). This is a very different approach than classical experimental-based child development research. The dialectic-interactive research focuses on the context, activity settings and interactions of the participants. Therefore a conceptual framing that could capture values embedded in the dynamic movements of the participants in their everyday contexts could give more authentic understanding of the research problem. In this study, The theoretical framing (discussed in chapter 3) and the personal, institutional and societal perspectives (discussed in this chapter) captured through the various data gathering methods therefore provides a valid basis for investigating the research problem outlined in this study. The researcher plays an active role in a cultural-historical dialectic-interactive study. An active role provides meaningful insights of the participant's perspectives and the researcher's conceptual perspective that maintains the reliability of the study. For example, in the study I interacted with the participants in a way so that they could also ask me questions and sometimes I participated in the activities for stimulating the conversations. Some of the interpretations were discussed with my intellectual colleagues at Monash University. The participants were provided with a CD with the pictures captured during the project.

4.7 Conclusion

The cultural-historical methodology guiding the present study has been discussed in this chapter. The close links between the theory, methodology, methods and interpretations have been presented using the wholeness approach of cultural-historical research. Through the dialectical relationships it has been shown how the everyday-ness of the data can be interpreted into the organic dynamism of the child's context. The next chapters present the empirical data and interpretations of child's concept formation process in everyday institutional practice. These are presented in Chapters 5 to 9

CHAPTER 5
Science in Preschool Environment

5.1 Thesis Including Publications

This PhD study is structured as a thesis including publications. The papers are sequenced in a way that allows the researcher to tell a story, combining all the publications to address the overarching research question. At the beginning of my PhD study my supervisor and I planned the number of papers to be developed from the data that were to be gathered, selected the conferences to present the papers and the target highly recommended, peer reviewed journals listed by the Monash Faculty of Education. Subsidiary research questions were formulated in line with the main research questions to frame the papers in more particular ways (See Chapter 1). Hedegaard's model of societal, institutional and individual perspectives (Chapter 4) are collectively integrated through all these papers since all these three perspectives can lead to a holistic understanding of children's concept formation (Hedegaard, 2008a), which is needed for this thesis.

Paper One and Paper Two are conceptually linked and report on science learning affordances in the preschool environment. The notion of teacher sciencing attitudes informs us of how the teachers draw on aspects of the preschool environment for teaching science. The following papers report mainly on home and preschool affordances for science learning in the everyday life of preschool children. Parent perceptions about science learning in their children's everyday life and the home-preschool relationships that create the conditions for science learning possibilities are identified in these papers. The overall findings show that teacher perceptions and parent perceptions together the children's family home and preschool practices collectively inform us about the possibilities embedded in preschool children's scientific concept formation process in everyday life. Preschool and everyday home environments reciprocally contribute in this process of children's scientific concept formation.

The first paper focuses mainly on the science walk approach as a live data gathering method to capture preschool science learning availabilities. The theoretical model on everyday concepts and scientific concepts presents the foundation for the subsequent papers. The science walk method was replicated and teacher sciencing attitude was further explored in the second paper to capture the social relations teachers draw upon in the everyday environment for science learning in the everyday context of preschool children. The third paper draws on parent perceptions about science and play in a preschool child's everyday home context and a child's motive orientation towards science in everyday home activity settings. The fourth paper reveals a preschool child's motive development in relation to home and preschool science learning play experiences. Chapter 9 uses the analytical concept of scientific perezhivanie to examine the relationship between emotion and scientific concept development process (the main focus of the broader ARC study).

The papers are all connected to each other and together present a complete picture on scientific concept formation possibilities in preschool children's everyday life through a cultural-historical conceptualization of child development. The background of the first paper is presented below.

5.2 Background of Paper One

The literature review in Chapter 2 shows that many science-learning opportunities are available in the everyday preschool environment, but in most cases the teachers do not use them (Tu, 2006). The literature review also shows that primary and early childhood teachers struggle with the confidence, competence and content knowledge to teach science (Garbett, 2003). Many everyday science-learning opportunities are missed in preschools because of the lack of teacher's conscious introduction of science to the young children (Blake & Howitt, 2012; Fleer, 2009b; Larsson, 2013). However, the literature had not yet discussed teacher attitudes and thinking in ways that could unveil the relationships they build with the environment for teaching science in preschools.

In the first paper included in this thesis a science walk method was applied and the concept of 'sciencing' (Neuman, 1971; Tu, 2006) was used to understand the teacher's sciencing attitude regarding the various science affordances available in the preschool indoor and outdoor environment. Vygotsky's theoretical discussion on the everyday and scientific concept (1987) gave a basis for conceptual framing in this paper. This paper was developed as part of my supervisor Professor Marilyn Fleer's ARC study (Project No. DP110103013). I was the second author of this paper. I worked as a research assistant in the project and gathered science walk data and analysed the data as part of writing up the paper. I also developed a working theoretical model (Fleer et al., 2014, p. 41) on everyday concepts and scientific concepts (Vygotsky, 1987) that gave the theoretical basis for my PhD study. This paper introduces the teacher's 'sciencing attitude' that had not been reported earlier in the literature. The study found that teacher's conscious sciencing attitude could include intentional science teaching in preschool using the everyday natural and material environment. This paper is both theoretically and methodologically conceptualised for a cultural-historical reading of the preschool environment. It offers further insights for researching science learning in the natural everyday environment to enhance preschool teacher's science pedagogical knowledge.

Paper One was first presented at the 43rd Australasian Science Education Research Association (ASERA) conference in 2014 (27-30 June), held at the Sunshine Coast, Queensland, Australia by my supervisor Professor Marilyn Fleer, me and Dr. Sue March. The co-authored paper was later published in 2014 in the peer-reviewed *Australasian Journal of Science Education (AJEC)*. The Journal Website (http://www.earlychildhoodaustralia.org.au/our-publications/australasian-journal-early-childhood/) describes the Journal as follows:

For the latest early childhood research, debate, innovation, and developments …

The Australasian Journal of Early Childhood *(AJEC) is Australasia's foremost scholarly journal and the world's longest-running major journal within the early childhood field. Published quarterly, AJEC offers evidence-based articles that are designed to impart new information and encourage the critical exchange of ideas among early childhood practitioners, academics and students.*

The full paper is included below as it was published in the AJEC Journal.

5.3 Paper One: Science Learning Affordances in Preschool Environements

Science learning affordances in preschool environments

Marilyn Fleer
Judith Gomes
Sue March
Monash University

THIS PAPER REPORTS ON the findings of a study into the perceived everyday science practices occurring within an early childhood centre in a southern part of Australia. In drawing upon cultural-historical theory, the study maps the possibilities for everyday science learning through photographic documentation (*n* = 223) and through undertaking a science walk with an early childhood teacher in order to establish how the environment was perceived for creating opportunities for science learning (planned or otherwise). The results foreground: science within the constant traditional areas within the preschool, building science infrastructure into the centre, and using science in everyday life in the centre. The findings show the importance of a sciencing attitude on the part of the teacher for affording meaningful science learning for preschool children.

Introduction

While there are a growing number of studies that have examined the science learning of pre-schooler children, little research has been directed towards how the physical environment of a preschool affords science learning opportunities. What possibilities are there for children to learn science concepts as part of their everyday interactions in these settings? We begin this paper by reviewing those studies which have focused on how children and teachers scientifically relate to their preschool environment. This relation is named in the literature as a *sciencing approach* (Tu, 2006). We argue that whilst the previous research has identified the possibilities for science learning in preschool environments, they do not go far enough in showing the relations between the environment and the *sciencing attitude* of the teacher.

The second part of the paper presents the study design and findings. We show through our single case study additional possibilities for science affordances (Goulart & Roth, 2010) than identified in the previous research. We specifically examine teacher science thinking in relation to the preschool environment. We argue that there are many unique possibilities for science afforded through the preschool structure, the routines, and through the *sciencing attitude* of the teacher. We use cultural-historical theory to discuss the unique nature of the early childhood teacher, the childcare environment and the preschool children for affording *science within the constant traditional areas within the preschool*, for *building science infrastructure into the centre* and *for using science in everyday life in the centre*. The study expands upon the categories of science learning already documented in the literature for science possibilities in preschool environments. Our research adds to an under-researched area in early childhood science education.

Science affordances in preschools

Hadzigeorgiou (2001) puts forward the view that 'wonder' as an emotional quality captures an important relationship between the child and their environment and that this can be pedagogically supported in preschools by teachers. Hadzigeorgiou (2001) argues that in building a strong conceptual base through science, learning 'cannot take place without the establishment of a long-term relationship between the world of science and the child. This relationship can be established only if children are helped to develop certain attitudes towards science' (p. 64). We also notice this affective relationship of wonder in a study by Siry and Kremer (2011) where Isabella (the teacher) supports two kindergarten children's sense of wonder by actively eliciting their ideas:

Isabelle: *If you want to touch a rainbow, how does it feel?*

Leyla: *It [the rainbow] quickly disappears. And when a child wants to touch it, it quickly disappears so no child can catch it.*

Julia: *I know what Leyla wants to say, when you touch it then you feel nothing at all because then the hand is through it. Because the rainbow is out of nothing.*

Leyla: *So, invisible, right?*

Julia: *No, how could we see the rainbow then?* (p. 648; children are five and six years old)

An affective relationship between the children and their environment is being built here as the teacher and the children explore rainbows, something that is not only visually appealing, but also intriguing to them. Wonder is being privileged by the teacher as a form of scientific engagement with their environment, as the children explore the different attributes of rainbows through their own physical and imagined interface with the rainbows. Science as a cultural knowledge system is being privileged by the teacher in her encouragement of collective wondering. In Siry and Kremer's (2011) study, wonder was being collectively constructed through particular dialogue, with the following questions asked by the teacher throughout the children's exploration of rainbows:

> *'What do you see on the picture? … Have you seen a rainbow before? When and where? … How does a rainbow arise? … What does a rainbow feel like? … Can you stand on a rainbow or use it as a slide? … What happened when the rainbow isn't there anymore'* (Siry & Kremer, 2011, p. 654).

Wondering can be viewed as a qualitative relationship of the child to their environment. Knowing more about the scientific possibilities within preschool environments is important for noting what children can wonder about. Tu (2006) has argued that 'as soon as children realize that they can discover things for themselves, their first encounter with science has occurred' (p. 245). Tu states that 'wondering, questioning, and formulating ideas and theories' (Tu, 2006, p. 245) are part of scientific enquiry into the world surrounding children, and this is a form of 'sciencing'. In a study which sought to examine the opportunities for sciencing in 20 preschool settings in the US, Tu (2006) video recorded two consecutive days of morning free play time and analysed both the environment and the activities against two checklists and a coding form. Tu (2006) was particularly interested in how preschool settings naturally afford science learning for children. Tu used the categories of formal sciencing, informal sciencing and incidental sciencing to examine the environment of the preschool settings.

Here *formal sciencing* refers to specifically planned science activities that are deliberately organised by the teacher, such as providing a cooking activity or introducing a pet into the centre. *Informal sciencing* captures the way in which a teacher might organise a space within the centre for promoting scientific interactions and explorations, such as a science table, or science corner. *Incidental sciencing* refers to interactions that occur between children and the teacher as a result of an occurrence in the centre, such as the weather suddenly changing or a child bringing into the centre a dried seahorse they have found on the weekend, and the teacher in drawing upon scientific concepts elaborates on the child's comments.

In using the categories of formal sciencing, informal sciencing and incidental sciencing to analyse the 20 centres, Tu (2006) found that the 'activities that the preschool teachers engaged were mostly unrelated to science activities (86.8 per cent), 4.5 per cent of the activities were related to formal sciencing, and 8.8 per cent of the activities were related to informal sciencing' (p. 245). The results show that although half of the preschools had a science area, the teachers mostly spent their time in the art area. Of particular interest is the analysis made by Tu (2006) of the materials and equipment for science within the preschool centres. Tu noted that the most common natural materials available to children were plants, seashells, fossils, and pinecones. In addition, vinegar, baking soda, sensory bottles, toad tank, fish tank and tornado bottles were also commonly found in the preschools studied. Tu found that none of these materials were used by the teacher or the children. Interestingly the preschools also had available for children prisms, timers, flower pots, and binoculars, affording a great many possibilities for scientific wondering. None of these were utilised during the data-gathering period.

Other opportunities for informal sciencing were reported by Tu (2006) including the provision of a sensory table by 65 per cent of the centres and a sand or water area in 55 per cent of the centres. These results would tend to suggest that while there were many opportunities for science learning and a collective sense of wondering about the everyday environment to be created by the preschool teachers, this did not happen. Tu (2006) suggests that 'teachers can model with their children a passion for discovery that is common in the world of science. It is acceptable for educators to say "I don't know, why don't we find out together"' (p. 251). Tu (2006) also suggests that teachers need to exploit the existing science opportunities already available in the centre environments, and argues that if we are 'to improve science teaching in the preschool classrooms, teachers need to reflect more on their own practices and utilise the science materials that are available in their environment' (p. 251). That is, we need to know more about how teachers reflect upon the science learning affordances in their preschools.

The study design

Our single case study specifically examines the environment and the teacher beliefs for realising the science learning opportunities available to children in one preschool context through a science walk. We are mindful that teacher interaction is critical for the process of creating science learning affordances through the normal and planned activities and environments within preschools (Vygotsky, 1994) and as such we focus on science possibilities over eight weeks of teaching.

Our study sought to determine:

1. What science learning opportunities are afforded for three and four year old children attending a childcare centre?
2. How does the childcare educator perceive the science affordances for her children?

Case study

The study site is a childcare centre. The centre occupies part of a community house in a middle SES location approximately 75 km from a major capital city in Australia. Other community groups use the centre, such as bridge club, martial arts, pilates and language classes, as well as a range of children's services including occasional care, vacation care, playgroup and the three-year-old activity group in which the present study was undertaken. The centre is of historical significance to the community and is located in an attractive part of the small coastal town. Many of the children and families know each other from other community activities. Space in the centre is constrained and many materials are kept in a separate room at the back of the centre, or stored in cupboards and on shelves in the kitchen, which doubles as the office for the staff.

The three-year-old activity group includes approximately 65 children (aged from 3.3 to 4.6 years) who attend on one or two days per week, with a five-hour session on Mondays, three-hour sessions on each of Tuesday and Thursday mornings and a three-hour session on Wednesday afternoons. Approximately 25 children attend each session and most children come on two days per week, many coming on Mondays and Thursdays, a few on Mondays and Tuesdays and some on Tuesdays and Thursdays. Some children come only one day per week. Many children also attend the occasional care sessions which run on Tuesday and Thursday afternoons, Wednesday mornings and a five-hour session on Fridays. According to the director, this lends a 'rotating nature' to the program, with activities repeated in each of the three-year-old sessions, in order to ensure each child has been included in the activities of the centre and also to ensure the children are familiar with and comfortable with each activity.

The staff: The three-year-old program is run by a Bachelor degree qualified teacher-director and a Certificate III qualified assistant. A retired volunteer from the community regularly helps at the sessions on a Monday and Tuesday and on Thursdays the mother of one of the children volunteers as part of her Certificate III training which she is undertaking at the community house under the supervision of the centre director. Parent helpers are also rostered and on Monday mornings the three-year -old group receives a visit from the infants and mothers in the playgroup held in an adjoining part of the building.

Research approach

The study design featured:

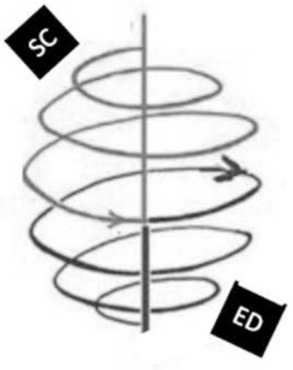
1. Taking photographs of the inside and outside of the centre with and without children (*n* = 1180 photographs) engaged in normal preschool activities
2. Video recording the teachers and children interacting in the preschool setting over an eight-week period (*n* = 242 hours of video observations) engaged in normal preschool activities as well as those deemed to be planned for supporting science learning
3. In week six of the study, the teacher-director was invited to conduct a science walk, explaining to the research team the science opportunities that were in her centre. This was video recorded. Because the science walk was undertaken whilst the director was teaching, she regularly stopped and interacted with the children, then explained to the research team the purpose of the activity or learning area within the centre in relation to science, and occasionally mathematics. This science walk took place within a full five-hour pre-school session, with the teacher stopping and starting her science walk throughout the session. Eighteen children were in attendance on this day and four hours of video data were recorded by two researchers on two cameras.

Analysis

This study draws upon cultural-historical theory where the dynamic relations between the material and social environment are central methodological components in analysis for realising the research questions. Although Vygotskian perspectives are well established in the science education literature (e.g., Fleer 2009a; Howitt, 2011; Mason, 2007; Robbins, 2003), an important but less discussed aspect of cultural-historical theory is that of everyday and scientific concept formation (Fleer 2009b). Here Vygotsky (1987) introduced two important ideas: everyday or spontaneous concepts, and academic or scientific concepts. Everyday concepts are usually based on empirical observations of the way things look or feel, and these are often intuitive. Scientific (or abstract) concepts are usually learned in a formal context and require introduction by another more knowledgeable person. Vygotsky (1987) stated that scientific concepts are closely intertwined with everyday concepts as a dialectical relationship. Basic everyday concepts lay the foundation for scientific concepts. This contrasts with constructivist views where these everyday or alternative views are thought to get in the way of advancing a scientific understanding.

Everyday concepts are experienced in a person's day-to-day practice. 'It (everyday concepts) tends to move upwards toward abstraction and generalisation'; on the other hand, 'scientific concepts start with the verbal definition and descend to the concrete' (Vygotsky, 1987, p. 168). Scientific concepts strengthen the everyday concepts supporting the structural formation of concepts (Fleer, 2007). Figure 1 below shows concept formation as a complex process where everyday (moving clock-wise) concepts and scientific concepts or academic concepts (moving anti-clockwise) support each other (Gomes, 2012).

Figure 1. Everyday concepts and Scientific concepts are dialectically related



In our initial analysis of the photographs and video observations taken during the science walk, we categorised a selection of 223 photographs that were representative images of both the indoor and outdoor areas within the preschool area where most of the teaching takes place. Within the indoor area we identified six areas with science learning opportunities, in addition to the kitchen and storeroom areas. For both video observations and photographs we used Tu's (2006) categories of formal, informal and incidental sciencing. To take this a step further, we also identified possible science concepts afforded by these materials related to everyday and scientific concept formation.

Findings

We begin this section by presenting a content analysis of the 223 photographs from a total of 1180 photographs followed by an analysis of the science walk in the context of the 242 hours of video data gathered across eight weeks of everyday practices within the centre. The additional photographs and video recordings allowed for cross checking and validation of the sample set discussed in this paper.

Content analysis of photographs

A summary of the data in relation to these categories is shown below in Tables 1 and 2. In addition to Tu's categories (FS = Formal sciencing; IfS = Informal sciencing; InS = Incidental sciencing), we also found three new categories:

1. new types of science infrastructure
2. science content in traditional areas
3. using science to support life in preschools.

These latter three are discussed in relation to the science walk discussed below. We signal the connections between the photographs and the science walk by underlining the specific categories in the content shown in both tables. These new categories, along with Tu's work, not only provide possibilities for a more expansive study across preschools in a range of communities, but would allow for the expansion of the concept of sciencing, thus supporting educator knowledge of this concept.

Table 1 shows the materials in all the indoor areas of the childcare centre. These areas contain many opportunities for incidental science learning. Table 1 summarises six indoor areas. Indoor Area 1 is where the projector and wooden shapes with coloured cellophanes and the prism are located. This area provides the opportunity for formal sciencing, where the teacher explicitly examined concepts about light and reflection/refraction. The aquarium in area 1 provided a context for informal science, featuring concepts such as living-non-living, breathing, classification, and ecosystems.

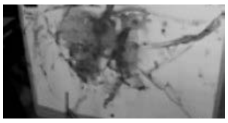
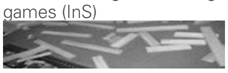
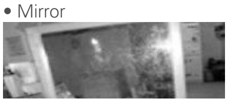
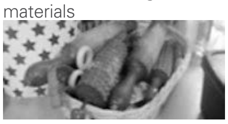
Area 1 contained further opportunities for incidental science learning. For example, concepts relevant to sound could be introduced through the radio-CD player and didgeridoo that are located in indoor area one; concepts like change of state of matter could be taught purposefully through craft and cooking materials.

Part of indoor Area 2 summarised above provided informal sciencing opportunities where materials such as plastic dinosaurs, bark, wooden logs, tree branches, plastic leaves, pinecones, and rocks were available for science learning. This area gave the possibilities for teaching science concepts such as evolution and living-non-living.

Indoor Area 3 allowed for the teaching of concepts such as habitats, living-non-living, respiration and relevant biological science related concepts for lizards and insects with a view to formal sciencing. Together with Areas 3, 4 and 6, a range of science concepts could be explored informally and formally by the children with their teacher.

Table 2 summarises the materials and opportunities

Table 1. Document analysis of indoor area photographs—before science walk

Indoor Areas	Science concepts (abstract/scientific)
Indoor area 1	
• Projector (FS) 	• Light/reflection/refraction (colour)
• Shapes with coloured cellophanes (IfS) • Prism (location on windowsill) (FS)	• Day and night
• Aquarium (IfS) 	• Living/non-living • Breathing • Classification • Ecosystem
• Radio-CD player (InS)	• Sound/vibration • Electricity
• Vinyl animals (InS)	• Living/non-living
• Soft toys (InS)	• Materials
• Lego/Wooden blocks (InS)	• Balance/gravity
• Spool (large) (InS)	• Motion
• Birds' nest (InS)	• Habitats
• Twigs/branches (InS)	• Habitats/living/non-living
• Didgeridoo (InS)	• Vibration/breathing (topic=sound)
• Boomerang (InS)	• Flight/aerodynamics
• Lanterns (rainbow colours) (IfS)	• Reflection/colour (topic=light)
Indoor area 2	
• Plastic dinosaurs (IfS)	• Evolution
• Bark (IfS) • Wooden logs (IfS) • Tree branches (IfS) • Plastic leaves (IfS) • Pine cones (IfS) • Rocks (IfS) 	• Living/non-living
• Coloured liquids in bottles on windowsill/rainbow coloured netbag (InS) 	• Light/reflection/refraction/ colour
• Glass pane condensation (InS)	• Water cycle
Indoor area 3 (FS)	
• Plants • Glass house/terrarium for live animals (e.g. lizard)	• Living/non-living • Life cycles • Respiration • Photosynthesis • Habitats
Indoor area 4	
Book corner (InS)	• Possible science books for various concepts
Indoor area 5	
• Painting easels (InS) • Painting colours (InS) 	• Colour concepts
• Puzzles, magnetic fishing games (InS) 	• Shapes/magnetism/ habitats
• Playdough (InS)	• Change of state of matter
• Blocks and legos (InS)	• Balance/gravity
• Coloured boxes (InS)	• Reflection (Light)
Indoor area 6 (Home corner) (InS)	
• Mirror 	• Reflection
• Cooking corner	• Change of state of matter/ heating
• Toy bassinet • Old cell phones • Dress-ups	• Role play of science concepts
Kitchen/Store room	
• Science books (24) (InS) 	• Digestion • Sensory • Brain science
• Microwave	• Heating
• Craft and cooking materials 	• Change of state of matter
• iPad	• Representation of science concepts

Type of science related activities: FS = Formal sciencing; IfS = Informal sciencing; InS = Incidental sciencing; Underlined aspects in open area discussed in science walk analysis.

Table 2. Outdoor area of the preschool

Outdoor Area	Science concepts (abstract/scientific)
• All the trees	• Classification of plants
• Sensory garden 	• Light and shade, seasons • Classification of leaves • Senses
• Sea-saw (InS)  • Soccer balls (InS) • Basketball corner (InS) • Hoola Hoops and Jumping Balls (InS) • Tyres (InS) • Slide (InS) • Climbing equipment (InS) • Slide (InS) • Climbing equipment (InS)	• Gravity • Force • Motion
• Drain pipe	• Water cycle
• Weather station	• Weather changes, water cycle, air pressure
• Coloured Wind wheels (InS) • Wheels on trees (InS) • Water trolley	• Evaporation, water cycle, pullies, volume, floating and sinking
• Flower garden (Fairy garden)	• Growing plants/living and non-living
• Recycling bin/ rubbish bin/composting bin food scraps/food on the tree  • Vegetable patch	• Decomposition, food chain
• Grass/cement path way, bark, sand	• Properties of materials

Notes: Type of science related activities: FS = Formal sciencing; IfS = Informal sciencing; InS = Incidental sciencing; Underlined aspects in open area discussed in science walk analysis

available in the outdoor environment for affording science learning. For instance, the water trolley in the outdoor area provides scope for teaching about the water cycle, evaporation and floating and sinking. During the eight weeks of teaching in the centre, we noted many of these science possibilities realised by the teacher. These findings are consistent with previous research. We now turn to the findings of the science walk, where we interviewed the teacher about the formal and informal possibilities for science learning across the preschool environment.

Science walk

In contrast to previous research, the science walk of the teacher in our study provided both an historical account and present analysis of the science opportunities for the children as is shown in Table 3. That is, the teacher was able to share how she organised her formal sciencing, how she went about planning for informal sciencing, and how she capitalised upon the incidental moments with children as they asked questions or noticed phenomena. The latter proved to be a richer tool for analysis than a simple content analysis focusing on equipment, tools, planned activities, or teacher interaction with children. The categories that went beyond the existing literature are shown in Table 3.

Formal sciencing

During the science walk the teacher did not discuss the formal organisation of science. However, the video observations did show that cooking (heating, chemical change, change of state of matter) was planned and implemented, allowing for the discussion of the concept of heating and energy transfer. Planning for science was only raised in relation to informal sciencing. This is not surprising as many early childhood teachers who use child-centred approaches to planning and teaching tend to focus on informal activities rather than specifically planned lessons in science. Siry and Kremer (2011) suggest that science opportunities tend to present themselves in relation to what is of interest to children, and that these interests become the resource for supporting the teaching of science in a more informal way. Others, such as Hedges and Cullen (2005) have found that in most play-based programs teachers organise experiences for children as open-ended activities, where the acquisition of content knowledge occurs through *osmosis* (i.e. discovery learning) rather than through formal teaching. Edwards and Cutter-Mackenzie (2011) have investigated environmental education in early childhood play-based settings through three pedagogical approaches—modelled play, open-ended play and purposefully framed play—for supporting conceptual development of young children, and in drawing upon Wood (2007) suggest that a mixed approach is beneficial for 'specific skills and concepts' (p. 58).

Informal sciencing

In contrast to Edwards and Cutter-Mackenzie (2011) the teacher in this study actually used informal sciencing quite purposefully for concept formation. During the science walk the teacher sat with a child (Henry) who was moving and stacking coloured blocks (which had a

Table 3. Analysis of science walk

Type of science related activity	Tu category used for analysis of present study	Everyday and scientific concept formation in present study
Formal sciencing	Cooking (Heating, chemical change, change of state of matter)	Composting (decomposition)
Informal sciencing	Overhead projector and coloured blocks (light)	Light area (blocking light, light reflecting and refracting) Prism on window sill (refracting light) Coloured containers, rainbow stained glass (colour absorption) Windmill with coloured blades (white light and spectrum) Colour mixing at painting easel (colour absorption)
Science within the constant traditional areas within the preschool	Supporting block building, making concepts explicit for successful building (force)	Water trolley (water wheel—force) Sandpit (sand adhering together when wet—force) See-saw (force)
Building science infrastructure into the centre		Sensory garden (herbs—use, growth and care) Vegetable garden (plant growth and care) Flower garden (bulb growth)
Incidental sciencing	Possums in the centre grounds Textured path and chalk and water (force/change of state of matter) Weeding (plant classification in everyday life) Observing birds in the trees (eco-system in centre) Observing flowering of the gum trees in centre (study of plants)	
Using science in everyday life in the centre		Weather watch (Range of concepts) • Bureau of Meteorology (BOM) • Rain gauge • Windmill
		Observing the moon (Earth and beyond)

wooden frame) over the top of an overhead projector, and discussed with him what was happening. She then proceeded to discuss with the researcher the intentional use of the specific space for setting up science-related activities.

The teacher has squatted down next to an overhead projector:

Teacher: *Remember you need to lay it flat* (pointing to the coloured block) *so that colour* (child lays the block flat) *… That's it. What colour are you getting now?*

Henry: *What?*

Henry looks to the blocks and then to the wall where the coloured blocks are projecting. He then turns back to the teacher and smiles saying:

Henry: *Purple* (continuing to smile broadly).

Teacher: *It is a purple* (nodding at Henry). *What about if you try putting one of them on the yellow in the middle? What colour could you put on the yellow one in the middle?*

Henry observes the teacher's pointed finger, and then takes the block that is in his hand and places it over the yellow block. He then leans over the projector to look closely at the two coloured blocks that are stacked on top of each other.

Teacher: *OK. Did you put blue on it or green?*

Henry looks to the blocks and also the wall where the colours are being projected. He looks back and forth. Eventually the teacher points to the blocks and says:

Teacher: *It is this one, in the middle* (tapping with her finger; as Henry looks to her finger and to the wall). *What's it done to the colour on the wall?*

Teacher: *Made it green. It has too. So yellow and blue make green don't they?*

Henry smiles and then places two more blocks on top of each other and looks to the wall.

Teacher: *So what have you put on it?*

Henry: *Green and red.*

Teacher: *What colour does that make in the middle?*

Henry: *Orange.*

Teacher: *It is a funny kind of green colour on the wall. But it does look orange there* (pointing to blocks stacked on the projector) *though. So when it's reflected the colour is different.*

The teacher then turns to the researcher and says:

> The other point about this, is that they are learning that you can't put them up like that (shows block on wooden edge and not flat), that they have to lay them flat. We have had whole conversations about how there is mirrors and reflections, and the light casting shadows, so a whole lot of learning about light involved in having these (projector and coloured blocks). There is always in this space (pointing to the area) some type of light box, overhead projector, something to do with light and reflection.

The organisation of a specific science-focused area to promote high level adult–child dialogue in relation to concepts is rarely featured (see Hedges & Cullen, 2011). In these kinds of environments a form of sustained and shared thinking results (see Fleer 2011; Siraj-Blatchford, Sylva, Muttock, Gilden & Bell, 2002). Environments which do promote cognitive engagement through a deliberate balance between teacher-initiated and child-initiated experiences in play-based settings, constitute what Siraj-Blatchford et al. (2002) have termed an effective pedagogy in early childhood settings. The pedagogical practices of modelling, demonstrating, questioning and explaining are central for supporting sustained and shared thinking between the teacher and the child(ren). This has also been the focus of early childhood curricula, such as the *Early Years Learning Framework* (EYLF) in Australia, where *intentional teaching* is introduced as an important pedagogical feature of that curriculum so that focused attention on concepts by the educator is realised (2009). In our study the teacher used informal sciencing specifically to support children's learning of the concept of light. A concept-led area within the preschool setting that is always available to children, like other areas within the preschool, such as the block corner or the home corner, is not common: As Vygotsky (1987) noted, scientific concepts are usually learned in a more formal schooling context. The approach adopted by this preschool teacher, although atypical, provides a purposeful way forward for explicitly examining scientific concepts in meaningful and iterative ways, rather than focusing on the provision of activities without specific planning for science learning.

Sciencing as part of the constant areas within the preschool

Another example of informal sciencing but which is associated with the material and equipment that are traditionally always available to children was noted explicitly in the photographic analysis of potential science content—the water trolley. This constant area within a preschool is usually understood in terms of mathematical concepts. The science walk showed that the teacher had a more sophisticated understanding of the equipment and its use than noted in the previous literature (see Garbett, 2003). For example, when discussing the water wheel in the water trolley the teacher said:

> *They will be pouring* (shows with hands what the children will be doing in the water trolley), *and they will watch the wheels go, so there is a conversation about how the water is able to push the wheel and turn the wheel, and we have a lot of chats, we had a couple of children here yesterday afternoon, and we were having a long chat with, about that.*

Our findings are different to Tu (Tu, 2006). Tu's findings are illuminating because she found that 86.8 per cent of activities did not involve any science concept at all. Tu noted that no formal science corner was observed in the preschools in her study and most of the science materials were collected from nature. Tu found in her research that a mere 1.5 per cent of activities involved formal science activities, and only 8.8 per cent involved informal science activity with no incidental science activities noted. There was no evidence of these materials being used for science learning purposes during the data collection period.

In our study we only found out about the teacher's scientific thinking for informal sciencing because she was given the opportunity in the science walk to discuss her understandings of the science possibilities inherent in the materials and equipment within the centre, as the example of the water wheel shows. A cultural-historical approach foregrounds the environment in relation to how it is socially mediated to children by teachers. A cultural-historical lens invites more questioning about not just material conditions afforded for science (Fleer, 2007), but also teacher mediation of everyday and scientific concepts (Vygotsky, 1987).

Using science in everyday life in the centre

During the science walk the teacher discussed with the research team how she engaged the children in a weather watch, and how this activity was a central feature of her planning for what equipment and activities would feature on a particular day. She used the website of the Bureau of Meteorology for accessing the weather map for her community, and together with the children they discussed the activities for the day. Similarly, she had in the environment a rain gauge and a windmill for noticing weather features with the children. Weather watch was scientifically supported by the use of the prism to refract light, and to make rainbows inside the centre, linking this with the rainbows that the children regularly observed in the sky near their centre. Science was being used to support the everyday life of the centre, for both adults and children alike. The teacher's explicit mentioning of the Bureau of Meteorology in her discussions with children signalled a scientific way of thinking about organising the day, supported by the lived experience of the actual weather conditions that were accurately (or not) predicted by the Bureau of Meteorology. *Using science in everyday life in the centre* cannot be classified as incidental sciencing, because it occurred daily. It was real and it was meaningful to the children because the weather conditions determined if and how long they might play in the outdoor area, or if it was likely that they might see a rainbow in the sky or in the centre. It is an important category that relates directly to Vygotsky's (1987) discussion about the closely intertwined nature of everyday and scientific concepts.

Building science infrastructure

A further finding of the study was the science infrastructure that was built by the teacher in the centre. She actively supported natural science through the explicit planting of plants in the outdoor area. The thoughtful approach to changing the outdoor setting into different kinds of garden beds promoted a great deal of learning about plants and plant care and growth. Such an approach helps create the conditions for the process of child development within the ZPD (Vygotsky, 1997). The teacher planted a sensory garden (herbs—use, growth and care) which she encouraged the children to interact with regularly. She also planted with the children a vegetable garden, and she created a non-edible garden of flowering plants. She also had planted, with previous cohorts of children, bulbs into a part of the garden that was known as the fairy garden.

Incidental sciencing

The final sciencing that was noted in the centre through the science walk was incidental sciencing. During the science walk the teacher mentioned six areas that were incidental things, but which also featured regularly because of the way the grounds were set up and designed by the teacher, but also in relation to what the children noticed or that the teacher noticed and drew the children's attention to. For instance, the centre grounds regularly had evidence of possums and through feeding the possums the vegetable garden was preserved. The teacher mentioned the birds that visited the centre when the main gum tree was flowering, and she mentioned the discussions she had with the children about what was a weed and what were the plants she wished to keep growing in the centre grounds. Whilst incidental sciencing is science that is not planned, the teacher in this setting contributed to the incidental sciencing by designing spaces that would bring nature more explicitly into the teaching program. This is a slightly different reading of incidental sciencing to that of Tu (2006) who gives examples of 'An animal is unexpectedly brought into the classroom' (p. 246).

Conclusion

The study has shown some of the science affordances in preschools. It was noted that in this study of one early childhood setting in Australia that a *sciencing attitude* of the teacher is likely to maximise the scientific learning opportunities of young children immeasurably. A *sciencing attitude* has not been discussed previously in the literature in such an explicit way. The findings of the study demonstrate that with a *sciencing attitude*, preschool teachers are more likely to think consciously about the science that is already possible in the preschool environment. That is, teachers with a *sciencing attitude* are less likely to leave learning at an everyday level, and more likely to think consciously about how to draw out the science possibilities afforded through the preschool infrastructure. Consequently, conceptual development in science is more likely to be consciously considered by the children along with their teachers at the higher level for thinking in new ways about their everyday world. As noted by Vygotsky (1987), it is important for children to have experiences at both the everyday level, and at the scientific level, if true scientific conceptual development is to occur. This is in direct contrast to previous studies, where early childhood teachers (usually studies of pre-service teachers) (Cowie & Otrel-Cass, 2011; Garbett, 2003), are thought to have a negative view of science and poor knowledge of the area, as noted in recent and longstanding studies (Appleton, 1995).

The study also found that the teacher created new kinds of science infrastructure in the centre, not previously noted in the literature on preschool science education. The science areas, along with the traditional areas within the preschool (e.g. block corner), allowed science to be more visible to the children through the teacher and children using these areas purposefully and in the everyday life of being in, or running the centre. A *sciencing attitude* is something that we believe is important for maximising the science opportunities that this study has shown are available in early childhood centres. A further analysis, but taken from the child's perspective, would reveal even more insights into the concept of sciencing, but that is beyond the scope of the present study and paper.

As a result of the findings, we believe that, along with the day-to-day planning that teachers already do, they also design into the centre infrastructure for informal science learning that is focused on concepts rather than just activities—such as the permanent 'light' area set up within the centre by the teacher in this study. This approach is supportive of the pedagogical directions found in many national curricula (e.g. EYLF in Australia). We also believe that early childhood centres can easily build up the natural environment to bring in wildlife through careful planting and through the inclusion of activities that support wildlife. These kinds of science infrastructure provide ongoing sciencing opportunities. The inclusion of additional science infrastructure provides affordances for children to notice and express interest in the science within their natural environment, thus allowing the teacher to follow up with learning activities. The latter also supports teacher beliefs about following children's interests. We also noted that the use of science by the teacher for purposeful planning of what events and activities would take place through tools such as the Bureau of Meteorology website, a rain gauge and a windmill, all support scientific thinking of young children in meaningful ways. We believe that teachers who deliberately use science in running their centres, provide children with experiences that engage them in science for a real purpose. The additional categories of science learning afforded in the early childhood centre noted in this study, if adopted more broadly within early childhood education, could create the opportunity for increased science learning of young children.

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CHAPTER 6
Science Learning Affordances in Preschool Environment: Teacher Perceptions

6.1 Background of Paper Two

The Australian preschool curriculum framework, the Early Years Learning Framework (EYLF) (Department of Education Employment and Workplace [DEEWR], 2009) provides scope for teaching concepts and promotes intentional teaching. However, the body of literature on preschool science (See Chapter 2) shows that science is least focused in preschools. Given the literature background revealing little emphasis on preschool science teaching and teachers' lack of confidence, competence and content knowledge contributing to this problem, Paper Two builds on Paper One seeking a better understanding of preschool teachers' conceptualisation of the ways teachers see the everyday environment offering science possibilities for the children. The science walk method is replicated in this paper and data from this method, integrated with data from interviews and questionnaire responses elaborate on the teacher sciencing attitudes. The findings from this paper theorise the relationship that teachers see between science and children's everyday environment. I used the cultural-historical theoretical concepts of social situation of development (Vygotsky, 1994b) and everyday concepts and scientific concepts (Vygotsky, 1987) to analyse the teacher's conceptual relationship to the everyday environment. The findings show that a teacher with a *conceptually oriented sciencing attitude* integrates both everyday concepts and scientific concepts in giving a scientific meaning to the everyday environment children play in. On the other hand, an activity oriented sciencing perspective fails to capture the everydayness of the science concepts in children's daily environments. I represented these two sciencing perspectives through a model included in this paper. The findings provide significant insights for science pedagogy showing that science-teaching contents are available in children's everyday environment and teacher awareness about the everyday environment could bring this relationship between science and environment to the forefront in a more nuanced way.

This paper was first presented in the Australasian Science Education Association (ASERA) Conference (Gomes, 2016, 27 June-1 July). My supervisor and I wrote the paper together and submitted it to the ASERA conference associated Journal named *Research in Science Education* (RISE) on 3 July 2017 and it received final acceptance on 5August 2018. The peer-reviewed journal is distinctive for publishing high quality science education research papers. RISE is featured in the ASERA website as "one of the top four science education research journals in the world" https://www.asera.org.au/Publications/RISE

The paper is available as Online First at https://rdcu.be/7GT5 and at http://link.springer.com/article/10.1007/s11165-018-9760-5

(Please copy-paste any of the above URL on your browser for downloading). The paper is presented below as it was published.

6.2 Paper Two: Is Science Really Everywhere? Teachers' Perspectives on Science Learning Possibilities in the Preschool Environment

Research in Science Education
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Is Science Really Everywhere? Teachers' Perspectives on Science Learning Possibilities in the Preschool Environment

Judith Gomes[1] · Marilyn Fleer[2]

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Abstract

There is increasing interest in early childhood science education and a corresponding increase in research in this area. Studies have shown that in some countries the teaching of science in the early years remains low. These studies show that science pedagogy in the early years needs attention, despite the myriad opportunities afforded for the informal teaching of science concepts. What is not known is how teachers interpret the opportunities for science moments in these play-based environments. In drawing upon cultural-historical theory, this paper examines how teachers use the preschool environment to promote the teaching of science concepts. Specifically, two preschool teachers from one preschool site participated in an indoor and outdoor science walk where their discussion of the affordances for science learning was digitally recorded. Hedegaard's (2008) three-step analysis procedure and Tu's (2006) sciencing categories were used to analyse the data. Findings show that teachers in the same preschool setting have different levels of science awareness for the possibilities of informally teaching science. Specifically, an activity-oriented sciencing approach and a conceptually oriented sciencing attitude emerged. The complexity of teacher engagement in science teaching in play-based settings and their conceptualisation of science affordances in the environment point to new understandings about the relations between teachers' belief and practices in science learning. Therefore, the findings of this study contribute to early year science education just at a time when the Australian Government is seeking greater outcomes for the learning of STEM in preschools (Australian Government 2009).

Keywords Everyday and scientific concept · Early childhood science · Cultural-historical theory · Preschool environment · Teacher competence · Social situation of development

✉ Judith Gomes
[redacted]

Marilyn Fleer
[redacted]

Back Affiliation

Introduction

Drawing upon cultural-historical theory (Vygotsky 1987), the central problem reported in this paper is to explore how teachers in a single preschool conceptualise the environment for possibilities of teaching science. Play-based settings afford many possibilities for children to informally experience science education. However, the science activities in preschools are usually embedded with other aims, such as developing social competence and motor skills, and teachers may not extend the science learning possibilities of children (Sundberg and Ottander 2013). Yet the Australian Government, through the introduction of curriculum that includes greater cognitive outcomes and intentional teaching of concepts, has increasingly raised expectations for the teaching of more science concepts (Australian Government 2009). Therefore, one of the major challenges in preschool science teaching is how the existing pedagogy can support children to develop a scientific relationship to the play-based environment (Hammer and He 2014; Siry and Kremer 2011). A further challenge relates to teacher confidence and competence to teach science in the early years (Olgan 2014). For instance, research has shown that limited content knowledge of early childhood teachers is one of the major constraints underpinning their lack of confidence and competence for teaching science to young children (Garbett 2003). In addition, Sundberg and Ottander (2013) pointed out that preschool teachers' reluctance to teach science occurs because the teachers also have negative attitudes to teaching science. How teachers think and feel about the teaching of science may impact on how they view the science possibilities found in the play-based settings, environments that are rich with science learning possibilities (Fleer, Gomes and March 2014).

Research indicates that the problem of teaching science in preschools is much more complex than first thought, because teaching science in preschool is significantly different than teaching science in primary or secondary levels (Sundberg and Ottander 2013). Firstly, the play-based setting at the preschool level is less structured than upper levels. This means preschool science teaching demands that teachers' deliberately draw upon children's everyday play experiences and bring into this, science concepts in playful ways. Secondly, some teachers in preschool settings use the informal program to introduce science by simply placing objects of interest into the environment, with the aim to generate interest in learning science concepts through exploration of the materials. This discovery approach has been a longstanding practice in preschools. Previous studies have found other practices, such as formal, informal and incidental science teaching. But also, there are further sciencing (Tu 2006) opportunities available in everyday context that teachers could draw upon for teaching science in preschools—but may not do so. Thirdly, teaching in preschool contexts mainly takes place in teams, such as the main educator and an assistant teacher. As a norm, staff usually have different qualifications—therefore, competencies of a university degree and a technical diploma work together. We do not know how teachers, who traditionally work in teams in the same context, conceptualise their preschool environment or what affordances in terms of teaching science in a play-based settings may hold. Their views may be the same or different. We predict that how a teacher conceptualises science affordances in the preschool environment—as opportunities for conceptual learning or as a set of science activities—will influence their approach to teaching in the preschool environment. In the context of Government expectations for more intentional teaching of concepts in preschool settings, this is an important question that has as yet not been asked.

Therefore, to address this complexity of science affordances in the child's environment, confidence and competence to teach science and the building of scientific reading of everyday play-based settings means studying how teachers draw upon their preschool environment in support of teaching science concepts. The findings could productively contribute to knowing more about how to support early childhood educators working in teams in the changing curriculum context in Australia (Australian Government 2009). To achieve this goal, we used a cultural-historical concept of everyday and scientific concept formation and the social situation of development to understand what knowledge teachers' bring when interpreting the environment for supporting meaningful science learning. In examining the existing literature, we found that there were two key areas relevant to our study: teacher education studies on teachers' confidence, competence and content knowledge and the preschool context and science pedagogy. We introduce this literature, followed by the theoretical concepts, study design, findings and conclusion.

Teacher Education Studies—Content Knowledge, Confidence and Competence

Lack of content knowledge has been linked with confidence and competence in teaching science (Appleton 1992; Garbett, 2003; 2007). Early years science education studies from Australia (Fleer 2009), Turkey (Olgan 2014) and Greece (Kallery and Psillos 2002) suggest that developing teacher confidence and competence to teach science is often cited as the reason why so little science is taught in early childhood settings. For instance, Garbett (2003) found that most early childhood student teachers are unaware of key science content knowledge and that this appears to limit their understandings of how to design science activities for preschool children. However, others have suggested that content knowledge is not the only factor that impedes early childhood teachers' feelings about teaching science (Fleer 2009). Studies suggest that situating this problem within the individual ignores the broader social context and does not give a holistic picture of the problem. For instance, pre-service teachers are more likely to develop confidence in teaching science when they "see themselves having a role in generating scientific knowledge to inform their own scientific knowledge" (Fleer 2009, p. 353). Further, Andersson and Gullberg's (2012) analysis shows that other than content knowledge, teachers have other competencies, such as building children's confidence in their own learning, and skills in responding to the learning moments are more likely to develop a positive learning environment for children. Siry (2014) re-emphasises Andersson and Gullberg's (2012) point by saying, a much broader perspective on *what is science in preschools* and *what do teachers have to know to empower children* needs to be known since children's wonder and curiosity can often give content for investigation and that wonder and curiosity are often overlooked in studies of teacher competence.

Research has also shown that teacher competence is related to how the teacher interacts with and communicates science content to the learners. Studies have found that "in the context of teacher knowledge and confidence to teach science, the link between knowing science, and knowing science as it relates to the everyday cognition of children in their everyday lives, is significant" (Fleer 2009, p. 1074). Similarly, Thulin and Redfors (2016) emphasise that content knowledge is not the only aspect to be considered and that thought should also be given to the level of teacher experience in teaching generally and then in relation to the teaching of science content. Further, the authors mention that understanding a child's perspective as they experience science learning is also crucial, but this dimension is not usually discussed when considering teacher confidence and competence in teaching science. Considering a child's perspective when teaching science means to take into account the child's everyday experiences—what they know about the science concepts in relation to everyday practice. Science learning becomes meaningful when the child's everyday experiences are purposefully linked to the concepts, and longstanding research has shown that teachers who find out what children already know work more conceptually with children in play-based settings (Siry and Kremer 2011).

In sum, it would appear that teacher confidence and competence in the teaching of science are a complex area, and having science content knowledge is not the only factor that needs to be considered when examining early childhood science education. We now turn to a review of research that has examined the role of the environment for the teaching of science content in preschool settings.

Studies of Science Affordances in Preschool Environments

Although there is an increased interest in researching early year science learning, not many studies have looked into what the preschool environment affords for the teaching of science. The literature shows that there is a belief by some preschool teachers that science is everywhere, whereas for many others, they find it difficult to conceptualise science learning opportunities within the everyday environment of the preschool (Edwards and Loveridge 2011). Eshach and Fried (2005) mention that there is an abundance of richness of science learning within everyday phenomena and within the objects and materials in children's everyday contexts. The authors also suggest that it is important for the adults to create an openness to looking at the interesting aspects of the environment, rather than resisting introducing young children explicitly to phenomenon. We know from teacher education studies that preschool teachers often struggle with explaining the scientific concepts, due in part to a lack of confidence and content knowledge. However, teachers can deliberately create an openness to inquiry with young children and support them to develop scientific understandings by looking at what is there in the environment and to interpret how objects and materials relate to their everyday lives (Eshach and Fried 2005; Roychudhury 2014).

Generally, in preschools, the children are in an environment where they manipulate, interact and explore objects with the help of the teachers. Whilst these environments afford many possibilities for science learning (Eshach and Fried 2005), research focused on determining if these possibilities are realised has noted that in some preschools, science corners are rarely utilised, often there is minimal interaction between children and the teacher to discuss and unpack a science experience, and in many cases the children are often left alone to play with the materials and "discover" the science concepts for themselves (Fleer 2009; Kallery and Psillos 2002; Nayfeld et al. 2011). In some cases, science concepts like space science, life science and physical science are taught only with specifically designed teaching materials in a designated science area once or twice a month (Sackes 2014). It appears that only focusing on designated science corners could ignore the myriad of experiences available in the general preschool environment. Therefore, Tu (2006) examined science learning possibilities in preschool sites, paying attention to what the teacher in charge focused on, as well as what science possibilities could be realised across 13 sites. Tu (2006) introduced the concept of a "*sciencing*" approach to name the science learning opportunities in preschool environments in relation to the materials available and the teachers' engagement with realising these possibilities. Her study examined the frequency and use of science materials. The study found that there are lots of materials available in the preschool environment that can afford science learning for young children, but preschool teachers miss the opportunities to teach science. In analysing the environment from a researcher perspective, her study said little about the teachers' understandings of what might be the science learning affordances of that environment. In another study, Edwards and Loveridge (2011) pointed out that often teachers do not consciously recognise the learning opportunities existing in their preschool context because of a lack in pedagogical awareness of how to teach science in everyday preschool settings. In their study, some participant teachers also mentioned that the teachers do not catch the moment for science in an everyday situation because of their belief in the importance of children learning independently and with others.

Other studies have looked explicitly at the teacher's role in their environment and the pedagogical practices drawn upon to support science learning. In our previous study (Fleer et al. 2014), the concept of sciencing (Tu 2006) was extended to include a *sciencing attitude.* Studying the preschool environment and the teacher's perspectives, our previous study identified that "…with a sciencing attitude, preschool teachers are more likely to think consciously about the science that is already possible in the preschool environment" (p. 46). Siry and Kremer (2011) emphasise that learning does not happen if separated from its everyday context. In their study, the student teacher Isabella was curious to investigate children's conceptualisation of a natural phenomenon. Because of the geographical location, rainbows were a common everyday phenomenon for the children. The children thought that they could slide on a rainbow and wondered about where a rainbow comes from. A focus on the abstract concept of light in the everyday context of a rainbow was co-constructed between the educator and the children through sharing their ideas, through the recurring conversations and through responding to children's wonder and curiosity. In other words, children's learning needs to be embedded in the context of that which is meaningful to them.

The social and material relationship that teachers build with children about their environment matters for science learning in the early years. Whether or not teachers respond to a learning moment indicates how they interpret the relationship between the materials/environment and the child. Blake and Howitt (2012) explored science pedagogy in early learning centres. Their study found that through adult interaction in guided play, children could be supported towards developing conceptual knowledge in science. Their study also found that opportunities for teaching scientific concepts are often missed by educators because no follow-up or extension of the activity is afforded to children. In another study, they found that preschool children are able to develop understandings on forensic science concepts in the context of an educator developing an activity around a bear hunt (Howitt et al. 2011). The study showed that children found the forensic science concepts relevant to their everyday life because the program was contextualised within children's everyday life. The inquiry program supported furthering children's science learning skills, knowledge and imagination.

In other naturalistic studies of preschool environments, Hadzigeorgiou (2001) and Siry and Kremer (2011) discuss the significance of using wonder and curiosity as a pedagogical approach in the preschool environment. Hadzigeorgiou argues that a pedagogy is needed that will drive children into developing a scientific attitude that will guide children towards conceptual knowledge. He argues that a relationship needs to be built between the child and the environment. Roychoudhury suggests that by observing the everyday phenomena related to children's daily life-

> "…teachers and children are likely to develop a sense of personal connection to science. They will be able to see science is everywhere and it is closely related to many of their

decisions and actions… feeling a personal connection to science may be crucial for the teachers of the preschool and elementary grades since they tend to have limited exposure to science and also a dislike for it" (Roychudhury 2014, p. 314).

In sum, the existing literature into science learning affordances in preschool indicates that not a lot is known about what preschool teachers think about the possible science concepts afforded in everyday preschool settings. Given the play-based nature of the preschool setting, more attention needs to be directed towards examining how preschool teachers can make use of the rich infrastructure available and what they see as the science possibilities. Also missing from the literature was studies that focused on or acknowledged the unique staffing arrangements of preschool settings. We know from practice, team teaching is a common structure in preschools, with usually a degree qualified staff member and an assistant or a team of variously qualified technically trained staff (i.e. one educator may have 2-year diploma and another a 1-year certificate). But we do not know how teachers in the same context use the same environments for teaching science within the everyday practices in the centre. We therefore argue that knowing how teachers in the same preschool context interpret their environments is important for enhancing the possibilities for the teaching of science in preschool settings. Consequently, our study sought to interview two teachers from the same setting, in order to explore this area. Now, we proceed to the theoretical framing of the study.

Theoretical Concepts

This study is conceptualised from a cultural-historical perspective. In particular, we draw upon two central concepts—social situation of development Vygotsky (1994) and everyday and scientific concept formation (Vygotsky 1987) for analysing the data and theorising the findings of this study.

First, we use the concept of the social situation of development for our analysis so that we may understand how preschool teachers in the same environment realise science moments within everyday preschool settings. Details of this concept are discussed further below. Since the literature suggests that teachers have the possibility to use everyday play contexts to support scientific thinking, then it is important to know if and how teachers see the environment as a resource for making science relevant to children's everyday life.

Second, we draw upon the analytical relation between everyday concepts and scientific concepts to capture the everyday experiences provided for children in preschools, at the same time as considering the scientific concept that could be afforded in the practices of that preschool. This relation gives analytical power for understanding how teachers talk about their practices, the environment and their beliefs about science teaching in preschool settings. Details of this concept also follow further below.

Together, the concepts of the social situation of development and everyday and scientific concept formation make visible how two teachers in the same environment bring their own pedagogical awareness and understandings of science learning affordances. We assume the teachers may vary in their perspectives. However, we predict that the findings could bring important understandings relevant to preschool teachers who traditionally work in pair and who have different qualifications.

Cultural-Historical Concept—Social Situation of Development This concept captures both the everyday situation in the environment and the characteristics of the person. The social situation of development is not something that is located in the situation but rather this concept captures the relationship between the person and the environment. Each person relates to the environment based on their personal characteristics or motives, which colour how they read or relate to the particular situation or everyday experience.

This concept can capture how different people with their own personal characteristics, values, attitudes and motives can experience the same environment differently. Vygotsky introduced the example of three children with a mother with a substance abuse problem, to explain the concept of the social situation of development. He wrote about how the same social situation was impacting differently on the development of the three different children based on their unique social situation of development. In his example, the eldest child in the family was a 10-year-old boy, who was taking responsibilities like an adult to help care for his younger siblings, as a result of his mother being unable to care for them. The youngest child who was also exactly in the same situation found the situation difficult because he did not understand the mother's problem. Based on the different motives and understandings of each child, the same situation was experienced differently.

Vygotsky says, it is important to note that as the child grows, his/her relationship to the same environment also changes over time, even when there is minimal change in the actual environment. Therefore, the same environment brings different meaning to the child at different stages of their development. "…whatever the situation, its influence depends not only on the nature of the situation itself, but also on the extent of the child's understanding and awareness of the situation" (Vygotsky 1994, p. 342). This conceptualisation of the environment and the persons in unity is drawn upon for analysing how teachers in the same preschool setting may be interpreting the same situation different.

Cultural-Historical Concept—Everyday and Scientific Concepts Vygotsky states that, "the strength of scientific concept is the weakness of the everyday concept, the strength of everyday concept is the weakness of the scientific" (Vygotsky 1987, p. 187). This means everyday and scientific concepts have different developmental pathways that are dialectically related. Both concepts support each other in the development of better understandings of a particular concept. Everyday concepts are experienced in regular everyday contexts. Everyday concepts are concretely experienced. It is with the adult's help that they are given scientific meaning in the everyday situation of the concrete setting of the preschool. Basic everyday concepts lay the foundation for higher-order scientific thinking. Everyday concepts are experienced in children's day-to-day practice. According to Vygotsky, "The development of scientific concepts begins with the verbal definition. As part of an organised system, this verbal definition descends to the concrete; it descends to the phenomena which the concept represents. In contrast, everyday concept tends to develop outside any definite system; it tends to move upwards toward abstraction and generalization" (Vygotsky 1987, p. 168). For example, children experience day and night in their everyday life. A mother wakes up the child every morning showing the Sun in the sky or during sleep time showing the Moon in the night sky. At a later time, the mother explains this everyday moment with a scientific explanation that the earth and other planets move around the Sun in the sky, which together are called the solar system. In this way, the possibilities are laid for the intermeshing of everyday and abstract concepts. As this example shows, the emphasis is on adult's interaction with the child during the process of developing scientific understandings. Vygotsky (1987) foregrounded the importance of adult's role in everyday life of children since adults can provide scientific explanations and help children move beyond everyday understandings of the environment.

Research Question

The focus of this study was to examine how educators in the same preschool setting interpret the same environment for the possibilities of children's learning of science concepts. Our approach in understanding science affordances is in keeping with cultural-historical theory (Vygotsky 1987) and which we suggest speaks authentically to understanding the complexity of teacher competence and confidence to teach science in the preschool settings. We argue that through examining the science affordances of the same learning environment as identified by teachers, a better understanding of the complexity of preschool science education can be determined.

The main research question for the study was:

- How do teachers in the same preschool setting interpret their environment for science learning possibilities?

Study Design

The present paper reports on a study aimed to explore science learning possibilities for preschool children. The first named author's PhD study is linked to a larger research project led by the second named author that was funded by the Australian Research Council Discovery Scheme. Video data were gathered over 4 weeks in the preschool. However, a non-filming week due to staff sickness stretched the total duration of the project into 5 weeks. As part of the Australian Research Council Discovery Scheme project, the first named author in acting as a research assistant undertook the science walk and took photographs. As part of the first named author's PhD study, she also conducted interviews with the educators, administered a questionnaire and recorded field notes. All these methods are discussed later in this section.

Context of the Study

According to the centre director Rekha, the preschool was built 30 years ago as a long day care centre. It is located in a south eastern suburb in Melbourne. The centre is run by the parent committee for a not-for-profit body organisation. The centre philosophy integrates diversity and inclusion, respecting all abilities and voice of children to reward curiosity for better teaching and learning.

There are three rooms in the centre with different age groups of children. Each room has the standard learning areas of story books, dress-up area, a kitchen corner and as is expected with tables, chairs and hands-on materials in each learning area. There is an administrative office room, a staff room and a kitchen as well. The centre is well equipped with teaching materials and resources. The preschool building features the Victorian period with high ceilings.

Science activities are part of the preschool program together with literacy, numeracy and dramatic play activities and carried out almost in an equal proportion, as shown in the fortnight planning (Appendix 1). Planned science activities take place once every 2 weeks for preschool children as well as incidental science experiences take place any time of a day. The planned science activities are mostly experiment based, for example making volcano with vinegar and bi-carb soda, weight and measurement, making bubbles, making aeroplanes, floating and sinking, colours and the absorption of different things, making boats and floating them and having races, marbles and ramps, etc. The educators regularly document these science activities with images named in a "science and technology ideas" folder.

There is a spacious outdoor area which all children have access to for playing together. The outdoor area is landscaped and includes trees, plants, vegetable patch, sandpit and mud pit, a cubby house, a ramp, a wooden decked area where children play with large blocks and an artificial turf area with physical obstacles in the open ground, a table and a couch where children often sit together for story time. (See Appendix 2 for the floor plan.)

Sample

In Australia, the term educator is a generic name for all staff working in early childhood settings regardless of their qualifications. Educators with mixed qualifications work in teams or pairs. Generally, a teaching pair/team constitutes a Teacher with a Bachelor degree and team members with a Certificate or Diploma qualification. A team of four educators Tamara, Riana, Dan and Rekha working in the preschool voluntarily agreed to participate in this study. In this paper, the term Teacher will be used for Tamara who has a Bachelor degree and the term Educator will be used for Riana and for referring the teaching team or pair together. Rekha was the centre director and responsible for managing and leading the service. Tamara, Riana and Dan mainly worked together teaching the same group of preschool age children during the duration of the data-gathering period. All four of them participated in interviews. Teacher Tamara and Educator Riana participated in a science walk (Fleer et al. 2014). Tamara is a Caucasian Australian and Riana comes from an Indian cultural background. Tamara has a bachelor degree in early childhood education. She is an early childhood teacher and holds the Educational Leader position in the centre. All together she had been teaching in the centre for 5 years, with three of these years teaching preschool children. According to Rekha, Teacher Tamara's responsibilities include focusing on the programmes and educational aspects, mentor peers and continue good research practices to guide overall development of the programs. Riana has an early childhood qualification and during the project she was studying towards a Diploma. She had been working in the centre for 1 year. Her role is to work collaboratively with Tamara.

Data-Gathering Procedure and Methods

Five main data collection approaches were used: digital video observations of the science walk, video and audio-recorded interviews, field notes, photographs and open-ended questionnaire. The data gathered that constituted the first author's PhD data set included video and audio-recorded interviews, field notes and open-ended questionnaire.

> *Digital video observations and science walk and interviews:* From the second author's ARC project of 74 h, a subset of 1 h of video data constituted the science walk and interview which was analysed for this paper. Teacher Tamara's science walk took 10 min and the interview took 14 min. Riana's science walk took 36 min. The science walk and

interviews were conducted during the second, third and fourth weeks according teacher convenience.

Science walk is a resourceful interview method for gathering data because in a science walk a teacher is literally taking a tour in the preschool centre to explain all the science affordances they could think about (Fleer et al. 2014). In a science walk, the researcher follows the participant educators and captures their live detailing of the science affordances through video recordings and photographs. A science walk gives a teacher the opportunity to indicate every detail of their teaching practice that may not be possible to be captured through a traditional instrument or a regular interview.

Photographs: 303 photographs of the preschool environment were taken during the data-gathering period that related to the environment discussed during the teacher's science walk. Representative photographs from the science walk are presented in the data analysis tables.

Field notes: 14.5 h of field notes taken by the first named author were gathered and analysed for this paper.

Open-ended questionnaire and interviews: The educators were provided with a questionnaire designed by the first named author in the first week of the project. Responses from the open-ended questionnaire and the video and audio-recorded interviews captured data regarding teacher qualifications, teachers' views on science, play and science learning, science in children's everyday life, examples of regular science activities (planned or otherwise), play and imagination, teacher's role during play with children and teacher philosophy (See Appendix 3 for example of the questions).

Teacher Tamara and Educator Riana participated in the video and audio-recorded interviews conducted by the first named author. Educator Tamara's video recorded interview lasted for about 16 min. Tamara participated in two voice-recorded follow-up interviews for about 36 min. Educator Riana's video recorded interview lasted 22 min. No follow-up interviews were undertaken for Riana as she left the project site later in the year. Rekha participated in a 7-min audio-recorded interview. The interviews for Tamara, Riana and Rekha totalled 1 h 21 min.

Analysis Process

Science walk video data were analysed following Hedegaard's (2008) three levels of analysis process. The interview data, questionnaire responses and field notes supported the science walk data and gave context to the analysis. We will now discuss the three levels of analysis of the science walk data.

Common sense analysis: This first level of analysis gives a general understanding of the participants' interactions. According to Hedegaard (2008, p. 58), "This kind of interpretation does not demand explicit concepts, but some obvious relations stand out and the patterns in interaction can be seen". In this study, the two educators separately participated in a science walk. At this level, we analyse the preschool educators' identification of science in the preschool environment. The analysis shows that Teacher Tamara and

Educator Riana had differences in their views of science affordances with only a few common aspects between them.

Situated practice interpretation: At this level of interpretation, the general practice of the participant in an institution is identified. Any conflict between different person's intentions and possible new areas of development can emerge in this level. Data analysis at this level shows how the preschool environment affords with science in everyday practice of the educators in creating learning opportunity for the children. Both educators reflect on indoor and outdoor affordances. We identified different patterns are emerging from the two educators' responses.

Thematic level: At this level of analysis, "interpretation is directly connected to the aim of the research. Explicit relations are formulated by using theoretical concepts to find patterns in the situated complexity of the institutional practice level interpretation" (Hedegaard 2008, p. 61). At this level of analysis, the two educators' responses were analysed in relation to the aim of the study—how do preschool educators conceptualise the preschool environment. Theoretical concepts used at this level were everyday and scientific concepts and social situation of development. The educators' interpretations of the environment in relation to science learning affordances were analysed. New conceptual relations were formulated at this level of analysis.

Findings

During the science walk, the educators were asked to identify what science learning affordances existed in the preschool environment. The three levels of analysis unfold a nuanced understanding of how these educators conceptualise the preschool environment for science learning possibilities. We found two contrasting views of how the educators conceptualised the environment—conceptually oriented sciencing and activity-oriented sciencing. Secondly, the same affordances were identified but with different learning possibilities. Thirdly, affordances with possible scientific concept development are in a complex relationship. The themes that emerged are discussed in turn.

Scientific Concept Development vs. Activity-Focused Perspective

It was found that Teacher Tamara and Educator Riana's responses show science learning affordances in the preschool environment in two very different ways. Firstly, Teacher Tamara identified the affordances from a scientific concept development perspective and Educator Riana's identification was activity-focused. Teacher Tamara identified the science at an everyday level of children's life and then she continued relating the experiences conceptually, further mentioning teacher interaction with children in preschools that could help develop the scientific meaning of the everyday science concepts. In contrast, Educator Riana related science in children's life as a set of activities at an individual level focusing on what comes from children's interest only. Her focus was sensory and on motor skills development but not as an explanation of conceptual formation of science. Below are some examples.

During the interview, Tamara mentioned: "Children can learn science in their everyday life. Science is everywhere. Children notice things that we know scientific that they don't realise and that's our role to teach them or to expose them to the science concepts behind what's happening throughout our lives". For example, "…with storms, lightning and thunder and things like that I think they are really fascinated by how and why it happens… they don't have the scientific concepts with them but they do know that if it's cloudy—it will rain, might thunder and storm and things like that. I guess in home in families… would teach them those types of concepts, the everyday is just an explanation I guess and then they can come in to kinder and we can teach them scientific concepts so they can make that connection". In the open-ended questionnaire, Teacher Tamara identified Science as "Experimenting, hypothesising, problem solving and understanding concepts". During the interview, Tamara mentioned that generally the children enjoy science experiments but that they do not always flow from children's everyday experiences. According Tamara, "It is a great way to start science experiences from children's everyday experiences on what they know and then introduce the science behind it".

During science walk, Teacher Tamara identified some features with science learning affordances in the preschool that the children encounter in their daily interaction, such as knowing about sound echo while using the hallway for group meal times. Standing on the hallway during science walk Teacher Tamara mentioned*, during lunchtime we talk about echo and how our noise from our voices bounces to the wall and makes it louder*. Children's awareness of everyday concepts associated with sound is evident because the younger children have their sleep time when the older children have their lunch in the hallway area. She also mentioned that the kitchen near the hallway area was used a lot for everyday cooking and baking experiences because they afforded science concepts like chemical reaction. Tamara continued walking into the staff room area and opened the freezer section in the refrigerator and said to the researcher, "We put ice trays up here to make ice, the children love to come in here and put the trays in here and come back after lunch time and find the ice and they play with the ice. This relates with melting and freezing concepts".

During the interview, Educator Riana also mentioned the everyday concept of sound. For example, "…they (children) see everything right from the start of the day to the end of the day, what is happening around, they listen to the sound around, they are able to identify what is this—sound of the animal or the sound of the tree or sound of the train which is quite very obvious specially here we listen a lot. The children are able to identify so there are a lot of things and examples". In the open-ended questionnaire, Riana identified Science as "A way of understanding the world around us, how these concepts work for example, concept of day and night. It is another good way of questioning, a lot of why questions. Why we have rainbow after rain, but not when cloudy or sunny?" Although having such understandings of everyday science in children's life, it was interesting to notice that during the science walk Riana identified most affordances as focusing on an activity and linked directly to sensory or motor skills development rather than science concepts. She mentioned, "There is a scientific concept, I have known in Jack and the Bean stalk corner, I haven't seen it yet in the children and nobody has told me, so I am just keeping my mouth closed, I am waiting for that one to come up because most of the children now know that the giant says 'fi fy fo fum I can smell the blood of an English man', but they really have not come across the concept of the smell. So there's a very big concept of smell in the story… this is one of the big concept of sensing of smell which is one of the main thing… but anyway, I mean you cannot give them the hint obviously, I would like the children to pick this up by themselves, not me giving or directing them, that there's another way of finding it out, I would like children to find it out themselves".

During the interview, Riana also mentioned the setting up of a sensory activity as a science activity, for example, "…corn starch and mixing them with water it feels gooey and foamy, using a sponge it does not get gooey in water—children may think why does it happen". Riana also identified other aspects in the outdoor and indoor environment such as water straws, taps, cubby house, couch, sand pit, mud pit, fruit and flower trees, play dough with no science concept development perspective but only describing from a set of activity perspective. For example, she said, "the jumping mat and the obstacle courses are very good, Nadia and I did some obstacle course setting out for the children. And we continued these activities… which was very good in making sure how much they can run, how much they can fly through the obstacles, are they really able to follow the pattern which was… based on all their ideas we created the obstacle course".

Detail identification of the affordances by the Teacher Tamara and Educator Riana is presented in Tables 1 and 2 of Appendix 4.

Same Affordances with Different Learning Possibilities

The second level of analysis showed that there was a pattern in the way both Teacher Tamara and Educator Riana identified scientific concepts in the same activity setting. For example, the vegetable garden and the insect table were the two areas of the environment that both Teacher Tamara and Educator Riana (Table 3 of Appendix 4) identified. Riana's emphasis on the vegetable garden was from a sensory feeling perspective. She mentioned that the children used herbs during their play. She mentioned that children usually pick rosemary from the garden when playing and notice the fragrance on her hands. In contrast, Tamara's sciencing emphasis for the same activity setting of the vegetable garden was focused on conceptual affordances of plant growth. Tamara mentioned that there were herbs and carrots in the garden. The children collected the baby carrots and made sushi with the carrots in the kitchen. Tamara said that from this gardening experience, the children were able to develop understandings about plant growth and what the plants need to grow.

A similar difference for identifying science learning affordance with the insect table was also evident. Educator Riana mentioned that the insect table was set up because "It has come up from an interest, that is, it comes from children because we have been reading information about dangerous creatures. So out of their curiosity and interest we set up this insect table". Riana focused on the children's interest but did not mention any science concepts. In contrast, Tamara's focus was on the development of scientific concept. Tamara mentioned, "At the moment the children are really interested in mini beasts, bugs and things. We have started to set this up in the environment. The interest comes from out in the garden. Children find bugs, snails or slugs…they catch them, look at them and inspect them… we usually put the bugs in jars so that they can have a look at it throughout the day…to have an experience (the indoor insect table) where they can play with the bugs, talk about their habitat or what they eat". Teacher Tamara explained the insect table in relation to science affordances. First, she identified insects at an everyday level where the children experience insects in their everyday life in the outdoor and then she explained the purpose of having an indoor play area set up for exploring and explaining insects to children from a conceptual level such as insect habitat and living.

Affordances with Possible Scientific Concept Development

In summary, Educator Riana mostly identified affordances in relation to a sensory or activity-focused perspective. However, we found that she mentioned some other affordances that could be linked to some scientific concepts, but she did not mention the scientific concepts explicitly. In Table 4 of Appendix 4, we identify the affordances with what might be the possible scientific concept development as mentioned by Educator Riana. For example, musical instruments were identified as affording high and low pitch as a sound experience. Lego blocks, magnetic connectors in the indoor area, ramp and large blocks in the outdoor area were mentioned as affording informal sciencing or incidental science learning. The ramp in the outdoor area was a constant area in the preschool that Educator Riana mentioned from an everyday perspective to roll or slide toys. She also mentioned the water straws in relation to developing problem solving skills that she thought was not directly a science experience but a possible science learning skill. It is important to note that she mentioned the imaginary corner created by the educators and children during the project as affording learning science concepts on plant growth during the project.

Data analysis and findings show that Teacher Tamara and Educator Riana experience the same preschool environment differently. The different relationship with the environment exists at two levels. Firstly, Teacher Tamara relates to the environment from a conceptual development perspective, which could suggest a conceptually oriented sciencing attitude. Educator Riana appears to primarily present an activity-oriented perspective, suggesting an activity-based sciencing attitude. Therefore, it can be argued that the two educators are interpreting the same environment from two different perspectives.

Reading the environment from the perspective of science *concepts or as science activities appeared to orient the educators in different ways, as the interview data also showed.* In "The problem of the environment", Vygotsky (1994) discussed that the relationship between the environment and the person is important for understanding development. He mentioned that people in the environment may experience the same environment differently when they have different levels of awareness of the environment and what meanings it holds for the person. Findings in the present study echo with this understanding, as we found that the same affordances were identified from a different perspective. Also, different affordances actually give different meaning and this describes the relationship between people and objects, materials or everyday phenomena perceived in different ways.

According to Vygotsky (1987), everyday concepts give practical meaning to abstract scientific concepts, and abstract concepts help name everyday practices—both are important and are interrelated. Findings from this study show that when the relationship to the environment is scientifically oriented as a concept-focused sciencing attitude, then both everyday and science concepts relevant to children's life were brought together as a science affordance. However, it was also found that when an activity-oriented approach to the environment featured, then only everyday explanations of the affordances were mentioned. Figure 1a, b below shows the dynamic relationship between environment and the person. Teacher Tamara's responses (Table 1 of Appendix 4) tell us that there are both everyday and scientific affordances in the environment. From cultural-historical theory, we know that everyday and scientific concepts are dialectically related and adults

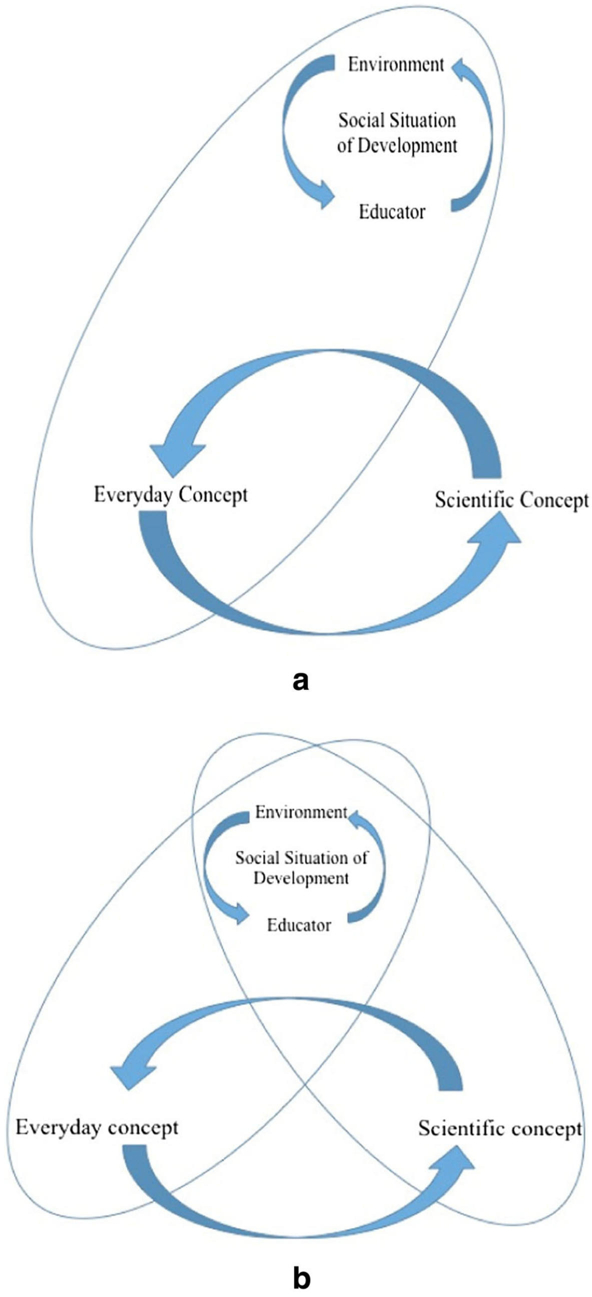

Fig. 1 **a** Scientific concepts are fragmented or left out in an activity-oriented sciencing. **b** Conceptually oriented sciencing relates the environment from both everyday and scientific perspective

play an important role in helping children to be oriented scientifically to their environment and through this to better understand scientific concepts.

In summary, when a teacher embraces conceptually oriented sciencing awareness, the concepts, environmental affordances and the person all interact in a dynamic way that we have captured in Fig. 1b. Data showed that affordances identified from an activity-oriented approach generally captured the everyday aspect of the affordances and are in contrast with less or no focus on the relationships to scientific concepts. This is represented in Fig. 1a.

Findings of the present study also reveal that there is a complexity in the relationship between the educators and the environment. In the interview data, the Teacher with a *conceptually oriented sciencing* perspective mentioned that during the research project the educators developed activities around the scientific concept of plant growth as part of their regular science experiment as well as a part of the research project. The everyday and scientific concepts were in constant interaction with the various planned activities. By bringing such awareness to the environment, the Teacher creates a social situation of development for learners. Although Educator Riana relates to the environment generally from an activity-oriented perspective, she also mentioned (Table 4 of Appendix 4) that the project imaginary play corner and the sound instruments afforded some science learning, such as teaching the concepts of plant growth and the concept of different sound pitch during the project. Therefore, during the project duration, the educators were aware of creating conditions and possibilities for the children. This indicates that during the duration of the project, the educators were interacting in relation to activities and concepts, which together raised the personal awareness of the educators to the affordances of their environment. This suggests that there are possibilities for the development of perspectives from an everyday to scientific concept level through how educators with different qualifications and understandings of science affordances can develop themselves through planning learning experiences together.

Discussion and Conclusion

In the context of an Australian curriculum landscape for the intentional teaching of concepts (Australian Government 2009), this study aimed to explore how the preschool environment is conceptualised by preschool educators to create conditions for teaching informal science. Two educators were interviewed in the same preschool context. Previous studies (Fleer et al. 2014) found that there are many opportunities available in the environment for everyday science learning beyond the formal, informal and incidental sciencing opportunities. More importantly, they found that sciencing attitude enables educators to use the preschool environment in diverse ways to teach science within any traditional infrastructure or incidental circumstances in everyday life including formal teaching of science.

The present study found that the two educators in the same environment perceive the environment differently because of their sciencing attitude. The two educators identified different aspects within the environment that held completely different affordances for the children's learning of science. One was in relation to science learning and concept development. This teacher showed a conceptually oriented sciencing attitude to both indoor and outdoor facilities and consistently took a science learning perspective. The other educator's identifications centred on activities with less focus on science or concept development. She primarily held an activity-based perspective. Previous studies have found that science teaching is very limited in preschools (Sundberg and Ottander 2013). In most cases, science learning is less focused and the activities centre mainly on physical or social skills development perspective (Sundberg and Ottander 2013). Findings from the present study suggest that this is an *activity-oriented sciencing attitude*. Similarly, the *conceptually oriented sciencing* attitude has not previously been highlighted in the literature. Participant educators in our study mention science is everywhere. However, the deeper exploration of their awareness about science in the environement revealed that the eduactor with a conceptually oriented sciencing attitude is also pedagogicaly aware of identifying science in the preschool environement. The educator with an activity-oriented sciencing attitude appears to have some understanding about science concepts in children’s everyday life; however, in terms of identifying the science affordances in the environment and bringing examples from her practice, the educator generally identified science within physical or sensory activites. Especially for early childhood settings, knowing the difference in this brings to pedagogical practice a more nuanced understanding of how the everyday educational context can bring about conceptual learning in science, and this awareness could support educators to be more confident in identifying the possibilities for teaching science to young children. This finding is consistent with studies that emphasise the importance of relating science to children’s everyday experiences (Roychudhury 2014; Siry 2014) and the need for building teacher content knowledge, confidence and competence for teaching science (Appleton 1992; Garbett 2003, 2007).

Earlier studies mention that having science infrastructure may give teachers more opportunity to teach science in preschools (Worth and Grollman 2003). However, studies found that despite having designated science corners or plenty of materials, there was scant science teaching happening in the preschools (e.g. Nayfeld et al. 2011; Tu 2006). Our findings show that regardless of the materials or equipment, it is rather significant how the environment/materials/equipment are conceptualised by the educators for teaching science. This matters, and this finding has not been previously reported in the literature.

We also found that Teacher Tamara identified less affordances but was more focused on concept development. On the other hand, Educator Riana identified many affordances but with a limited focus on conceptual development. In addition, we found that the two educators described the same activity settings and materials with these different affordances. Both these findings suggest that the kind of sciencing attitude a teacher possesses is rather important. These findings also contribute to the existing literature and foreground new thinking about how educators conceptualise the environment, and this may be a key contributor to understanding the teaching practices of science in preschools. These findings are also consistent with research that suggests preschool environments and the everyday phenomena could give content for teaching science (Eshach and Fried 2005; Roychudhury 2014; Siry and Kremer 2011). But it should be noted that our study was conducted in one preschool with two educators who participated in a science walk. As such, the findings are not representative of all childcare centres in Australia or elsewhere.

In summary, the present study found that the two educators conceptualise the environment from different perspectives. This tells us that the educators interact with the environment from the level of their awareness of science affordances for children’s conceptual learning in science. The finding of two educators identifying different affordances in the same environment may not seem significant. However, from a cultural-historical perspective, it can be argued that the findings support the view that scientific concepts are not developed in the person but are built in cultural and social practice. Therefore, it matters how educators conceptualise and draws upon the preschool infrastructure as part of interacting with children to afford science learning.

Our findings suggest that the science possibilities can intentionally be built in practices with any infrastructure. That is, the relationship between everyday and scientific concepts needs to unfold through the guidance of the educators who supports the linking between the everyday experience and the final form of the scientific concept. Conceptual development not only takes time but also a conscious awareness on the part of the child is needed to be able to think differently about an everyday situation and to think conceptually, using concepts to inform everyday practice (Vygotsky 1987). But to do this, the educator also needs to be aware of the possible scientific moments that everyday practice can afford for the child and to name these practices in ways that give new meaning for the child—as scientific meaning. In this way, young children will be able to build a conceptual relationship with their environment. Children with a conceptually oriented sciencing attitude are more likely to respond to their environment in scientific ways. Similarly, when the environment is interpreted from only an activity or sensory-based experiences, this can be limited because this orientation develops particular skills but does not fully accommodate conceptual development of science (Fleer & Pramling 2015). Our study offers insights into how teachers could deliberately draw upon the conceptual-contextual relationship and shows that teaching science in early childhood settings is much more complex than the literature has suggested. We suggest that it is simply not appropriate to demand that more intentional teaching takes place through curriculum initiatives. Rather, we argue that it is important to recognise that early childhood educators work in teams, where differing expertise is brought to bear on the interpretation of curriculum initiatives. The findings of our study therefore have implications for better understanding this context and for more appropriately identifying the professional support needs of preschool teachers. In this way, our study does add to the body of literature that blames early childhood educators for a lack of competence and confidence in science teaching. However, our findings give a new way of thinking about the special nature of the team context and the corresponding rich play-based preschool environment that affords different kinds of possibilities for the teaching of science in preschool settings.

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Appendix 1

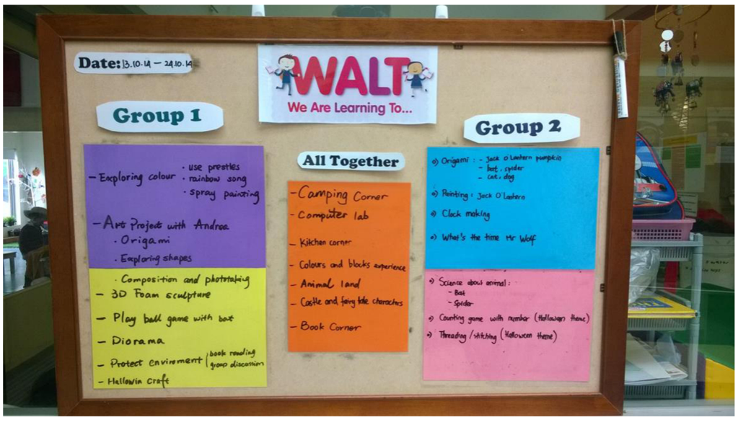
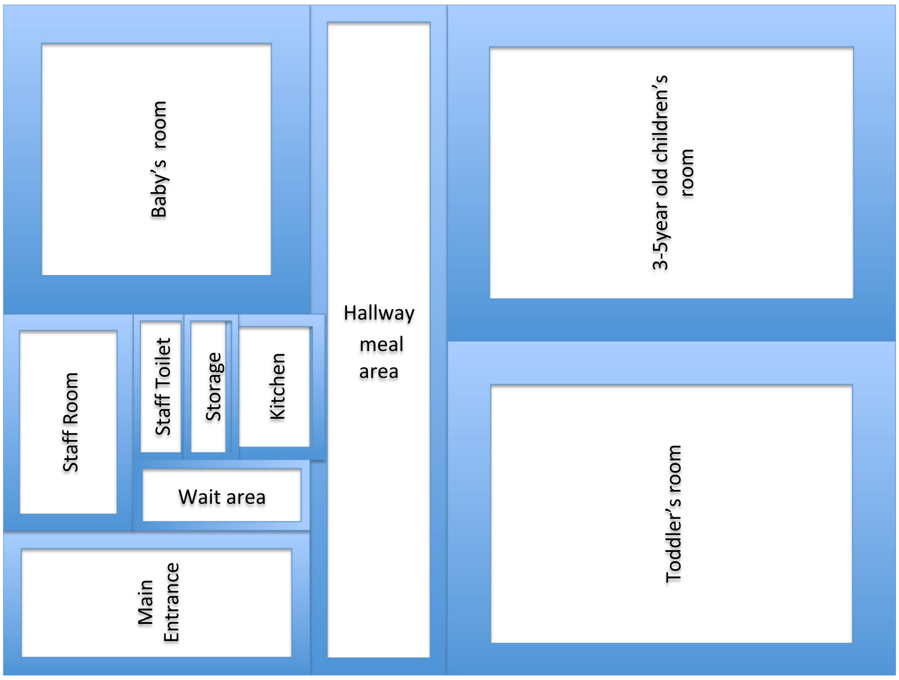
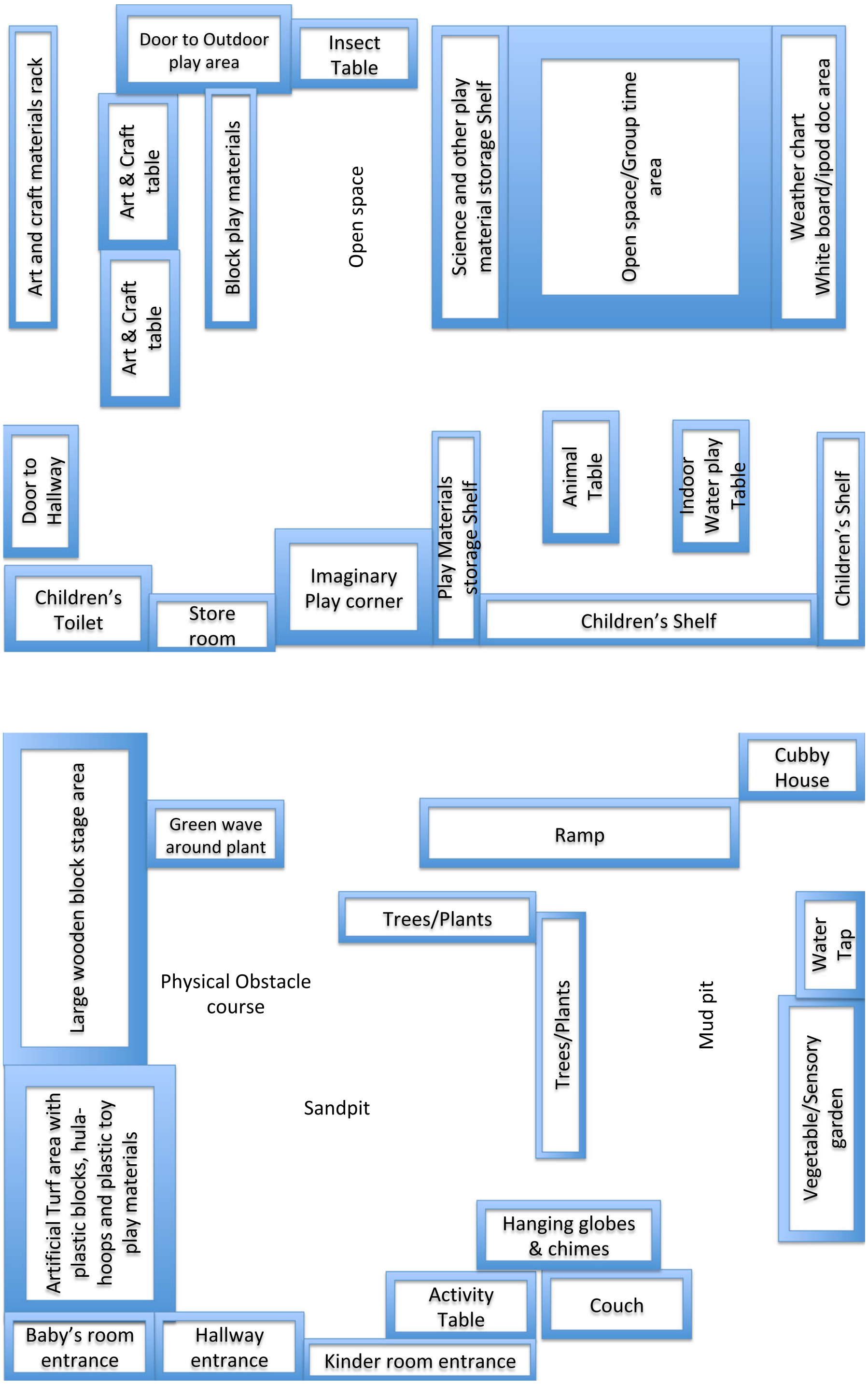


Fig. 2 Example of the preschool science activities as sits in fortnightly planning. WALT stands for "We Are Learning To". Children are split into two groups. Group 1 is the children going to school next year and group 2 are the younger children. There are experiences planned for each group as well as all together

Appendix 2





Art and craft materials rack
Door to Outdoor play area
Insect Table
Art & Craft table
Block play materials
Open space
Science and other play material storage Shelf
Open space/Group time area
Weather chart White board/ipod doc area
Art & Craft table
Door to Hallway
Play Materials storage Shelf
Animal Table
Indoor Water play Table
Children's Shelf
Imaginary Play corner
Children's Toilet
Store room
Children's Shelf
Cubby House
Large wooden block stage area
Green wave around plant
Ramp
Trees/Plants
Water Tap
Physical Obstacle course
Trees/Plants
Mud pit
Sandpit
Artificial Turf area with plastic blocks, hula-hoops and plastic toy play materials
Vegetable/Sensory garden
Hanging globes & chimes
Activity Table
Couch
Baby's room entrance
Hallway entrance
Kinder room entrance

Appendix 3

Science walk question

1. What science learning affordances can you identify in this preschool indoor and outdoor area?

Interview questions

1. Please tell me about yourself.

– Qualifications and teaching experience? How long have you been teaching in this centre?

2. What do you think about children's play and imagination?
3. What do you think about children's play and science in their everyday life?

Open-ended questionnaire science and play related questions

1. Please briefly describe what you understand by science.
2. Do you think young children experience science in their everyday life? Can you describe with an example?
3. Do you think children should be taught science concepts through play?
4. Do you do any science activity with preschool children? If yes, please give example of a recent planned science activity with preschool children.
5. Do you do any informal science activity with preschool children? If yes, please give an example of a recent informal science activity with preschool children.
6. Have you ever done any incidental/unplanned science activity with the preschool children? If yes, please give an example of a recent unplanned science activity with preschool children.

Appendix 4

Table 1 Scientific concept development affordances in everyday life

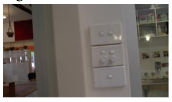
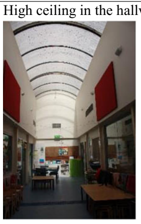
Teacher Tamara		
Sciencing from Teacher Tamara's perspective	**Everyday practice/ Teacher Tamara's science walk comments from video data)**	**Scientific concept mentioned by Teacher Tamara**
Light switches in the hall way 	Turning light switches on and off	Electricity
High ceiling in the hallway area 	During lunch time we talk about echo and how our noise from our voices bounces to the wall and makes it louder	Echo
In the kitchen baking and cooking 	We use the Kitchen a lot for cooking and things like that, I guess the chemical reaction is in baking and cooking and making things	Chemical reaction
Freezer in the staff room 	We bring the children in here and we put ice trays up here to make ice.	Melting and freezing
Blocks 	Play	Building and imagination.
Weather chart 	We have special cards that the children will have a look and look at the window and decide what the weather might be	Weather change, day concept

Table 1 (continued)

Animal table/plastic animals  	Some of the children have been to the zoo	Play using their imagination
Science & Technology folder  	Use the activities form the book for setting up Science experiments and keep children engaged	Weight and measurement, colours, absorption of different things, sinking and floating etc.

Table 2 Activity-focused affordances

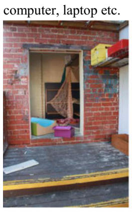
Educator Riana		
Sciencing from Educator Riana's perspective	**Video data** **Everyday practice/ Educator Riana's science walk**	**Scientific concept mentioned by Educator Riana**
Straws	Sometimes in summer we put those straws on the ground and get the children sit on the chair and put their feet inside them and feel cool and relaxed	Creates a relaxing atmosphere
Water trolly 	In winter because of rain they are not using them	Not mentioned
Water Taps 	To have access to water whenever they want, which is really good because to have water access always is good and handy as well.	-
Cubby House with Television, computer, laptop etc. 	Children use it as an imaginary space… You can't say it's not targeting on science, but you can say it is science in the way that wellbeing is looked after because this is something that comes as a natural way for them to have little room for them.	Wellbeing
Ropes, Hula-hoops 	Interesting and challenging things…some outdoor experience. I used them in a different way on the floor on circle to create a race to jump to the end.	Physical development activity
Green wave surroundings around the Plant 	Getting the children on walking on those…based on lot of gross and physical motor skills…move in circle to follow the pattern.	Motor-skills activity
mats and jumping mats, physical obstacles, ladders 	The jumping mat and the obstacle courses are very good, I and Nadia did some obstacle course setting out for the children. And we continued these activities…which was very good in making sure how much they can run, how much they can fly through the obstacles, are they really able to follow the pattern which was… based on all their ideas we created the obstacle course.	Physical development activity focus
Baby's toy basket	Music play	-
Activity table 	That table there, the purpose of that table is …most of the times we leave it empty, but whenever some activity is planned for outside, we usually get it outside. Like I used the leaves and other things in here. It's another feature of outdoor play. Because it's not only for one particular age group. When I did this activity, babies also did came and did some artwork.	-

Table 2 (continued)

Blue couch and book shelf 	Story time	
Sand play not only buckets and shovels but also pipes, kitchen area, constructions, dump trucks  	Self-explanatory but we have provided enough resources like pipes, kitchen cabinet etc.	-
Mud pit near sand pit Hanging globes & Chimes 	Close to the tap…Usually children bring a lot of water and use that place. When the sun shines they are attractive	
Picture drawing on the wall 	It's very catchy and the children identify the different creatures, the cat, the monkey etc. in it	-
Workman's place- a feature in the centre	Children are just fascinated by it, curious why the workman go up all the time?	-
Trees: Apple tree, Eucalyptus tree and Gumnuts, flower tree  	In summer time…growing time...children pick it (Apples) and eat it	-
	Children use them on sand play for making cakes, decoration	-
	Sometimes the boys ask me to pick them the flowers. They want to take them for their mom. And sometimes they make soup as well with the flowers and water.	-
Playdough 	Nothing much scientific	-

Table 3 Identifying different science learning affordances within the same content

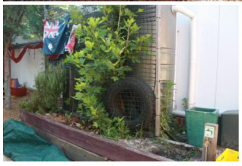
Sciencing from teacher's perspective	**Scientific concept**	
	Riana	**Tamara**
Vegetable and Herbs garden (Carrots, mint, rosemary)  	Sensory feeling (fragrances)	Plant growth
Insect table (mini beasts, and insects and bugs) 	No particular concepts mentioned	Habitat and food habit

Table 4 Affordances with possible scientific concept development

Sciencing from Educator Riana's perspective	**Scientific concept development possibilities**
	Riana's responses
Lego 	It has got lot of things if you see… because when they are doing constructing, they really realise the base has to be strong and if the base is strong, then the building or whatever they are constructing will survive.
Magnetic connectors	They are really very good. They accidently put this one in here (sticking it to the wall) and that's how they came with the learning that it connects, so they try to take this piece and lock it on the other places in the room, on the pillars to see where it attracts. This is always available… and they come up with different properties as well.
Musical/sound play instruments  	Concept of high and low pitch, sound, how the sound works, sound waves
Imaginary space created for the story, children's artwork on rainbow 	Science concepts during the broader research project
Ramp used for through to emergency exit 	It is very popular for toddlers putting their bikes, and other things. Even the other children they use their cars or other thing, they slide their toys or roll the balls…
Blocks	Blocks are very very popular…these construction box, they made spaceship with the blocks…they try to get the other resources and use their own imagination. …this is the spaceship and I think these ones over the top one over there are the controllers, these ones over there, the coloured one I think something to trigger the bullets or something like that
Water straws	A science experience- Connecting straws to make it as a pipe connecting with injection syringes to develop the keenness to know how the water flows in that pipe, where does it stop, what do you do to make it go in the trolley. Obviously you have to put more water to put more pressure more water with the help of the syringes. Even though it is not very directly targeted, they are all indirectly connected to the scientific concept. Not only providing with the experience of water and the play. It is not enough but some more activity on those lines as well.

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Affiliations

Judith Gomes[1] • Marilyn Fleer[2]

1 Faculty of Education, Monash University, Building A, Peninsula Campus, PO Box 527, Frankston, Victoria 3199, Australia

2 Foundation Chair of Early Childhood Education, Monash University, Peninsula, PO Box 527, Frankston, Victoria 3199, Australia

CHAPTER 7
Motive Orientation: Science Learning Possibilities at Home

7.1 Background of the Paper Three

This paper includes preschool children's home context and follows the previous paper in further exploring how parents as significant adults give meaning to science in the everyday life of preschool children and contribute to their motive orientation in science. A drawback to the literature (Chapter 2) shows that we know almost nothing about how children learn science in informal environments at home. Literature in this area is thin. Much more is needed to be known about children's informal home science experiences (Cumming, 2003) and about how parents' science understandings contribute to children's scientific concept formation (Fleer & Rillero, 1999). According to Hedegaard (2008a), to study child development, methodologically we can investigate the child's perspective through observing children in their everyday conditions and practice traditions across activity settings. This third paper uses the cultural-historical concept of motive orientation (Hedegaard, 2002, 2012a) and everyday concepts and scientific concepts (Vygotsky, 1987) to analyse a preschool child's everyday home science learning conditions and mother-child interaction. The study also sought the mother's perceptions about science learning possibilities for the preschool child in the everyday home environment. The findings suggest that the mother's intentional introduction of science aspects in everyday life could foster in the child a motive orientation towards science learning.

I solo authored this paper. The paper has been submitted to the *Early Child Development and Care* journal. The full paper is included in this chapter below.

7.2 Paper Three: A Parent's views on Science Learning in Everyday Family Life: Developing a Motive Orientation for Preschool Children

A parent’s views on science learning in everyday family life: Developing a motive orientation in science for preschool children

Journal:	*Early Child Development and Care*
Manuscript ID	Draft
Manuscript Type:	Original Article
Keywords:	early childhood science, parent’s belief, play, cultural-historical, everyday and scientific concepts, motive orientation

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A parent's views on science learning in everyday family life: Developing a motive orientation in science for preschool children

Abstract

What do families think is science for preschool children? Do parents believe children learn science in everyday life? What are parents' beliefs about the relations between play and science learning? Drawing upon cultural-historical concepts of everyday and scientific concepts (Vygotsky, 1987) and motive orientation (Hedegaard, 2002), this one-child case study examines a parent's understandings on science learning possibilities in everyday life and the family home conditions for the preschool child's development of a motive orientation in science. This study is part of a larger study exploring science-learning possibilities in preschool children's home and preschool environments. The larger study gathered data at home and preschool for two children including their parents and teachers. This paper reports video data from a home visit with Alisa (aged 4), field notes and parent interviews and questionnaire responses. The findings suggest that parents can use everyday moments to act as a stimulating motive (Hedegaard, 2002) and contribute towards a motive orientation for children's scientific concept formation. The study broadens our understanding of early years science learning and the process of concept formation in an everyday informal family home context.

Keywords: parent's belief; early childhood science; play; cultural-historical; everyday and scientific concepts, motive orientation

Introduction

This cultural historical study aims to explore the science learning possibilities in children's everyday family home context. A parent's perception about play and science learning is an integral part of this investigation. Although play is an area of interest for researchers for many past years; research on play and early years science education has gained increased attention over the past few decades (e.g., Fleer, 1995, 2009a, 2010). Most of the early childhood science education studies are available from formal preschool contexts (Baldwin, Adams, & Kelly, 2009; Bulunuz, 2013; Eberbach & Crowley, 2009; Goulart & Roth, 2010; Hadzigeorgiuo, 2001; Martins & Veiga, 2001; Rule, 2007; Sackes, Trundle, Bell, & O'Connell, 2011). These studies explore various areas in early years science, including: play and concept formation; emergent science curriculum and assessment; the significance of wonder; early intervention and science achievement in later years; developing children's observation skills from an everyday to a scientific level; and specific concept development using everyday objects. Traditionally studies in the vast literature available on concept formation have been set in formal teaching contexts that focus on children's ideas on particular science concepts, such as heat, electricity, light, magnetism. The 'interview-about-instances' (Osborne & Freyberg, 1985) was a commonly used approach in these studies that analysed the child's scientific understanding against the academic concepts. The broader social and natural everyday context was absent in such studies (Fleer & Robbins, 2003b).

In more recent studies, the child's social context and adult interactions with children for learning science concepts have been emphasized (Blake & Howitt, 2009; Crowley et al., 2001; Fleer, 2009b; Fleer & Robbins, 2003a; Robbins, 2005). Some attention has been paid to the value of visits to informal contexts like zoos, museums, and gardens in growing children's interest for learning science (Wigg, 1995; Zhai, 2012). Very few studies focussing on science have included the family home environment, everyday experiences and children's play. Some of these recent studies involved families from China (Hao & Fleer, 2016a, 2016b), Bangladeshi families from Australia and Singapore (Sikder & Fleer, 2015). Some studies involved informal community learning centers (Blake & Howitt, 2009), and others included both family home and preschool context (Coeiw & Ortel-Cass, 2011; Fleer, 1996; Gomes & Fleer, 2017). These studies bring new perspectives on the concept formation of children situated in their everyday context.

Research on play and human development has a long-standing history (Pellegrini, 2009). In the broader research context, cultural studies on children's play have found that understanding play is enhanced by knowing about community structure, parental beliefs about children's play, the socio-economic structure of the family and community, childbearing values in the community, everyday family and social activities, and family support for play materials (Gaskins, Haight, & Lancy, 2007; Göncü, 1999; Göncü, Jain, & Tuermer, 2007). Studies on play in children's learning and development in the family home and informal contexts have recently attracted increased attention in early childhood education (Mudiappa & Kluzniok, 2015).

Nevertheless, we know little about parents' perceptions regarding play and science learning in everyday contexts. This cultural historical study addresses this area. Vygotsky's conception of everyday and scientific concept (1987) and motives (Hedegaard, 2002) is used to analyse a parent's views about science in her child's everyday life. It is argued that knowing about whether or not parents' perceive science as important in everyday life for their children would help our understanding about the development of a motive orientation for science learning in the everyday informal context of young children.

Science learning in the family home

Science education researchers have recognised the value of and urgent need for contextual science learning. Eshach (2006) emphasised that science learning in context represents more significant learning than only knowing the factual science content. He argued that developing science skills like observation or problem solving is important for developing increased competency in science, however, mastering the skills alone does not indicate conceptual understandings of science. Importantly, drawing upon Nobel laureate physicist Richard Feynman's childhood stories, Eshach pointed out that parental involvement, intentional teaching and situating learning in children's everyday context are significant in helping children gain a better understanding of scientific concepts.

In 1995 Anne Wigg conducted a study on increasing pre-schoolers' knowledge and skills through hands-on activities. The author organised various science learning experiences in preschool—visiting museums, local parks and farms—and included families in the study. Wigg (1995) mentioned that there are many science possibilities in everyday life such as season change, weather watching, which parents could deliberately draw upon for introducing science to their young children. Wigg also found that parents who did not feel confident in discussing science with their children could have changed their views in a process of working together with the teachers. Although her study explored the science concepts in play-based settings, the activities were organised in accordance with a developmentally appropriate approach and play was not discussed in the study. Similarly, Alexander and Russo (2010) suggested that children's interest in science could begin with the everyday natural environment and families could become integral in this process. A few early studies also generally outlined some everyday science possibilities for preschool children through activities like cooking (Awbrey, 1989), playing with balls, swings and slides in the playground (Dreyer & Bryte, 1990), and exploring the natural environment (Galvin, 1994). These studies laid a foundation for identifying science learning possibilities in everyday life but did not go into depth by analysing motive orientation or concept formation or by including parents in the research.

More recently some studies began to analyse concept formation in greater depth.. These studies include play-based science-learning environments. Most of these studies are framed from a socio-cultural or cultural-historical perspective. For example, Coeiw and Ortel-Cass (2011) found that through visits to community places together with parents, using traditional cultural stories, and using multiple approaches like drawing, photographs and making clay models at preschool, children were able to develop increased cultural and scientific understandings about local forest animals. Blake and Howitt (2009) emphasise that adult interaction and guided play should be encouraged to extend children's scientific concept development. However, unfortunately some parents perceived science as a high school subject and saw preschool children as "too young to do science". Fleer (1996) found that when informed about children's preschool science experiences, parents could become more consciously involved with everyday science experiences with their children. Studies suggest that the relationship between home and preschool play creates a 'scientific motive' for children (Gomes & Fleer, 2017). Scientific motive explains the reciprocal relationship between home and preschool play. Their study (Gomes & Fleer, 2017) found that children were introduced the concept of earthquake in preschool and a scientific storyline was present in children's imaginary play at home. The findings show that parents at home supported their children with relevant toys and models that extended children's scientific play motive at home. Recent studies Hao and Fleer (2016a) found that parents who play with preschool children at home create a collective consciousness for learning earth and space science concepts. Such collective imaginary play contributes to science learning through the process of using everyday materials and objects found in the home, such as using a (round) watermelon to represent the Earth when role playing the concept of day and night.

Another study by Hao and Fleer (2016b) presented findings on children's scientific learning through pretend signs in everyday family imaginary play practice. Their study is grounded on the sign mediation principle of Vygotky's cultural-historical theory to explain a 3 year old Chinese boy's interaction with his parents during imaginary role play on the earth's rotation and rocket travel in space. The study findings show that in a collective family play parents' roles are significant. Parents can foster scientific learning through giving meaning to the child's imaginary play when they play together. In another study Hao and Fleer (2017) discussed Chinese children's learning motive development through imaginary play with parents in the family home. The study found the parents who value a learning motive for particular concepts—for example, counting or the earth's rotation—participate in role-play or imaginary play with their children and create the conditions for a learning motive. Their study concluded that the parents' role is important for creating a learning motive for their children during imaginary role play.

The literature review on learning in home contexts revealed that studies mostly used a socio-cultural or cultural historical approach emphasising the significance of the social situation, adult interaction and intentional teaching moments that can facilitate conceptual understanding for children. However, it is not clear what parents think constitutes science for young children in everyday contexts and in children's play. We do not know how the home environment affords science learning for young children in their everyday life.

Cultural-historical concepts used for data analysis

Drawing upon Vygotsky's cultural historical theory, this study used the concepts of motives (Hedegaard, 2002), and everyday and scientific concepts (Vygotsky, 1987) for analysing the data.

Motives: Motive orientation or motive development is a prerequisite for concept development (Hedegaard, 2002). "A person's motives develop through change in the dynamic of a person's social situation by participation in practice" (Hedegaard & Chaiklin, 2005, p. 64). Authors (Hedegaard, 2002; Hedegaard & Chaiklin, 2005) have discussed how motives can be formed from biological needs, where cultural ways of satisfying the need are often important. This means motives are culturally formed through human practices in different social institutions such as home, preschool or other institutions in which the person regularly participates (Chaiklin, 2012; Hedegaard, 2002, 2012). The child's surroundings can present possibilities for motive development through daily practices, culture and traditions. Therefore, the motive orientation can begin locally within the family. Often parents at home may create some conditions to attempt to teach everyday science to their children. Direct teaching of concepts is fruitless and family home contexts provide an informal

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Everyday and scientific concepts: While discussing the everyday concepts and scientific concept Vygotsky emphasises the importance of adults' support for children's concept formation. Vygotsky mentions that in the process of concept formation, there is a systematic relationship and cooperation between the adult and the child (Vygotsky, 1987). Everyday concepts can be experienced within any concrete everyday situation. About an everyday concept Vygotsky states, "it tends to move upwards toward abstraction and generalization" (Vygotsky, 1987, p. 168). Abstract scientific concepts are usually introduced in formal institutional contexts and children's learning is oriented with adult support at home or school. According to Vygotsky (1987, p. 168) the scientific concept "descends to the phenomena which the concept represents". Both everyday and scientific concepts are central for concept formation. The relationship between these concepts is described as the dialectic relationship where "The scientific concept blazes the trail for the everyday concept. … [Hence] it is a form of preparatory instruction which leads it to its development" (Vygotsky, 1987, p. 169). This cultural historical understanding of concept formation is used in this study for analysing children's science learning possibilities in the home context.

Research Questions

1. How does parents' knowledge about science contribute to children's learning in science in play-based settings?

2. What do parents think is science in the everyday life of their children?

3. What are parents' perceptions about learning science through play?

4. What science learning opportunities are available at home for preschool children?

Research design

Data reported in this paper form part of a larger project that set out to explore science-learning possibilities for preschool children at home and in preschool contexts. Two preschool children and their families participated in the larger study. This paper presents data gathered mainly from one child's family home context. Data from the other child's family were presented elsewhere (Gomes & Fleer, 2017). Following a wholeness approach (Hedegaard, 2008), this qualitative case study intends to explore everyday science moments at home that could contribute to children's scientific concept development. Parents' perceptions about science is considered important in this aspect, assuming their knowledge further contributes to possibilities for scientific concept development through play and everyday family practices for their children.

Participants

This paper presents data on family home visits to one preschool child, Alisa, in a southeast suburb in Melbourne. Alisa was a 4.1 year old girl at the time of the visit. Her father was Australian and her mother was of Canadian background. Alisa had a younger brother. Their family had recently moved to Australia. Alisa's mother participated in the study. She used to work at a university and specialised in health science.

Open-ended questionnaire and interviews

The participating family was provided with a short, open-ended questionnaire which was filled out by the mother. The questionnaire helped the researcher gather information on parents' perceptions about children's regular play practices at home, parents' perceptions about science, children's interest in science in everyday life, parents' intentional explanations of science concepts about everyday life experiences, and science learning possibilities in indoor and outdoor play experiences. The responses guided the later unstructured interviews with the mother during home visits. Interviews drew upon children's favourite play practices at home, play and imagination, preschool and home play experiences, play and everyday science experiences, and the role/s of parents during play. The interviews took place informally during the home visits and were audio or video recorded. Questionnaire and interview responses supported further analysis of the video recorded data.

Digital video observation

Two visits were made to Alisa's home at Alisa's and her mother's convenience. The first visit was made during afternoon leisure time (3.30pm-5.30pm) and the second visit during afternoon mealtime (3pm-5pm). All home visits were video recorded. Alisa's two home visits totalled 4 hours. A research assistant for filming accompanied the researcher while the researcher was busy interacting with the child or parent/s. The researcher entered the family home with the camera rolling. This was familiar to Alisa since she was the researcher had already followed and videoed the children in the preschool. The first home visit took place during the third week of the project. The follow up visit was made six months after the previous visit.

Field notes

Field notes were made after each home visit to record the details that could not be digitally recorded, for example, the researcher's personal reflection about the home observations in relation to the research questions and theoretical underpinnings of the research together with brief details of each of the observed activities.

Analysis and findings

This section presents data analysis and findings from the questionnaire response, interview, field notes and video recorded observations. Data and findings presented from Alisa's home visits reveal her mother's perceptions about science affordances in everyday life including play activities and Alisa's motive orientation towards participation in scientific concept development possibilities within everyday family practice.

Motive Orientation in everyday family practice and play

The first home visit was an introductory visit to become familiar with the family home. Before coming to their house the researcher had a brief discussion with the mother about the focus for the home visit. Below is an excerpt from researcher's field notes about the first home visit to Alisa:

On a Sunday afternoon I went to visit Alisa's house. Alisa's mother showed us all her (Alisa's) play stuff. They had made a cubby house out of carton boxes because they had many boxes since they had recently moved to this house. Alisa also has an art corner. She does a lot of artwork. Alisa's mother and father showed me her playroom.

There's a cubby house, Barbies and a lot of other play materials. Then we went to the backyard. I asked Alisa to show me her favourite toy. Her mother said "did you want to show your body parts book to Judith?" Alisa went inside and brought her favourite book on human body parts. She showed her favourite pages on the digestive system and talked about the digestive system. Then afterwards we went outside and walked towards the neighbourhood park. Alisa showed some climbing tricks, played hide and seek with her younger brother. (Field notes, 5May, first home visit)

The first home visit data shows Alisa's general play interests. Importantly, the excerpt shows that Alisa has a particular interest in human body parts. Her favourite book had images of human body parts from inside and outside. Alisa's mother told the researcher that Alisa was currently very interested in the human body. They discuss the digestive system. Alisa's mother's specialisation area is health science and Alisa gets to know a lot about human body functions from her mother. From the questionnaire response it was found that Alisa's mother often intentionally discusses science concepts with Alisa. She mentioned, "*We have a body book which talks about various bodily functions – why/how we breathe, circulation, reproduction. We had one when Alisa was younger and now bought her a more 'grown up one' as she is very interested in how the body works".* The mother also mentioned that Alisa asks many science related questions. For example, they were *"mostly related to how the body works. e.g., why do we get cavities? What happens to the food that we eat? We also talk about what food is good for our bodies and which food should only be an occasional treat".* During interview the mother gave another example about Alisa's curiosity about everyday science phenomena. The mother said, *"*for example *we come outside and there's condensation on the car, so she will ask me why is the car wet?"* This evidence of practice of the mother's awareness about science in everyday life for the child suggests a mother-child interaction on science can be part of everyday life (Vygotsky, 1987).

In the questionnaire regarding Alisa's regular play interests her mother mentioned drawing, building with blocks, pretend play with other objects, pretend play with costumes, play dough. She commented- "*the kids like to roll out the play dough and they have lots of different shapes to press into it. They like cutting it and making it into different forms; they like mixing colours to see how they change"*. Alisa's mother also thinks that through some indoor play like cooking and building structures with blocks children can learn chemical science and physical science concepts. Also through outdoor play like exploring for insects or tending to the plants children learn biology concepts. Overall, Alisa's mother perceived her play interests at home to include natural, chemical and biological science knowledge.

Everyday experience at home: Making muffins for afternoon tea

Video data from Alisa's second home visit includes a banana muffin making experience with her mother for the afternoon family meal. Below is a vignette from the second home visit.

I enter Alisa's house with the camera rolling. Her father opens the door. He leads us to the kitchen bench area where Alisa, her mother and the younger brother are busy making muffins. Alisa scoops some yoghurt into the flour in the muffin-mixing bowl. Then she pours some milk into the mixture and mixes it with a spoon. Her mother says, "So it becomes more liquid." Now the mother brings three frozen bananas and chocolate chips. Alisa is so excited. She says, "Can I peel the first one." Mother says "Ok, mummy will do the little one and you guys can take turns. "Ok?" Alisa repeats," Can I do the big one". The banana skin looks dark brown. Mother: "What *happened to the banana Alisa?" Alisa says, "They went into the fridge, they got all brown" she moves her hands and body and tilts her head while explaining. Mother to Alisa, "How come they are not frozen now?" (Pouring the rather soft banana—with Alisa— into the mixture). They mix all the ingredients together with a spoon. Alisa picks up a handheld mixer and wants to mix with that. She says it is the best thing to mix with and then keeps mixing the dough. Then the mother lets Alisa pour the muffin mixture into the baking tray. Mother says, "Don't fill it up to the top. What will happen if you fill it right to the very, very top?" Alisa, "Let's cook and see what happens." The mother reminds Alisa of the previous muffin making experience, saying that if they put it up to the top of the muffin holder, it will overflow. Alisa then expresses the change of size by widening her hands showing it becomes bigger and says it will become a round shape (moving her hands in a circular tumbling motion, blowing her cheeks full of air as if bursting).*

The vignette shows that Alisa's mother was guiding her purposefully through the steps of muffin making, where a major science learning possibility existed regarding the change of forms of the ingredients. At the beginning step the mother mentioned how the solid flour becomes somewhat liquid after pouring in the milk. Later Alisa's mother reminded her not to put the mixture up to the top of the baking cup. From her previous experience Alisa knew that the mixture changes its shape and size because of temperature so that they had to put the muffin mixture at a lower level into the baking cups. Alisa described the change of the dough through her body gesture. Alisa's participation in the muffin making activity was very spontaneous. She followed every step and willingly engaged with the muffin making process. This indicated her motive orientation to the activity and her gestures showed her understandings of the consequences evident in the process of the changes of the ingredients. The cultural-historical understanding of motive orientation allows us to interpret Alisa's spontaneous interest in this experience. Her interests help us to learn about her motive orientation for science related activities in everyday family practice.

In the questionnaire Alisa's mother mentioned that she thinks children can learn science in everyday life. She mentioned, "…for example often the kids will cook with me. They see how the dough changes when we make muffins (add water, etc.) and then how the form changes when it is baked." She also mentioned, "I sometimes explain things when we are cooking (in terms of how ingredients change the food) and often when we are reading the body book." At home Alisa also takes part in everyday activities with her mother taking care of their backyard garden. She showed the researcher how she waters the plans, trims them and that all entire she had learnt from her mother. She also showed the researcher her large collection of artwork. She made framed artwork with shells that they had collected from the sea beach. Alisa expresses her appreciation for aesthetics and beauty through her interest in artwork that she creates with her mother during leisure time. During the interview Alisa's mother mentioned that at home both the mother and father take part in imaginary role play with their children. For example, Alisa and her sibling arranged the chairs imagining Alisa was the captain of an aeroplane and the parents were the passengers. Alisa also took the role of serving food to the pretend passengers.

Findings and Discussion

The analysis shows that Alisa's mother used everyday moments as stimulating motives for creating conditions for teaching everyday science (Hedegaard, 2002). The mother is creating some conditions in the everyday social situation that change the everyday moment into a learning moment for the child. As such, everyday concepts can blaze the trail for scientific concepts (Vygotsky, 1987).

The findings show that children with parents at home participate in everyday practices that can lay possibilities for developing motives for scientific concepts. The questionnaire response shows that Alisa's mother thinks that children can learn science in play. The findings show that there are possibilities during everyday moments where simple everyday science concepts can be introduced. Certainly, the concept of *stimulating motive* (Hedegaard, 2002, p. 64) appears important for studying family practice and parental interaction with children, and to learn about children's motive orientation. Everyday meal preparation time can be a stimulating motive for introducing scientific concepts. Since motives are formed through the practice tradition and social situation of the institution (Hedegaard, 2002), parents play a significant role in this instance. Through deliberate support for their children to explore everyday science, the parents can create a social situation for their children to develop scientific concepts.

Discussing the process of language development, Vygotsky (1987) gave the example of children's oral and writing ability, contending that "when the child first learns a new word, the development of its meaning is not completed but has only begun" (p.170). Therefore, at the beginning it is understood more at an everyday level. While the child learns to write the word, each letter carries particular meaning, so that the child also moves towards developing a scientific concept about word meaning. Alisa's experience and interaction with her mother shows these are the beginnings of scientific concept formation. Parents can create the social situation where everyday and scientific concepts can become meaningful during everyday practice situations that they make available for their children. For instance, Alisa was able to connect to the scientific concept of muffins becoming bigger while the mixture was heated. The child's participation in reading books, baking activities with parents or noticing everyday phenomena with curiosity in the family home environment can be one micro moment among many hundreds of moments in a child's everyday life that can continue the motive orientation for developing a scientific motive (Gomes & Fleer, 2017). Moreover, the parents' intentional introduction of and overall understanding about science in everyday life stimulated the child's social situation for concept formation.

Although the study presents data on one child, the findings offer new understandings in relation to the process of children's motive orientation for scientific concept formation, and these address little explored matters in the existing early childhood science education area. The study is situated in everyday family practice for a preschool child, whereas earlier studies looked at motive orientation for toddlers in particular (Sikder, 2015) or analysed only play in family contexts (Hao & Fleer, 2016a, 2016b, 2017). Moreover, the present findings go beyond studies that have generally identified science learning possibilities in the everyday environment through some inquiry approach (e.g., Alexander & Russo, 2010; Dreyer & Bryte, 1990; Galvin, 1994). The study findings are based on everyday situations in a family home environment. The parent's perceptions and the family practice inform us about the family home affordances for science learning in a preschool child's everyday life. The findings on the parent's perceptions about science affordances during play moments are supported by cultural studies that suggest parental beliefs about children's play, everyday practice and play materials can bring important understandings about the social relations (Gaskins et al., 2007; Göncü, 1999; Göncü et al., 2007). Parents' intentional science pedagogy can be further explored in a broader sample to identify science-learning possibilities that can also include other informal contexts.

Conclusion

According to (Hedegaard, 2014, p. 6), “gradually though, a child through her upbringing moves from orienting herself in the concrete situation to also become oriented temporally to days, weeks and years ahead and to what is going on in other settings beyond the immediate situation in a specific activity setting in which her activities take place”. The present study gives some direction towards understanding the relationship between a parent’s perceptions and family pedagogy about science in natural everyday practice situations. The study found that adults’ purposeful introduction of their child to science in everyday life could lead to the continuation of children’s motive orientation towards learning science. Such motive orientation can therefore be further explored through children’s participation in different institutional practices—for example in preschool—for better understanding of child development and children’s scientific concept formation.

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CHAPTER 8
Scientific Motive Orientation Across Home and Preschool

8.1 Background of the Paper Four

Literature search (See Chapter 2) showed that studies combining both home and preschool environments are rare (e.g., Fleer (1996b). The previous paper explored a child's home experiences contributing towards science motive orientation. This paper takes a step ahead and includes both home and preschool environments as a child's everyday participating institutions. Following the child both at home and preschool gives a wider picture of their motive orientation. This study also captured the mother's perspective about science in the everyday life of the child. Vygotsky's cultural-historical concept of play (Vygotsky, 1966), everyday concepts and scientific concepts (Vygotsky, 1987) and motives (Hedegaard, 2002) were used to analyse the child's preschool play-based science experiences and informal home play experiences. The study finds that there is a reciprocal relationship between science learning possibilities across a child's everyday participating institutions. This relationship has been theorised by introducing the concept of *scientific motive* in this paper.

I co-authored this paper with my supervisor Professor Marilyn Fleer. As a first author I received the Australian Scholarships Grant (ASG) travel grant ($4000AUD) for nominating this paper.

The paper was first submitted to Research in Science Education (RISE) Journal on 1 April 2015 and received final acceptance on 28Feb 2017. The paper is available as Online First http://link.springer.com/article/10.1007/s11165-017-9631-5 and at http://rdcu.be/uxNx (Please copy-paste any of the URL on your browser).

The full paper is included in its published form below.

8.2 Paper Four: The Development of a *Scientific Motive*: How Preschool Science and Home Play Reciprocally Contribute to Science Learning

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The Development of a *Scientific Motive*: How Preschool Science and Home Play Reciprocally Contribute to Science Learning

Judith Gomes[1] **· Marilyn Fleer**[2]

Abstract There are a growing number of studies that have examined science learning for preschool children. Some research has looked into children's home experiences and some has focused on transition, practices, routines, and traditions in preschool contexts. However, little attention has been directed to the relationship between children's learning experiences at preschool and at home, and how this relationship can assist in the development of science concepts relevant to everyday life. In drawing upon Hedegaard's (*Learning and child development*, 2002) cultural-historical conception of motives and Vygotsky's (*The collected works of L.S. Vygotsky: problems of general psychology*, 1987) theory of everyday and scientific concept formation, the study reported in this paper examines one child, Jimmy (4.2 years), and his learning experiences at home and at preschool. Data gathering featured the video recording of 4 weeks of Jimmy's learning in play at home and at preschool (38.5 h), parent questionnaire and interviews, and researcher and family gathered video observations of home play with his parents (3.5 h). Findings show how a scientific motive develops through playful everyday learning moments at home and at preschool when scientific play narratives and resources are aligned. The study contributes to a more nuanced understanding of the science learning of young children and a conception of pedagogy that takes into account the reciprocity of home and school contexts for learning science.

Keywords Play · Concept formation · Science · Cultural-historical theory · Early childhood

✉ Judith Gomes
Judith.gomes@monash.edu

Marilyn Fleer
Marilyn.fleer@monash.edu

1 Faculty of Education, Monash University, Frankston, Victoria 3199, Australia

2 Foundation Chair of Early Childhood Education, Faculty of Education, Monash University, Frankston, Victoria 3199, Australia

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✉ Judith Gomes
Judith.gomes@monash.edu

Marilyn Fleer
Marilyn.fleer@monash.edu

[1] Faculty of Education, Monash University, Frankston, Victoria 3199, Australia

[2] Foundation Chair of Early Childhood Education, Faculty of Education, Monash University, Frankston, Victoria 3199, Australia

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Introduction

Constructivism Since the 1970's, science education research has centred on children's thinking about a range of science concepts and the conceptual change process during science teaching, although the former emerged from 1945 (Gunstone and White 2008). Through a review of 8400 studies, Duit (2009) examined the nature of research into children's scientific thinking and the theories used by researchers since 1903 (the earliest documented study). They found that most researchers drew upon alternative conceptions theory to name the practice of children holding particular ideas and non-scientific understandings of science concepts, but these researchers did not investigate the underlying social and cultural dimensions of how these ideas about concepts were formed at home or in preschool.

The large body of research on children's science or alternative views (Driver 1983; Osborne and Freyberg 1985) examined children's ideas about a range of concepts including light (e.g. Silfverberg 2006), electricity (Tsai et al. 2007), temperature (Appleton 1985), and weight (Galili 1995). Informed by constructivism, these studies concentrated on documenting the science concepts held by children, where the researchers focused on identifying concept formation as an end product. That is, they discussed what children know, rather than how they came to develop these scientific ideas. These studies represent children's individual thoughts on particular science concepts and give a basis for what is currently known about children's thinking. Constructivism has been a useful conceptual framework for determining, what Vygotsky (1987) has referenced as the product rather than the process of children's development. In the context of science, this means learning about the concept that a child knows (as the product) rather than the process by which the child has come to understand that concept. Critiques of constructivism have foregrounded how culturally and historically situated knowledge of concepts is absent from the study designs (O'Loughlin 1992).

Science as a cultural activity The studies undertaken since the 1970's appear not to have investigated children's learning outside of formal schooling, representing a serious omission in understanding how young children learn science as part of everyday cultural practices. Learning science as a cultural activity (Fleer and Pramling 2015) is evident in families and communities, as we might see when for example, people in rural Bangladesh (first author's home country) use clay jars to keep the water cool during summer. People in that community came to know that the microscopic pores in the clay jars accelerated the vaporisation process giving a cooling effect, thereby keeping the water inside the jars cooler for longer periods than metal jars. This is an example of culturally and historically situated knowledge.

Studying children under 5 years Studies on the development of children's scientific thinking under the age of five are also limited (Fleer 2009b), and even less is known about how scientific development is supported across the institution of the preschool and the home. There appears to be a genuine gap in the literature on the learning of science at home and in the context of learning science in preschool. The study reported in this paper seeks to fill this gap, but in ways that capture how culturally and historically situated knowledge across home and the preschool are made available to young children. What is missing from the broader literature, and particularly in the early childhood period, is a deeper and broader understanding of how children develop their scientific ideas about their world across home and preschool.

In drawing on cultural-historical theory, the study reported in this paper seeks to present a different way of conceptualising concept formation, because a cultural-historical study of science examines the process of development, rather than the product of that development. As such, the present study seeks to fill a gap in understanding by drawing upon cultural-historical theory to conceptualise concept formation of children aged 3 to 5 years. A small body of theoretical and empirical work has been directed to cultural-historical framework for science research, but more needs to be understood (Fleer 1991, 1995, 1999, 2007; Fleer and Beasley 1991; Fleer and Robbins 2003).

Theoretical Framework Informing the Study

This cultural-historical study was informed by Vygotsky's (1987) conception of everyday and scientific concept formation, a cultural-historical conception of play, and a cultural-historical conception of motives. These are discussed in turn.

Dialectical Relations Between Everyday and Scientific Concepts

Vygotsky (1987) argued that both everyday and scientific concepts are dialectically related and foundational for concept formation. Everyday concepts and scientific concepts support each other in the process of concept formation, which is different from Piagetian theorising of concept formation that tends to discuss everyday concepts as being replaced by scientific concepts—one replaces the other. In a dialectic process, one does not become the other, but rather there are two types of concepts (everyday concepts and scientific or academic concepts) interacting to develop a more robust understanding of the science being learned (for a model representation see Fleer et al. 2014). We need both concepts for the process of concept development. For example, in everyday life, a parent needs to cool down hot baby food. The parent could use various methods of cooling the food, for example, stir the food with a spoon, make a whirlpool by stirring, blow on to the spoon, or maybe lift a spoon of food into the air and bring it back to the bowl continually. All these methods cool down the food, which is an everyday concept and everyday practice of the parent. Thermal conductivity explains that stirring with a metal spoon would lower the temperature faster than using a plastic spoon, as metals are good conductors of heat. The stirring action is an everyday concept. Thermal conductivity is a scientific concept. According to Vygotsky (1987), the concrete experience of stirring to cool the food paves the way for the scientific concept of thermal conductivity. Similarly, the concept of thermal conductivity explains the concrete experience of stirring to cool the baby food. In this way, everyday concepts support the development of scientific concepts, and scientific concepts support understandings of everyday concepts. This dialectical relation underpins learning in science as theorised through cultural-historical theory. This dialectical relation theoretically frames this study of children learning science at home and at preschool.

A Cultural-Historical Conception of Play

Central to the preschool period and the pedagogical practices that are supported at home and in preschool is play. As theorised by Vygotsky (1966) and El'konin (2005), play is not just biologically determined, but rather it is a cultural activity. In play, children change the meaning of actions and object, giving the play a new sense and therefore ascribing new meaning to the objects and actions. For example, when children are in reality in a swimming pool, and they create the imaginary situation of pretending to be a fish swimming in a lake, they may change the meaning of leaves they see floating on the water, by pretending they are food for the fish to eat. The children bring to the imaginary situation, their life experiences of observing fish in the real world or virtually on TV or through the internet. Here, they explore life and living through play. Given that children's everyday experiences, interactions, rules in everyday life are embedded in play, then paying attention to children's play when studying how a child develops scientific concepts is important (Fleer and Pramling 2015, Fleer 2009a). Studying children's play gives insights into how they are making sense of their everyday world at home, and this opens up the possibility for studying a child's development of scientific concepts in both contexts of the preschool and home, where play is a valued family practice and underpins preschool play-based programs.

A Cultural-Historical Conception of Motives

While discussing play from a cultural-historical perspective, it becomes necessary to discuss the concept of motives in children's play. When children play with others, we observe a strong play motive (Fleer 2012). Studies on motivation/disposition in science learning are ample in the area of primary education (e.g. Milner et al. 2011), secondary education (e.g. Yen et al. 2011) and teacher education (e.g. Watters and Ginns 2000). However, it must be carefully noted that an understanding of a cultural-historical concept of motives should not be confused with studies that discuss motivation from a constructivist approach or as an intrinsic construct in science education. Chaiklin (2012, p. 209) discusses the cultural-historical conception of motives: He mentions, "motives is not located solely in a person, nor solely in a situation or condition external to a person. It describes a general relation which must be discovered analytically in the particular substantive relations in which persons are engaged".

A cultural-historical theorization suggests that a motive for play is developed through children's cultural and social engagement with others in everyday life (El'konin 2005). To understand what a child is doing while engaged in play, it is important to understand his or her perspectives in relation to the activities s/he participates in. The activity settings in everyday life are important to analyse because the development of the child's motives are supported through the institutional practices of home or preschool, and what is valued by the teacher or the family, and this creates the conditions for a child's development (Hedegaard 2012). Motives are culturally and socially determined (Hedegaard 2002). The various institutions that a child participates in, such as preschool or home, make a significant contribution in motive development. Family and preschool environment are our primary interest for the purpose of this study.

Attention has been directed to the importance of discussing the development of motives for understanding the development of children's play (Fleer 2012). Motives defined from a cultural-historical perspective are developed through participation in family, institutional and community activities, rather than as something that is biologically determined. However, there is some evidence that there exists a tension between the motive for learning and motive for play in some preschool contexts. For example, when an educator seeks to engage children in a perfume making activity using a mortar-and-pestle that is outside of the children's experience and interest, the children simply manipulate objects rather than engage the materials scientifically (Fleer 2012). It was shown that the educator did not frame the play materials within the children's real world experiences and as such the activity was limited and did not result in the development of a play motive for learning science. Therefore, to understand concept formation in science in the context of the development of motives may provide useful insights into the development of a *motive for learning science concepts*.

According to Hedegaard (2002), motives can also develop as a result of children moving across different institutions, such as the preschool or the home. When a child develops an interest in an area, such as science, through their day to day interactions at home where significant others explain what they see using science concepts, then these same children's experiences in their preschool environment will also change (Fleer 1996). The science based activities that a child experiences across the institutions of home and preschool can play an important role in children's motive development. How a child conceptualises an object or action and the corresponding conditions surrounding these will guide their motive development. This will in turn shape a child's future actions. This is known as a motive orientation (Hedegaard 2002). Analysing the relationships between the child, activities, practices, and traditions helps the researcher to understand the process of motive development.

In drawing upon cultural-historical theory, Hedegaard (2002) has theorised motives and has identified different kinds of motive orientations, such as dominant motives, meaning-giving motives, and stimulating motives.

- Dominant motives: According to Hedegaard (2002, p.63), "Dominant motives are associated with the types of activities that are central and important for a person's life". For example, play is the central activity for preschool children. Therefore, preschool child's activities are dominated by their play motive.
- Meaning-giving motives: Hedegaard (2002) suggests that dominant motives are always meaning-giving motives because they guide how a child attends to things or expresses her/himself in their everyday life. She emphasises that meaning-giving motives are necessary for self-expression. For example, when play is a dominant motive for a preschool child, they attend to objects and actions by using these objects in their play to create new meaning in imaginary situations. By conceptual play (Fleer 2011) or imaginary role play, a child is constantly in a state of practicing meaning-making motive.
- Stimulating motives: "Dominant motives can be used as a stimulating motive in a teaching situation to stimulate activities which in themselves are not at first motivating" (Hedegaard 2002, p.64). For example, children's stories, puppets, and poems may generally be used to please children. The same story or poem may also be used in a playful context where the purpose might be to introduce literacy, numeracy or a scientific concept. Dominant motives, such as a play motive, can be used by preschool educators to engage children in some activity they may not have interest in. Hedegaard has conceptualised this practice as a stimulating motive because it involves young children and gives some particular purpose for learning and development.

When the literature is considered together, it can be argued that the theoretical concept of motives will always be culturally shaped and that to understand how motives can act as opportunities for development, one must organise the study to "follow the child's actions in the same activity setting over time [and] to follow what leads the child's activities" (Hedegaard 2012, p. 23) so that we may be able to work out the child's intentions. There is a lack of research in science education that has focused on child's intentions and motives during everyday interactions and play across the institutions of home and preschool, and where there exist possibilities for children's concept formation in science. The present study seeks to fill this gap.

Research Questions

This qualitative case study investigated how children's play experiences at preschool and home foreground everyday concepts and gives meaning for the formation of scientific concepts. Specifically, the study sought to investigate:

1. How do children's scientific concepts develop across home and preschool?
2. How do playful contexts contribute to children's development of scientific concepts?

Study Design

The Context

Data reported in this paper draws upon a larger study linked to a study by the second named author. Data were collected at home and at a preschool. Thirty-six children participated in this study. This paper will focus on one child—Jimmy. Video observations were made of Jimmy's everyday interactions at home and in his preschool, which is located in a South Eastern suburb in a major city in South East Australia.

The preschool follows the Australian *Early Years Learning Framework* (Department of Education Employment and Workplace [DEEWR] 2009) as the main source for planning regular activities for children's learning and development. On average, 23 children attend each day in the kindergarten room. The age range for the children in the kindergarten room is 3.3 to 5.3 years. The average age is 4.2 and median is 4.1 years. A regular day for the kindergarten children could be described as following a morning circle to register attendance, morning tea, free play (indoor/outdoor according children's choice), lunch time, sleep time, afternoon tea, and free play. Every day, the kindergarten children participate in activities, such as physical, fine-motor skill play activities, artwork, and other activities associated with the early years learning framework.

Participants

Three preschool educators participated in this study. They were involved in the planning of the children's activities at different times during the data collection period.

The focus child Jimmy is Australian. He was 4.2 years old during the time of data collection. He comes to the preschool 3 days a week. One of the other days he participates in outdoor activities with his mother and younger sister. His mother is an academic in a university and his father works in industry. Both of the parents have a tertiary degree from a university.

Video Observations

Digital video observations were the main source of data gathering. The camera captured children's everyday experiences at home and preschool. In the overall study from the second named author, and the additional data gathered by the first name author, a total of 60 h of data were gathered using two cameras, and sometimes three. Data were collected for 4 weeks in the preschool. Three home visits were made to Jimmy's house as part of data collection for the first named author. The first visit was made on the third week of data gathering in order to note directly how preschool experiences might be influencing home play and vice versa. The second visit was made 6 months later in order to capture any persistent science learning or interests. A final home visit was made 13 months after the second home visit to further gather data on play. In the final visit, Jimmy and his mother were shown the previous video clips on planting activities in his preschool. They were also shown selected home play video clips from 3.5 h of home data that the parents and the researchers captured earlier. A video camera was left with the family to capture Jimmy's everyday play practices at home where possible. Still photographic images were also captured in the preschool and at home. Field notes were recorded to give context to all the video and photographic data gathered.

Interviews

The educators and Jimmy's mother were interviewed at different times during the data collection period in the context of video recording the everyday practices of Jimmy at home and in the preschool. Interview questions were informal and in relation to the context being filmed.

Open-Ended Questionnaire

A short open-ended questionnaire was provided to the participating educators and the families prior to the interviews. This questionnaire guided the researcher to understand the practices and activities related to science, and to gain deeper understanding about the educators' beliefs on science, teaching science through play, and the science learning opportunities that they believed they created for children. Jimmy's mother also completed a brief open-ended questionnaire about Jimmy's play interests at home and her views on science and play.

Procedure

The aim of the project was discussed with the teachers prior to commencing the research. Two professional development meetings were arranged for the staff interested to be involved in the project. In order to design the regular teaching activities around some science concepts the early childhood teachers chose to design and plan the activities based on the popular fairytale "Jack & the Beanstalk". The activities were planned and embedded in such a way by the educators so as not to interrupt the regular activities and routines that the children were familiar with in the centre. Some specific science concepts associated with the fairy tale such as sound, vibration, growth of plants, bread making were explored at different times. Sixteen sessions were filmed in the preschool of which 12 were morning sessions and 4 afternoon sessions.

Through the activities described in Table 1, the educators created the conditions for children's thinking in play in relation to the science concepts inherent in the chosen fairytale, so as to enhance imagination and make explicit a range of scientific concepts

In addition to the planned science experiences related to the fairy tale, the preschool teachers also promoted science learning in other contexts. For example, during the interview, the teacher, Dan, said that they did experiments on floating and sinking, and an experiment with bi-carb soda and vinegar to show the children how foam and gases are created during an earthquake. This was a planned fun activity for the children that grew out of the children's interest in volcanoes. In Australia, many early childhood teachers plan their programs around children's interests (Australian Government 2009). This activity took place a few months before the teachers introduced the fairytale of Jack and the bean stalk to the children.

Analysis

The data were organised into a series of video clips which were analysed using a three-level analysis framework (Hedegaard and Fleer 2008)—commonsense interpretation, situated practice interpretation, and thematic level interpretation. At the first level, Jimmy's participation in all the science related play activities were coded. At the second level of analysis, his interaction in relation to science concepts was noted. The institutional practices and the complexity of the interaction gave more meaning at this stage. At the third level, meaningful patterns were

Table 1 Planned teaching activities and scientific theme emerge in the preschool activities

	Rationale of the activities in relation to J&B fairy tale	Activities in relation to J&B story		Scientific concepts
Week 1	Creating a scientific theme in the centre (Siry and Kremer 2011)	• Morning circle—educators read out the J&B story • Children share best part of the story during group times • Children and educators collectively create a giant and a castle through art work representation, used recycled materials • Creating a scientific theme in the centre (Fig. 1) • Children and educators built an imaginary corner in the playroom. • Educators re-read the story to the children through a puppet show. Children take turns for role playing.		
Week 2	Beanstalk growing in a day (everyday concept)	• How do plants grow? • What do plants need to grow?	Planting beans, observing plants growing (Fig. 2)	Plant growth
	The giant wants to grind Jack's bones to make his bread (everyday concept)	What do we need to make bread?	Bread making experience.	Mixing ingredients, changing forms, yeast is a living agent, bread making
Week 3	The giant's steps make very loud sound on the ground	• Experiments on sound concept- for example, water filled up to different levels in five glasses and the children explored the difference in sound patterns; experimenting sound travel through wires connected to metal cans; experimenting sound travel by using coat-hangers and strings		Sound
Week 4	Plant growth concepts coming along together	Representing plant growth in storyboards using playdough (Fig. 3)		Plant growth

Fig. 1 Creating a scientific theme in the centre

identified in relation to the theoretical concepts and the aim of the study. The theoretical concept of motives featured at this stage of the analysis. However, motives as a concept cannot be used for analysis on its own, and it must be used in conjunction with other concepts, forming part of a system of concepts. The concepts used were a cultural-historical conception of play, everyday and scientific concept formation, and Hedegaard's theoretical model of institutional practices (home and school), societal values and traditions (e.g. valuing Western science learning), and the child's personal perspective. It is through the dialectical relations between everyday and scientific concepts examined during data analysis that we are able to gain insights into the development of Jimmy's scientific engagement with his world.

In addition, data were also collected for triangulation purposes (Merriam 2009), employing parent-teacher interviews, video observation, and field notes. The video data were also shown and discussed with the preschool educators and the focus child parents on separate occasions.

Findings and Discussion

Analysing home and preschool play: One of the aims of teaching science is to support children to develop understandings of concepts beyond the discipline of science and to make this learning relevant to their everyday experiences. This cultural-historical study sought to examine the process of concept formation not only in terms of the subject matter and what children bring into the preschool, but also to understand the process of development of the concept within the *dynamic relationship* of everyday life, practice and traditions of the formal

Fig. 2 Planting beans, observing plants growing

Fig. 3 Representing plant growth in storyboards using playdough

and informal life of the child. We sought to understand how subject matter knowledge of plant growth becomes personalised for the child—this means how the concept of growth becomes active for the child in their thinking and in the focus child's activities.

In this section, we present a summary of the outcomes of our analysis. We discuss four vignettes and relevant data taken from the home visits and the relevant preschool activities documented during the observation period. The first vignette presents data on the scientific themes that emerged in the preschool. The extracts of data capture examples of dominating and stimulating motives that appeared in the preschool activities. The later three vignettes present home data that shows the relationship between home and preschool science experiences. Together, these contexts and intentions begin to give insight into the development of scientific concepts associated with life and living, where growth is a central concept. Our study design allowed us to capture an analysis of the complexity between dominant motive (play is a dominant motive for a 4-year-old child), meaning-giving motive (imaginary play storylines on plant growth) and stimulating motive (playful conditions created at home and preschool on plant growth theme by the teacher or the parent) which together foregrounded an emerging scientific motive.

In the preschool—scientific themes emerge

Vignette 1: This vignette is an example of the interaction between the educator and the children exploring plant growth as an activity, and drawing upon the fairy tale narrative established in the preschool (1 May 2013).

Children are sitting outdoor with educator Dan. Dan has planned for a planting beans experience for the children.
Dan: Ok, what [was] happened when Jack got the magic beans? What happened with the magic bean?
Gem: His mum [throw] that outside.
Dan: His mum [throw] it outside...exactly…and then, when the mom throw it outside, the magic bean is falling to the ground (Dan is drawing images of the beans on a paper). And then what happened on the next day?
Jimmy: It was raining…
Dan: It was raining…
Jimmy: and then it [growed] up to a bean stalk (stood up from his chair. Showing the length high above with his hands).
Dan continuing his drawings.
Dan: It was raining, and then [at] the next day, the bean grow really really high to the sky.
Jimmy: It was a beanstalk.
Dan: Yes, then… what else do we need to make the bean grow?

Melissa: sun
Dan: Sun! Well done Melissa…yes…lucky that we have sun today (pointing to the sun towards the sky). We need sunlight (drawing a sun in the paper. Dan is showing his drawing to the children). So we need rain or water, we need sunlight and we need beans and we need the soil. To make a bean grow.

In this vignette, Educator Dan is unpacking plant growth by linking it to the fairy tale and to the children's everyday experience.

Later, in the unit on fairytales, the educators not only told and re-told the story, but they also followed up the storytelling with a series of science related experiences, including a puppet show, role play, and growing beans (see Table 1). As part of investigating plant growth, the teacher asked the children to represent their ideas of plant growth through a range of mediums. The children used playdough and made models on how beans grow with the help of sunlight and water. These play experiences integrate the children's dominant motive for play, stimulating motive for bean growth by the educators, and the establishment of a meaning-giving motive as shown in Table 2.

In these playful experiences, a scientific narrative (Siry and Kremer 2011) appears in the teaching and learning program in the preschool. A pattern in the science learning activities was observed. Through these experiences, Jimmy becomes engaged in developing a scientific narrative during play and becomes oriented towards science concepts.

In addition to the vignette from preschool above, the following observation from the home context further supports this idea.

At home—scientific themes are enacted through imaginary play

Vignette 2: This vignette below shows how the play objects at Jimmy's home continues his motive orientation towards play in relation to the science experiences in his preschool.

First Home Visit, 18 May 2013, 9:53am
Jimmy decides to show his Lego to the researcher as this is his favourite play object. Jimmy starts creating something. As his play progresses, Jimmy builds a narrative of a firefighter using the ladder, a storyline which he adopted from the Jack and the beanstalk fairytale (i.e. the ladder reflected for him the climbing of the beanstalk).
Judith: What are you going to make? (Jimmy is silent and concentrating on building. He builds something vertical- joining some Lego on horizontal and vertical positions. Most pieces are green while some are blue, red, orange and yellow as well.)
Judith: What's that?
Jimmy: beanstalk.
Mother: A beanstalk… I have read him the 'Jack and the beanstalk'. Do you wanna tell the story, Jimmy?
Jimmy concentrates on building. His mother mentions Jimmy had brought the beanstalk at home that he planted at the preschool, it grew nice and afterwards it died…
He holds the Lego beanstalk on top of a green Lego bin and joins it to the rubbish truck.
Jimmy: Beanstalk in the gardening bin. Beanstalk in the gardening bin… It's gonna go in the rubbish truck. We have a Lego rubbish truck.
His play continues as the gardening rubbish is put in the dumping area.
Judith: Is your beanstalk dead? (Pointing to the beanstalk in the dumping area)
Jimmy: The beanstalk is going down when it is in the dump.
Judith: Is it going to grow in the dump you think?
Jimmy: It won't grow.

Table 2 Data analysis—*scientific motive* develops over time

Concepts	Science in the fairy tale and relevant play activities in preschool	Play at home	Categories	Interpretation	
Dominating motive	Planting beans experience with educator, group time discussion and sharing the best part of the story, enacting puppet show.	Lego play storyline: Firefighter climbing up the ladder, earthquake demolishes the beanstalk, garbage collector collects the beanstalk and takes away into the recycling field.	Institutional practice	Play is the central activity as observed in case of Jimmy across home and preschool. Relevant science concepts from the fairy tale are enacted in play. Puppet show enacted by the educators on the J& B story. Jimmy takes imaginary roles in the puppet show. Fairy tale theme on beanstalk emerge in his play at home.	Common sense interpreta-tion
Meaning-giving motive		Jimmy creates own storyline around beanstalk.	Interaction and relationship-child- object relationship	Meaning making of the objects are enacted through telling and re-telling of the story through various play episodes.	Situated practice interpreta-tion
Stimulating motive, *Everyday and scientific concepts*	Educator creates a playful environment together with the children. The Educator asks questions on what do plants need to grow. Children become curious, they want to know how long it takes to come out the stalk from the 'magic beans'. Educator asks the children, how high does	At home parents discussed about the jack and the bean stalk story. They provided the child with additional science experiences such as biological and earth science books, playdough kit, and models.	Child-educator, Child-parent interaction	The children's imagination of plant growth is aligned to the story. Such as, plants grow in a day, they grow up to sky high. The educators' questioning creates curiosity and consciousness between the everyday and scientific concepts of plant growth. All these are happening among the	Situated practice interpreta-tion

Table 2 (continued)

Concepts	Science in the fairy tale and relevant play activities in preschool	Play at home	Categories	Interpretation	
	the beanstalk grow?			children in a common shared space.	
Scientific motive, *scientific concepts*	Particularly science topics are enacted through play.	An imaginary storyline is created in home play. Preschool themed play on plant growth and previous play experiences on earthquake are combined in the imaginary play. A complex combination of everyday experiences and science appear in the storyline.	Interaction, practice	Through role play, representation of plant growth on storyboard and imaginary play, a scientific narrative of plant growth is built in the preschool by the educators. The children are collectively investigating plant growth being part of the scientific narrative. The plant growth theme is carried through Jimmy's home play. Concept of plant growth becomes conscious to children through these collective experiences.	Thematic interpretation

In the above episode, Jimmy is involved in imaginary play where he is changing the meaning of objects (Vygotsky 1966), where the Lego brick becomes the growing beanstalk. A meaning-giving motive is observed here in Jimmy's home play (Hedegaard 2002). This play is relevant to his everyday play experiences in the preschool context and his home experiences about gardening. During the second home visit, his mother mentioned that Jimmy was most interested in gardening. His mother thinks this is because of the bean planting experience Jimmy had in his preschool.

Jimmy's mother thinks he does not experience science in a technical way in play (questionnaire data). This was further investigated during the final home visit. It was noted in the home observations that his family provides him with a range of resources, artefacts, books (on science facts such as volcano model), and Lego pieces. It was found that Jimmy's family practice contributes to his science learning motive at home. Vignette 3 below details a video observation that was recorded by Jimmy's mother. This vignette outlines an example of how Jimmy's family practice contributes towards his development of scientific concepts.

Vignette 3: Jimmy's mother bought a new playdough kit for him. Jimmy is using the playdough kit on a playdough table to make something with light blue coloured playdough. He says to his mother he is making petrol for the car from playdough. He tried but could not use the equipment properly at the beginning. His mother then showed him how to put the playdough inside the machine and to press it to get the shapes of playdough he wants. He was able to make some round shaped petrol. After this he says now he is making some snakes from playdough. These were thin and long shaped. Later he starts making a banana for the snakes. He said to his mother that he thinks snakes eat banana. (Home camera video data. This was captured by Jimmy's mother on 27 May, 2013).
Mother: Jimmy, do you want to tell me what are you making?
Jimmy: Banana
………
……………
Mother: Why do you think that the playdough comes out when you push that in the bottom?
Jimmy: mmm….because that's how you do it!
Mother: Aw…
Jimmy continues pressing the playdough from the top of the banana making equipment.
Mother: Can you make other things in the same process?

In this vignette, Jimmy's mother is attempting to unfold some everyday science that Jimmy experiences in his play while manipulating the objects. We consider this vignette as an example of the interaction and the role the mother takes during play. In this interaction, we observe that the mother is deliberately attempting to make Jimmy conscious of the push/press effect. The dominant motive for play, as was noted in the Lego play, is enacted in Jimmy's home play. The mother attempts to focus on Force in the playdough example, and this acts as a stimulating motive for thinking scientifically during imaginary play (Hedegaard 2002).

In Vignette 4, a more nuanced understanding about Jimmy's imaginary play is shown. The play collectively builds upon his preschool science experiences and the family practice of the scientific affordances they create for him through various artefacts. In this study, it was found that one of the major activities the children did in the preschool that featured science was volcano experiments. The teacher Dan made a volcano with vinegar and bi-carb soda with the children to explore eruption. It was observed that the preschool experiences on volcano experiment and the science activities generated from the science themes taken from fairytale laid a scientific narrative in Jimmy's home play.

Vignette 4: Second Home Visit, 22 November 2013, 10:53am
Jimmy is showing his volcano book to the researcher.
Jimmy: This is the picture of the volcano. Volcanoes are closer to earthquake but they are not closer to tsunami.
Judith: What is earthquake?
Jimmy: Well, if there's a earthquake under the water, then there will be tsunami, and the tsunami could push over big heavy ship and the ships that are not heavy.
Jimmy pointing to a picture in his book: earthquake, this earthquake was very dangerous that it crack opened one house...

Later, Jimmy in his play room with his Lego blocks on the floor. He puts four Lego blocks parallel to each other. He pulls out a beanstalk shaped Lego and places them on top of the Lego placed parallel earlier.
Jimmy: This Lego beanstalk in here, so it can be turned into ground, happening shaking.
Jimmy quickly picks up the Lego elephant, collides the elephant to the 'ground' piece of Lego and makes an 'aweee….' sound to imagine the underground collision. The Lego pieces scatter apart.
Jimmy: That's what earthquake is turned like.
He picks up a Lego man, places on a Lego block and in similar way, clashes the two to show a collision.
Jimmy: And then if a people standing in the earthquake, then they fall in the hole, very very deep hole.

Jimmy discusses the facts about the volcano and the tsunami with the researcher, explaining key concepts from his volcano book that his mother bought him. Moreover, his imaginary play follows a storyline where he again brings the beanstalk into the narrative. He is imagining an earthquake scenario where a collision happens as the beanstalk and other living things scatter apart down the earth hole. This imaginary play presents an earthquake as a natural scientific phenomenon that crushes plants and animals. Such understanding is beyond the everyday concepts mentioned in the fairytale, where the everyday concept was that the beanstalk was demolished when the giant climbed down the beanstalk. Dominant motive, stimulating motive and meaning-giving motive are all in play in this example of Jimmy's home play. These interactions are creating a new form of motive orientation, where a scientific aspect is present. Figure 4a–f presents the moments of Jimmy's imaginary play and science learning affordances at home.

During the final interview (11 February, 2015), Jimmy's mother mentioned that "Jimmy's play interests have moved to creating and constructing things. He takes his own initiative to do this". In the questionnaire, his mother mentioned that they do not explain scientific concepts with their child "mainly because they (the child) do not ask too many 'science-like' questions at age four and most parents would not know how to answer many real science questions

a. Explaining earthquake with model and book
b. Lego beanstalk
c. Earthquake model with Lego pieces
d. Home play with playdough kit
e. Human body book
f. Lego models constructed by Jimmy

Fig. 4 **a**–**f** Home play affordances with science learning opportunities properly". About everyday science and play his mother thinks, "science is not in his play specifically, but he brings it in his play. Such as if this is a train" (showing a Lego train model made by Jimmy) "and he has worked out how to make it move…he is using the principles in his construction" (interview data, 11 February 2015). We identified this in the video observations as well. Jimmy showed a lot of complex models, such as Star Wars, trains, and fire truck models to us, and explained how they work using these models. Jimmy's mother also mentioned that in everyday science, he always gives an explanation or shares a story about his constructions/models.

Scientific Motive Develops over Time

This study captured the many forms of children's thinking in different contexts over time. Table 2 presents an overview of the findings where we show a motive orientation to science through the everyday practices in which Jimmy participates in. The concept of plant growth appears to be central in Jimmy's home and preschool play episodes as illustrated in the examples introduced above. Science learning possibilities in play appear to be present in his family home too. Hedegaard and Chaiklin (2005 p. 35) mentions, to understand concept development, "Vygotsky emphasised the inseparability of forms of thinking from the content of thinking". The inseparable nature of thinking and actions are appropriated in Jimmy's play in relation to science concepts, but more as a motive for science than explicit teaching of science content. The objects, meaning making of objects, culturally constructed play opportunities by using fairytale, and family support play, all represent valued cultural forms of activity found in this study. In Table 2, we present how the educators in their planned teaching experiences in the preschool used the dominant motive of *play*. A science narrative was being built through both the activities and the storytelling. The meaning-giving motive, as afforded through the objects and through the role playing acts, were evident in both the institutions of the home and preschool. In Jimmy's imaginary play, meaning-giving motives for science learning were being appropriated at home and in the preschool.

In Jimmy's play, the storylines appear as enacted collective experiences that appear to strengthen his imagination. The play also seems to structure his knowledge about concepts that were at an everyday level. The play themes were shown to move back and forth between the institutions (home and preschool), and this created the holistic conditions that helped us to formulate our understandings of the emerging scientific concepts being explored by Jimmy. We observed how Jimmy changed the meaning of the objects to give them a new sense (Vygotsky 1966). The role, rules, actions, and how the objects are given new meaning in play emerged in our study. The experiences taking place in different institutions are not discrete; rather they are all tied together, happening at different times and over many days.

Jimmy's play episodes demonstrate that through the experiences, actions and interactions Jimmy is moving towards a scientific orientation on the subject matter of science, (for example on plant growth, earthquake). Some of the concepts are borrowed from the fairytale narrative introduced by the educators in the preschool and used in his home play activities. The educators identified some everyday concepts in the fairytale on plant growth through the planned conceptual play (Fleer 2010) activities (see Table 1). In the preschool Jimmy appeared to develop an understanding that plants need sunlight, water, and air to grow. He also came to know that plants are living things and they die at some point. From his everyday experiences, he knew that garden litter needs to be collected by the rubbish collectors, and plants do not grow once they die. He has some knowledge about natural disasters, for example that earthquakes destroy living things and plants on earth. In the observations of Jimmy's imaginary play at home, we can see he turns the meaning of the Lego objects into plant growth, and we also see everyday life characters in his imaginary play being aligned with the fairytale. Vygotsky's (1966) theorising on play and learning and the concept of meaning-giving motive conceptualised by Hedegaard (2002) helps us to understand the complexity of Jimmy's play and to understand the development of a *scientific motive* through his play across different contexts.

Therefore, we found in our study of Jimmy's life at home and in preschool (and as illustrated through examples in this paper) that children's everyday concepts about a science phenomenon become structured when the appropriation in thinking takes place in a social institution. We bring together the findings of this study by introducing a model to illustrate a preschool child's *scientific motive* development (Fig. 5).

The model is an illustration of our understanding of the relationship that the play experiences provided within the home and preschool support the development of a *science motive*. The underlying aim of the preschool educators is to foster a learning motive for scientific concepts (institutional practice). The child's dominant motive for play is used by the educators to plan conceptual play (Fleer 2011). The small arrow connecting play and conceptual play represents the relationship in different forms of play across the institutions. Different forms of motives are present in children's play. Interest and engagement in learning science concepts, which we have named as a *scientific motive*, appear in children's play. The small arrow in the right hand of the model represents the relationship between a scientific motive and concept formation. This concept of a *scientific motive* has not been reported previously in the literature. A *scientific motive* goes beyond explaining just a moment in a child's development, but explains the relationship across institutional practice and the relationships over time where an interest in learning science develops. Vygotsky (1987) has mainly described the mechanism of developing scientific concepts in the context of formal schooling. Less is known in relation to informal context, such as the home environment and preschools.

This study draws attention to the relationship between preschool and home contexts to explain the possibilities for children's concept formation in science. Through introducing the

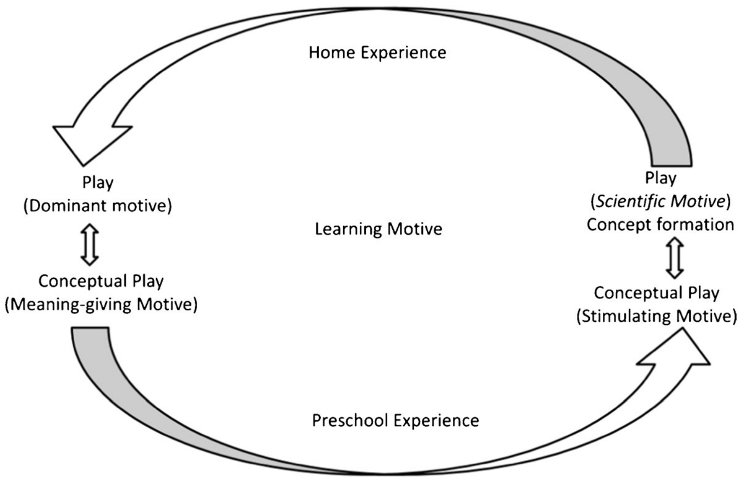

Fig. 5 Different motive forms are present in play. A *scientific motive* emerges in play and supports concept formation

idea of a *scientific motive* for supporting science learning in the preschool period, we can better understand how children develop science narratives in their play and become actively oriented towards science learning.

Introducing the Idea of a Scientific Motive into the Literature

The findings show that there is progress in the process of scientific concept formation in the case of Jimmy's everyday play practices. The fairy tale provides various everyday moments for engaging with concepts of plant growth and demolition. His creative storylines as revealed through his imaginary play are relevant to his real life contexts where the meaning-giving motive has given a new sense to the play objects that surround him, and which together provides the scope for a new form of motive development.

Hedegaard (2002) mentions a person does not enter into an activity with a motive but it is through interactions and the social situations that are created though the activity that motives are formed, which eventually contributes to personal development. She highlights how "motives are a result of taking part in activities that the child has felt positive" about (p. 61). With this conception of motives for examining the data, we find the *scientific motive* helpful for articulating a motive orientation that transcends the relationship across the preschool and the home. The *scientific motive* names the sustained interest shown by some children across institutions as they actively play with concepts through their play materials. As discussed by Hedegaard and Fleer (2008), identifying the core relations between the practices and the product of the concepts (e.g. artefacts/models created through changing meaning of objects) helps us to produce new knowledge within a problem area. By analysing the relationship and interactions between the concepts and everyday practice and activities, such as children's play, we identify how the leading motive for play develops and expands into a *scientific motive*. The deliberate planned teaching around scientific concepts has created a sustained common theme in the preschool that has been reflected in Jimmy's home play that has been observed over time. His other play episodes and family practice show that science is embedded in his play all the time. We identify some contradictions and some deep relations within the child's everyday activities and the adult interactions that is supporting a back and forth development of a *scientific motive*. The home play and preschool play are supporting each other. They are often contradictory as parents do not realise children can experience science in play, but educators are trying to create scientific play. The dialectic relationships are therefore found within adult support, and between institutions within various play experiences. We identify that

1. *The play practices vary across home and preschool*. Through planned activities the preschool educators can create the conditions through play for illuminating children's everyday concepts and fostering scientific concepts.
2. *Parents often do not have an understanding of how children can learn science in play*. However, the home play experiences, and the family practices have rich possibilities that together with the preschool science activities can contribute developing a *scientific motive*.

Hargraves (2014) discusses the development of working theory held by children through the support of the educator. We argue that looking at only the process of developing working theories is not sufficient when discussing child development, especially in the context of science concept formation. Our research has shown that it is important to look at the range of possibilities and pedagogical support for children's scientific concept development, as well as innovative pedagogical strategies which may create a stimulating motive for science play and learning. In addition, our study has shown that the home and preschool play episodes came together allowing through our study design the possibility of capturing a holistic picture of concept development for Jimmy.

Earlier studies (Fleer 1999) have found that follow-up discussions with children provide a context for children to ask interesting scientific questions. Our study showed that not only were discussions with Jimmy important, but also it was important to gain parents' input and this was created through inviting both Jimmy and his family to share with the first named researcher the relevant artefacts, materials and other important family practices that they felt sustained or engaged Jimmy in science learning. Similarly, we see this in Siry and Kremer's (2011) study, where they showed how children's interest in science can be a strong support for the development of the preschool curriculum. The findings from our study show how a child's creative use of play materials for explaining a natural science phenomenon, and his involvement in a planned science unit, can together support the development of a scientific motive.

Often, it is difficult for children to create models or represent complex science ideas, as the study of Siry and Kremer's (2011) showed, where they found that when teacher Isabella tried to create real rainbow it was difficult for the children. However, when they were able to simultaneously create and explain sustained thinking on making a rainbow in the preschool this resulted in success. In our study, Jimmy's play episodes present a similar picture. Jimmy explains and at the same time creates a model of an earthquake, which has been possible because of the continuity of pedagogy in the preschool and the support from his parents through extending his interests at home. Siry and Kremer (2011) note how children deal with an abstract concept that they come across in their everyday life. In our study, Jimmy explains his concept of earthquake from his interaction with his peers, parents, teacher, and books. Also, his earthquake model shows how his collective experiences in science in preschool impacted on his conceptions about abstract science phenomena.

The long time frame of the study is an advantage for understanding children's concept formation. Additionally, the home and formal context gives better scope for analysing data from a holistic view. In the preschool, the role play with puppets and other planned activities around the fairytale of Jack and the bean stalk was significant for creating the conditions for a scientific motive. The intended goal of the educators was to trigger the interest for learning the science aspects of the story by the children. The dominant motive for play by the children was used by the teachers for stimulating a scientific motive. Through this, the teachers were able to orient children towards learning science concepts.

Conclusion

In this study, the combined preschool and home practices have shown evidence of creating the conditions for the possibilities of developing motives for science learning through play in the early years. The cultural-historical analysis extends our understanding of the nature of children's play and motives where the everyday concepts and scientific concepts have possibilities of being interlaced together. The theoretical model explains the process of development of scientific motive.

Findings from this study contribute to the broad literature in science education that has become increasingly concerned with student interest, attitude, and engagement in science (Tytler and Osborne 2012). It is well documented in the science education literature that one of the reasons disengagement in science occurs is because academic science concepts are not taught in relation to everyday science concepts. Our study identified that a scientific motive develops through a process whereby everyday and scientific concepts both give meaning to each other and contribute to developing scientific understanding. Our study emphasises the findings of Fleer (2012) who showed that pedagogy without a scientific motive orientation is less likely to develop a scientific motive for young children.

In this paper, we did not have scope to discuss deeply the educator's philosophical understandings in relation to the social situations and conditions created for learning science for the children. A separate study is needed for that. Also, the findings reveal that family pedagogy for science learning and play in an everyday context is an area we need to know more about. There are significant others in a child's life, such as grandparents or siblings, who might make valuable contributions to developing a scientific motive. Identifying the role of the significant others for developing scientific motives across different cultural contexts could also contribute to advancing understandings of how a scientific motive develops.

Though the study is limited to a one single-case design, the overall study design and findings of this study suggest the possibilities for developing a *scientific motive* by preschool children. The findings suggest that there is scope for developing new forms of play for supporting concept formation of preschool children. This in turn can lead to better support for children with the formal learning of science. Overall, the findings provide us with evidence of child development and learning of science in play. The findings of this study provides evidence for the development of a *scientific motive*, where enhancing children's interest in science learning from an early age is possible.

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CHAPTER 9

9.1 Background

This chapter includes a brief review of literature on science and emotions. The chapter draw attention to the emotional aspects of science learning that was the main focus of the broader ARC study. It builds on the findings of papers 4-7. The research questions that guided the PhD and ARC studies for this Chapter are:

- How do home and preschool everyday environments contribute in children's scientific concept formation possibilities? (PhD)
- What is the nature of relationship between emotion and scientific concept development in children's imaginary play? (ARC)

Over the course of the papers included in this thesis, the relationship between emotion and scientific concept development process (the main focus of the broader ARC study) also became important to this PhD study in relation to children's everyday science experiences.

The findings of this chapter were presented as a paper at the 5th International ISCAR Congress (International Society for Cultural-Historical Activity Research) from 28 August – 1 September 2017 in Quebec, Canada.

9.2 [*]Science Learning in Play-Based Settings - Introducing the Analytical Concept of a *Scientific Perezhivanie*

Introduction

Research in early year science learning is increasing paying attention to the social and material relationships in which young children develop scientific understandings. The strengths of a socio-cultural or cultural-historical perspective in science education research have been discussed by Roth (2012); Roth, Lee, and Hsu (2009) and (Fleer, 2009a). The authors argue that the dialectic relationships between cognition-emotion; everyday and scientific; and social-individual as a theoretical framing gives newer understandings for studying the problems faced in science education. Increasingly early years science learning research is drawing upon cultural-historical theory focusing on examining children's play and the dialectical relations between everyday and scientific concept in preschool or informal contexts (e.g., Fleer, 2009b; Howitt, Upson, & Lewis, 2011; Siry & Kremer, 2011). An important aspect between the child and their environment is the child's emotional engagement in the learning experiences of everyday life. General studies on affect use terms like emotion, emotional state, joy, wonder, interest, attitude, moods (Reiss, 2005). In this cultural historical study, we drew upon Vygotsky (1994) concept of perezhivanie to discuss the emotional engagement of children in everyday science learning experiences. Perezhivanie is a Russian word that has been translated in many different ways because there is no exact English word to give its original meaning - the closest of which is emotional experiences. Veresov (2015) mentions "*perezhivanie* is not a term or a definition of certain emotional state of

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an individual; it is a theoretical *concept* which should be *understood (p.1).”* Ferholt (2010) describes perezhivanie as a phenomenon. Therefore, perezhivanie as a concept and phenomenon are both integral to each other (Veresov & Fleer, 2016).

Vygotsky theorises human development as being studied from a wholeness approach where emotions are intertwined as part of the course of a child’s development (Vygotsky, 1994). He argued that the Cartesian philosophy of mind and body as separate entities are incomplete in describing development, since human development is a continuous process that is constantly in motion as a moving system of personal and collective experiences observed on a social plane. While introducing the concept perezhivanie, Vygotsky mentions that affect and intellect are inseparable. This means cognition and emotion has a special relationship to each other. According Monk (2017), perezhivanie as a concept “unifies emotion and cognition, and the individual with their environment, in a single unit to better conceptualise the process of human mental development (p. 19).” It is this holistic approach of Vygotsky’s, that we draw upon when studying the relationship between emotion and scientific concept development in children’s’ everyday life.

Vygotsky initiated a method where child psychology should be studied in relation to social interactions. This is why he argued that development cannot be just age based. Vygotsky opposed the ‘botanic nature’ as core go studying human psychological development and preferred to discuss the ‘cultural child’ (Vygotsky & Luria, 1994). Vygotsky noted that traditional studies did not advance child development. Rather, he suggested that the relationships that a child has with their environment becomes a major source of development, and as such, research should seek to capture the holistic system of relationships that bring about conceptual development of the child (Vygotsky, 1994).

Studies in early childhood science education also emphasise the importance of a relationship between the child and the environment (Eshach & Fried, 2005). In a previous study, we have found that educators who have a science concept focused orientation when interacting with children are aware of the affordances of the possible scientific concepts in their everyday environment. They draw upon these to build a scientific relationship between the child and their environment (Gomes & Fleer, 2018). Such awareness is beyond engaging children in simply 'developmentally appropriate' science activities, but rather begins to take into account children's wonder, curiosity and imagination as it relates directly to their everyday world. But this relationship is not yet fully understood.

Recently, more attention has been centered on achieving cognitive outcomes in science, yet researchers appear to have put less emphasis on the associated emotional nature of learning (Brennan, 2014). Some empirical studies draw upon perezhivanie when researching in early childhood, but these are primarily focused on children's emotion regulation (Chen, 2015, 2017), social competence (Hammer, 2017), emotional imagination and anticipation in science learning (March & Fleer, 2017) and emotional imagination and scientific playworlds (Fleer, 2017a). These studies are important, but more needs to be known. Based on the second-named author's ARC study on the emotional nature of science learning in early childhood, and the first-named author's PhD study on science learning possibilities in everyday life, this paper focuses on children's play-based everyday experiences that supports scientific concept development. As part of the second-named author's ARC study the teachers in the preschool created a scope for imaginary play environment based on a fairy-tale. Analysing the emotional engagement and everyday experiences of the first-named author's PhD focus child Alisa potentially gives us deeper understandings of how children develop scientific concepts in the early years in emotionally charged everyday moments. Using the concept of perezhivanie our paper aims to examine this affective dimension of learning science concepts in everyday life and to theorise the outcomes from a cultural-historical perspective.

To achieve this aim, we begin this paper with a discussion of the relevant literature on science and emotions followed by the theoretical concepts that guides the study design and analysis. Finally, we report upon the findings and theorise the outcomes introducing a new concept *scientific perzhivanie* that helps to analyse the special affective dimensions of learning scientific concepts in everyday environment that appears to be unique to young children because of their developmental orientation to imaginative play. This new concept will further help understand scientific concept formation process for young children.

Science and emotions

In his paper 'the importance of affect in science education', Michael Reiss (2005) mentions, "science education has traditionally paid little attention to the emotions…" because a general view is "… the objectivity of science somehow requires that science and the emotions operates in separate worlds; that emotions can safely be left to those who teach the arts and humanities (p. 17)." Therefore, researchers argue that such general views are incompatible because in any scientific investigation scientists' enthusiasm, passion, and imagination, involve emotional engagement (Fleer, 2014; Reiss, 2005). Although there is an ample amount of studies on what children know in science, researchers argue that emotions in science learning has not received the same attention (Alsop & Watts, 2003; King, Ritchie, Sandhu, & Henderson, 2015). Some studies have found that emotion has a significant role in science learning (Roth, 2012; Zembylas, 2005). Adams and March (2014) discussed discourse in science classroom and perezhivanie. These studies are mostly conducted in primary and secondary classroom context.

Recent studies exploring emotions include areas such as – teacher emotions at both in-service and pre-service teacher education context to develop understanding on teacher professional development (Bellocchi, Mills, & Ritchie, 2015; Bellocchi, Ritchie, Tobin, Sandhu, & Sandhu, 2013), classroom emotional climate, student mental state on learning science concepts (Liu, Hou, Chiu, & Treagust, 2014), emotional experiences of pre-service teachers in online learning (Bellocchi et al., 2015), type of activities that evoke positive emotions in science (King et al., 2015), science teacher's views on teaching emotional issues in science (Zembylas, 2004). In their study, Liu et al. (2014) emphasise that it is significant for educators to know about the affective state of learners for teaching science concepts. Alberto Bellocchi and his colleagues (2015) investigated emotions based on interactional theory for enhancing social bonds between the teacher educator and learners in an online pre-service teacher education context. In another study Bellocchi and Ritchie (2015) studied the emotions of pride and triumph of seventh grade learners for learning the concept of transfer and transformation of heat energy. The authors discuss surprise as a positive emotion for the learners in the process of the development of the concept of energy. Their study fills a gap in the literature by researching the emotions of pride and triumph and discussing the emotional changes in the cognition of the concepts.

Neuroscientists have studied relations between cognition and emotion widely. However, understanding about the cultural-historical relationship between emotions in everyday context for science learning remains low. Researchers like Wolf-Michael Roth (2008) emphasise that research needs to shed more light in the area of emotion and cognition that Vygotsky sketched in his theory of child development. In their study, Wolf-Michael Roth and Alfredo Jornet (2013) explain that emotional dimensions are integral to intellectual aspects for learning science. In some recent studies, attention to emotional qualities such as wonder, curiosity in early years science pedagogy has been emphasised. Hadzigeorgiuo (2012) discusses a sense of wonder as significant for science teaching and learning. The author explains that a sense of wonder combines both emotional and cognitive dimensions. He suggests aesthetic and emotional dimensions such as surprise, astonishment with awareness of the scientific phenomenon as the cognitive dimension are characteristics of the emotional quality of wonder. In their study, Hadzigeorgiuo (2001) and Siry and Kremer (2011) discuss the significance of using wonder and curiosity as a pedagogical approach for teaching science in preschools. Hadzigeorgiuo (2001) therefore argues that a pedagogy is needed that will drive children into developing an attitude towards science that is important for developing children's conceptual knowledge. Recent research emphasises that to move beyond the traditional science teaching approaches, we need imaginative approaches (e.g., art, drama, storytelling) for effective teaching and learning of science (Hadzigeorgiuo, 2016) and new ways of conceptualising science-learning models in the early years (Fleer, 2017a).

We now look at studies relating children's play and emotions available in the area of science learning.

Imaginary play, emotion and science learning

A number of studies suggest play-based settings for teaching science in the early years (e.g.,Howitt et al., 2011). Longstanding studies in science education have discussed the role of play for developing science process skills, such as problem solving, fluency, flexibility (Severeide & Pizzini, 1984). Also, there are studies that discuss different kinds of play-based activities that could engage adults and children in informal context (Hobbs, 2015). However, these studies do not go further analysing children's play in relation to scientific concept development. It is recently that researchers focus on analysing different dimensions of children's play such as adult position in children's play, imagination, role play that gives deeper understanding of play pedagogy for supporting science learning (Fleer, 2009a, 2009b, 2010, 2011).

Children's play has been indicated significant for science learning not only in early childhood, but also in secondary school. For example, in their study Andree and Lager-Nyqvist (2013) observed secondary students engaged in spontaneous informal play in a science classroom. The study found that imaginary play emerges as an integral aspect in science lesson. The pivots for the imaginary play that students use are the real objects used for the science investigations. Such play involves the students in science for positioning them as scientists and helps explore the norms and values in science. The study also suggests that imaginary play in early years has possibilities for furthering student engagement and valuing science in formal schooling.

Imagination acts like a bridge between play and concept development (Fleer, 2011). We found some preschool science studies that explore imaginative play in different cultural contexts situated in formal and informal settings. Emotions appear as a significant aspect in these studies (e.g., Fleer, Adams, Gunstone, & Hao, 2016). Studies that come from family home context inform us that adult involvement in play at family homes can support imagination and science learning. For instance, Hao and Fleer (2016) found that parents that play with preschool children at home create a collective consciousness for learning earth and space science concepts. Such collective imaginary play contributes to science learning through the process of using everyday materials and objects found in the home, such as using a watermelon to represent the Earth for role playing the concept of day and night. Fleer et al. (2016) explored science learning for preschool children among an expatriate African Dinka community in Australia. In Dinka community there is no word for explaining the abstract science phenomenon such as gravity. Therefore, a worldview elaboration was occurring while the participants were encountering such western science concepts. The study also found that in an informal play context, parents and children were able to communicate abstract science concepts since the play involved emotional exchange of feelings like laughter and fun. Participants had a conscious feeling of the abstract concepts in such emotionally framed play environment.

Along with the aspects of play and imagination, storytelling are argued useful pedagogical tool for teaching science concepts and creating a space for catering affective qualities such as wonder, imagination and creativity (Anastasiou, Kostaras, Kyritsis, & Kostaras, 2015). Some characteristics of fairy-tale discussed by Elkoninova (2002) appear central for describing children's emotional engagement and learning. Characteristics of a fairy tale such as, misfortune or a tension in the life of the main character or others that the main character tries or take initiative to solve. Secondly, some incredible problem situation that the main character tries to take initiative of creates an emotional tension. Third, a separate world different from the real world and problems can be solved only in some magical way between these two worlds through some trials and finally the main character succeeding to overcome the misfortune with a happy ending of the story. Another important aspect of fairy tales is *time.* The time in a story differs from the time in real life and everything in a story happens very rapidly. Children often engage emotionally, feel and imitate the main character of the story that unfolds their emotional relationship to the story or the character (Elkoninova, 2002). Such characteristics are found relevant discussing children's emotional engagement in a fairy-tale based science pedagogy context. It was found that children draw upon science concepts during role-playing the fairy-tale characters. As such, fairy-tale as a cultural and pedagogical tool enables foregrounding children's emotions and their understanding of science and technology concepts (Fleer, 2013; Fleer & Pramling, 2015). Dualism of emotion and flickering between imaginary and real world, the play for the scientific and technology problem solving were observed in children's further developed role-play. Given the fairy tale as a pedagogical tool, such emotional imagining of solving a scientific and technology problem during role-play is explained as affective scientific imagination (Fleer, 2013). More recently, a scientific playworld pedagogy has been introduced as a model for teaching science concepts to young children (Fleer, 2017b). Playworld is a play-based model where the educator and children work collaboratively to build a scientific narrative in their everyday play practices. In a scientific playworld educators use cultural tools such as folk stories, fairy tales or some technological tools that emotionally engages and creates a learning space for children.

The existing literature contribute in our understandings that studies on emotions have an important role for science teacher education, primary grades and secondary science classroom context, it appears we know less about the cultural-historical relationship between emotions and scientific concept formation for preschool children. Overall, there is a gap in applying the concept of perezhivanie for better understanding of the relationship between person and environment in the process of scientific concept formation in children's everyday life. This cultural-historical framed study fills this gap in early childhood science education.

Theoretical concepts

Over the past two decades, a cultural-historical framework for studying child development is emerging as a strong theoretical orientation (Fleer, 1995). For discussing emotional engagement of preschool children in everyday context and develop our understanding about scientific concept development this study draws upon the cultural-historical concepts of play, everyday and scientific concept formation and perezhivanie. These concepts are discussed below.

Cultural-historical understanding of play

Vygotsky's play theory suggests a strong connection between children's everyday life and imagination. According Vygotsky (1966), "Play is not the predominant type of activity at preschool age…play is the source of development…action in the imaginative sphere, in an imaginary situation, the creation of voluntary intentions and the formation of real-life plans and volitional motives- all appear in play and make it the highest level of preschool development." Vygotsky's play theory explains that giving new meaning of objects in play is a core activity of children. As such Vygotsky further explains, in playful experiences, "…a child consciously recognize his own actions, and becomes aware that every object has a meaning… (p.17)". While discussing the dialectic relationship between play and concept development, Vygotsky mentions “a complex of originally undeveloped feature comes to the fore at the end of play development- features, that had been secondary or incidental occupy a central position at the end, and vice versa (p.17).” This cultural-historical understanding of play is used in this study for analysing the relationship between imaginary play and concept development of preschool children.

Cultural-historical understanding of everyday and scientific concepts

Vygotsky (1987) argues both everyday and scientific concepts are dialectically related and foundational for concept formation. Everyday concepts and scientific concepts support each other and make qualitative change for concept formation. Vygotsky states that, everyday and scientific concepts have different developmental path that are dialectically related. Both concepts support each other to develop better understanding of a concept. In an empirical study Fleer (2008, p. 302) suggests ‘playful events provide an important conceptual space for the realization of dialectical relations between everyday concepts and scientific concepts’. In this study, cultural-historical understanding of everyday and scientific concept supports the analysis and theoretical framing for explaining children’s scientific learning on plant growth.

Cultural-historical understanding of Perezhivanie

Vygotsky introduces the concept of perezhivanie stating that – “in an emotional experience [perezhivanie] we are always dealing with an indivisible unity of personal characteristics and situational characteristics, which are represented in the emotional experience [perezhivanie]” (Vygotsky, 1994, p. 341). This quote is very significant where Vygotsky has crafted that – an emotional experience [perezhivanie] is a unit where, on the one hand, in an indivisible state, the environment is represented, i.e. that which is being experienced – an emotional experience [perezhivanie] is always related to something which is found outside the person – and on the other hand, what is represented is how I, myself, am experiencing this, i.e., all the personal characteristics and all the environmental characteristics are represented in an emotional experience [perezhivanie]; (Vygotsky, 1994, p. 341). Vygotsky emphasises that the aspects that are to be achieved at the end of a developmental process are just not simply present in the environment. These are continually interacting and influencing the child to achieve the development. Veresov and Fleer (2016b) argues that, "*perezhivanie* as a concept allows us to study the process of development, which means that this concept is an analytical tool, and a theoretical lens" (p.326). Perezhivanie is a unit of analysis that carries the characteristics of the whole. Perezhivanie captures not an event in the environment or a phenomenon in itself, but the 'meaning' of this event or phenomenon for the individual (Bozhovich, 2009). According Vygotsky, "The social becomes the individual, but the dialectics of this becoming is that only those components of the social environment that are refracted by the subjective perezhivanie of the individual achieve developmental significance" (Vygotsky, 1998, p. 294).

In this study, perezhivanie is used as a phenomenon and a unit of analysis. As a phenomenon it captures the emotionally charged moments in science learning in a child's everyday life. As a unit of analysis it explains the relationship between emotion and everyday and scientific concept. This concept further helps us to theorise *scientific perezhivanie* that explains children's consciousness of scientific concept. A child's awareness and understandings can be expressed through verbal, gesture or other means of communication. As such perezhivanie as a unit of analysis helps to understand the complexity of the problem as we consider the emotionally charged experience as a dramatic source of scientific concept development.

Participants

Data were collected at home and at a preschool. This chapter focuses on one child - Alisa who was an Australian-Canadian child who participated in both studies; the ARC study in the centre and the PhD study in the family home. She was 4 years old at the beginning of the data collection period. Video observations were made of Alisa's interactions at home and in her preschool, which is located in a South Eastern suburb in a major city in South East Australia. On average 23 children attend each day in the kindergarten room. The age range for the children in the kindergarten room was 3.3 to 5.3 years. The average age was 4.2 and median was 4.1years.

Three preschool educators were involved in the planning of the children's activities at different times during the data collection period.

Data gathering procedure and methods

Five main data collection approaches were used: digital video observations of the everyday activities at preschool and home, video and audio-recorded semi-structured interviews, field notes and photographs. The data gathered that constituted PhD data set, included video data on the focus child Alisa, and audio-recorded semi-structured interviews with parents and educators and field notes.

Digital video observations

From the broader ARC project of 74 hours, Alisa's play activities in preschool were noted in 20 hours of video data of which 8 hours were selected for analysis for this paper. At home I collected 4 hours of video data. Two home visits were made to Alisa's house. The first visit was made during the fourth week of data gathering in order to note directly how preschool experiences might be influencing home play and vice-versa. The second visit was made six months later in order to capture any persistent science learning or interests. In the final visit, Alisa and her mother were shown the previous video clips on planting activities. Alisa's mother was interviewed informally during the home visits. Alisa's mother also completed a short questionnaire about Alisa's play interests at home about her views on science and play (reported in Gomes, under review). Field notes were recorded to give context to all the video and photographic data gathered.

Procedure

The aim of the projects was discussed with the teachers prior to commencing the research. In order to design the regular teaching activities around some science concepts the educators chose to design and plan the activities based on the popular fairy tale 'Jack & the Beanstalk'. Some science concepts associated with the fairy tale, such as sound, vibration, plant growth, and bread making, were explored at different times. This chapter reports on data relevant to the concept of plant growth.

Analysis

Data were organized into a series of video clips that were analysed using a three level analysis framework suggested by Hedegaard and Fleer (2008) – 1) common sense interpretation, 2) situated practice interpretation and 3) thematic level interpretation.

Level One – Common sense interpretation: Analysis at this level identifies play-based everyday moments that are related to plant growth activities. Emotions aroused during these moments were also identified. Table 1 shows detail of these moments. For example, the imaginary play moments that supports positive emotions such as joy, happiness.

Level Two – Situated practice interpretation: Emotional moments that foreground contradictions between real life and imaginary world gives deeper level of understanding of children's awareness about everyday and scientific concept development at this level of analysis. For example: Alisa's wonder while looking at the bean seedlings appears as a dramatic moment for conscious awareness about plant growth.

Level Three – Thematic interpretation: Finally, relations between emotions and everyday and scientific concepts are analysed for understanding children's scientific concept development. Data analysis of the observations made in the preschool and home, data on some qualities like aesthetics and beauty, supports further understanding the continuous process of concept formation. For example, the intense emotionally charged moments explain conscious awareness about the scientific concepts that feature new understanding about relation between cognition and emotion.

Data presentation and Findings

The three-layer analysis of children's everyday experiences leads us to the findings that develop our understanding on the relationship between emotions and scientific concept development. The findings suggest that 1) play-based everyday activities create opportunity for emotional engagement for children; 2) dramatic moment creates conditions for conscious scientific awareness

Play-based emotionally charged everyday moments

In this section, some everyday play-based moments at preschool and home are discussed that capture emotionally relevant moments to the concept of plant growth.

At preschool: Imaginary play and emotionality during dramatizing the fairy tale

Educators created a free play area with the props that they made collectively at the beginning of the project (for the practices of the centre, please refer to Fleer & March, 2015). There were bean seeds in a bowl and a bamboo stem covered with plastic leafy greens that used to be the bean stalk which was put standing on a bucket of sand in the imaginary play corner. The puppet characters were also left there for children to choose. An intense emotionally charged role-play episode shows Alisa's flickering between the real and imaginary world.

During free play, it was observed that Alisa and her friends sometimes negotiates to take up the role of the giant or Jack or the mother in the imaginary play corner. In a particular episode Alisa was seen carrying the puppet 'Jack' and Bella be the mother. Both of them are laughing, giggling and jumping during role-playing the characters. Soon in the story as the giant was coming to catch Jack, Alisa facial expression show fear as if urging for escaping the Giant's castle. She quickly runs the puppet Jack climbing down the bamboo stem. Alisa closes her eyes, puts her hands upwards and lies on the ground pretending the giant was fallen from high up the beanstalk. She lies there for some time and as the story ends she looks up to Bella and says smiling to her- "That's a good story!"

Alisa's comments about the story, role-play of the characters, and pretending the giant falling down from the beanstalk captures intense emotionally charged moments that she is closely immersed into the main characters of the story. Her final comment being lying on the ground and making a comment about her positive feelings about the story and through negotiating the characters, dramatizing the characters captures the moments on the children flicker between real and imaginary world. As well intensely identifying them as characters of the fairy tale the children live through the emotions of the story (Fleer, 2016). Vygotsky's (1966) conception of play explains children give new meaning to objects as they imagine and take new roles as different characters during play. Meaning making of the objects appears a strong theme in this imaginary play experience and in other role- play episodes during this study. The educators take up a role together with the children from the fairy tale. For example, on day two educators Riyana and Tamara take part in role-playing the fairy tale using some puppets. During the following weeks by telling and re-telling the story and through imaginary role-play the educators continue building a common theme on the fairy tale that emerge in the centre (El'koninova, 2002).

At home: Playful everyday experiences supports continuing scientific concept development

During the first home visit Alisa shows the researcher her favourite human body book. She pointed to the digestive system as most interesting to her. Alisa makes a lot of craftwork with her mother at home such as wall hangings, painting. They use carton boxes for play with her sibling. During the second home visit Alisa's feeling for garden plants were noted. She describes the researcher how she takes care of plants in the backyard with her mother.

Alisa takes a garden scissor and cuts out some dead part of the leafs saying, "…and I cut like this to make it a bit short so that it doesn't grow long." showing some plants she says, "and these are my vegetables. My mummy and I brought them."

Researcher: Do you water your plants?

Alisa: Yes… I got a watering can… (She looks for it but can't find it. Then goes near her toy cans and pulls up a toy tea-pot.

Alisa: I can easily grab some water because it rained…(she keeps collecting some water from the water trolley with her toy tea-pot can.)…and then, I can water my plants… like that…(puts some more water in the tea-pot with another cup and goes near the plants and pours the water). See…I water them….

Alisa goes indoor and takes a paper and pen for drawing. She draws a plant, some raindrops and a sun. She says, " this is the plant, these are the raindrops and that's the sun"

The home observations gives further understanding about Alisa's engagement with science in everyday life. The plant nurturing practice at home tells us that her family culture and home environment affordances further supports continuing the preschool planting experiences. At Alisa's home it was also seen she has ample art and craft work collection that she does with her mother. It appears that parental support in such playful activities also keeps Alisa engaged in art and craft activities in the preschool. Her home practice informs the studies that find the reciprocal relationship of children's preschool and home play practices (Fleer & March, 2015; Gomes & Fleer, 2017). These practices eventually combine imagination, emotion and cognition that support a holistic or wholeness approach in studying scientific concept development (Fleer, 2016).

Alisa's home and preschool experiences collectively provide evidence for her conceptual movement in various possible play-based emotionally charged moments. In the second-named author's ARC study the Jack and the Beanstalk fairy tale was chosen out of children's interest as a pedagogical tool for foregrounding the scientific concept of plant growth. The characteristics of a fairy tale discussed by El'koninova (2002) all exist in the 'jack and the bean stalk' fairy tale (see Fleer & March, 2015). Jack and his mother's financial struggle is the problem situation in the story. Jack's decision to exchange the cow for the bean seeds as an initiative to overcome poverty finally brings luck when the magical incidents begin in the story as the bean seeds grow into plants. The trial attempts of stealing the golden egg chicken create emotional suspense. Finally defeating the giant brings a happy ending to the story. In our study the educator and children draw out the storyline at different times through role-play, puppet play, group time discussion. Telling and re-telling and enacting the story several times creates a context for the children to consciously realize the borders between the real life and imaginary life (Elkoninova, 2002). The everyday moments such as puppet play, group time discussion, dramatizing the fairy tale or nurturing plants at home foreground children's emotion generally. For Alisa, the play of dramatizing the fairy tale as different characters, negotiating the characters eventually lead her for engaging intensely to the story with emotions of happiness and feeling of satisfaction that she comments the story being a nice one. Alisa emotionally identifies herself with the characters of the fairy tale. Emotional imagining features in imaginary play while children anticipate the imaginary character's emotions in their imaginary play. According to Fleer (2013) dramatizing fairy tale creates scope for emotionally charged moments that support conditions for conscious awareness of scientific concepts among children. Data below further discuss some dramatic moments regarding real planting experience.

At preschool: Planting experience brings forth the contradictions between real and imaginary world

Transition moment: Children participated in a planting beans experience with their educators during the second week of the project. They planted the seeds in paper cups and put them outside for sunlight. After a few days the seeds grew into seedlings that were placed inside the room.

Vignette 1: I was following Alisa with the hand-held video camera. Educator Tamara gives a cup to Alisa and walks together towards the next door. Alisa stops walking, as soon as she saw the seedlings in the cups, she becomes highly surprised and exclaimed, “Look, how high this one is!” Alisa looks at the researcher, brings out the sprout and says again wondering- “Look, how high it is!” Researcher also exclaims saying, “it is!”. Alisa pauses and wonder, “…but I don’t know how high the bean stalks grow…” Alisa now puts the seedling back into the cup and follows the teacher. Suddenly, she stops again, runs back to the bench top where all the other seedlings were and looks into some more other cups.

Bella: Look at this one growing! (Surprised, pointing to one of the seedlings in a cup.)

They both look down inside the cup.

Alisa: Wow…that one is really good! (Highly exclaimed with surprise while looking down inside the seedlings)

Bella: How many leaves…see! (Curious)

Alisa picks another cup and they both look into the plant it.

Alisa: Oh...look at that one! Look, it's tiny! (Her voice goes thinner as she sounds further more surprised since this seedling is much smaller than the other ones)

Bella shows her cup to the Researcher: Look at this one…. (Surprise and wonder)

Researcher: They are really grown! (Happy)

Bella showing her cup: This one growing!

Alisa: Wow! It's so BIG! (Surprise).

She takes another cup showing the researcher: Look at this baby! (crying out). It's tiny!

Alisa Takes another cup and wonders as her eyes glowing, eyebrows up and exclaims: Oaaakh…! (This seedling seems even smaller)

The conversation between Bella and Alisa took place during a transition moment before the formal discussion about the plant growth with the educator and the children. Children's emotion of surprise and wonder is captured during this everyday moment of transition. This vignette is further discussed together with the following vignette later in this section.

Group time: Later, Alisa with the educator Tamara and other children are sitting around a table. This vignette shows the educator also creates a collective emotional wondering moment while discussing plant growth.

Vignette 2:

Tamara takes a paper cup with a beanstalk grown in it, showing it to the children.

Tamara: Have a look at our beans that we have grown… so tall…. (Surprised)

Mel: look at this...(showing her beans grown in a paper cup)

Tamara: They look so ***tall…*** *(a longer emphasis to the word tall)…how did they grow?*

Sara: With sun and water…(moving her hands upwards to show height, smiling, looks very happy)

Tamara: ***With sun and water****...didn't they! (Emphasis)*

Alisa: so…so they grow quicker…and when I came back, so that day when I saw them they were just tall and Daniels' was grown tall… (Alisa's eyes upwards imagining the plant's height… standing up from her sitting position and using hands to show the height of the plant).

Tamara: yea...and they grow everyday...don't they? ...we should continue to put them outside in the sunlight and continue to water them…

The vignettes capture the emotionally charged dramatic moments during plant growth related experiences. Firstly, Alisa is immensely wondered to see the plants of different sizes and curious about the real growth of plants. Together the educator creates a collective wondering moment for the children discussing the scientific aspects of plant growth (Hadzigeorgiuo, 2001, 2016; Siry & Kremer, 2011). The educator plays an important role to make the scientific concept explicit to the children that links children's imagination with reality. The fairy-tale characteristic of 'time difference' (El'koninova, 2002) is a noticeable aspect here as well. During the group time the educator and children collectively draw the time difference aspect between fairy tale and reality regarding plant growth discussing 'plants grow everyday'. The above vignette from home data also shows that Alisa drew the picture of plant growth where she was able to show the gradual growth with sunlight and rainwater.

According to Vygotsky, the child's thought must be raised to a higher level for the concept to arise in consciousness (Vygotsky, 1987, p. 169). Refraction and consciousness has a deeper meaning in describing the emotional experiences in cultural-historical theory. Table 2 below shows the conceptual contradiction between everyday and scientific concepts in the story and real life. Alisa knew from story, the magic bean was grown sky-high over night, but in reality she can see plants are of different sizes-"tiny", "tall", "baby". We carefully note that this is emotional experience of a scientific conceptual contradiction, not just the simple reflection of a four-year old child who becomes curious about the everyday phenomenon in the social conditions created by the educators. The playful planting experience sourcing from the fairy-tale foregrounds both everyday and scientific components of plant growth. The cultural-historical understanding of the principle of perezhivanie as a refractive prism is understood as the internalisation mechanism of one's thoughts of becoming the social as individual (Veresov & Fleer, 2016b; Vygotsky, 1994). Similarly, these vignette show that both everyday and scientific concepts are experienced with some emotions. These are subjectively experienced by the child's consciousness and refract as a sense of wonder and curiosity. For example, Alisa is not only wondered (wonder- emotional component) but also becomes curious about knowing more how actually plants grow (curiosity-cognitive component) (Hadzigeorgiuo, 2012). This mechanism of experiencing the situation and expressing the emotions can be explained with the example of everyday phenomenon of light refraction through a prism. When light is reflected on a mirror, it creates the image of the object only but does not create a rainbow. The same 'incident light' will create a rainbow when passing through a prism. We are not able to see the spectrum in simple mirror reflection. This is what happens when we see the child's experiences of both everyday and scientific experiences are expressed through emotional assertion of wonder and putting the child's understanding towards a newer scientific understanding of plant growth in real life. Such newer scientific understanding developing through various everyday experiences and interactions at home and preschool can be imagined as a rainbow that is visible after light refraction through a prism though the spectrum is always contained in the light. Until the collision for light refraction, we are not able to see the spectrum. In Alisa's everyday experiences such conceptual contradiction of concepts also capture the dialectic relationship between everyday and scientific concepts that are different but at the same time supports each other towards newer scientific understanding in a child's scientific concept formation.

Table 9.1. Conceptual contradictions between real life and imaginary world

Everyday concepts	Scientific concepts
Magic beans grow up to sky high in a day	Beans grow everyday with sunlight and water.

Discussion

Dramatic moments are a source of scientific awareness and emerging scientific perezhivanie: Everyday and scientific concepts are foundational and both concepts support each other for concept development (Vygotsky, 1987). The cultural historical understanding of the relationship between everyday and scientific concept in children's everyday life and perezhivanie helps us to understand the process of scientific concept formation. Vygotsky mentions, every situation is social situation but not every situation is social situation of development (Vygotsky, 1994). According Vygotsky (1998), the dramatic moments in a person's life, drama or crises, create the conditions for development. In this study there are some everyday moments and some dramatic moments in children's life. Dramatic moments can be experienced in everyday life. Everyday moments such as dramatizing the fairy tale, caring for plants lay conditions for foregrounding children's emotions that generally engage them to the story and to the everyday concepts in the story such as magic beans grow sky high over night. On the other hand, there are some moments in everyday life in this study that we find as dramatic moments such as the transition moment and group discussion with the educator about plant growth. During these moments we find the emotional state of surprise and wonder that are a dramatic moment for Alisa's conscious awareness about plant growth. The dramatic moment that comes live through Alisa's emotions of wonder and surprise captures her awareness is the driving force for concept development – that plant growth is not a magical process; plants actually grow everyday gradually with the help of sunlight and water.

The findings also support Roth's (2012) arguments on whether there is transferability of science learning across formal and informal contexts. Amy's family practices inform us that she has grown interest in plants, human body and other biological science areas. Also, her home environment supports her with a lot of art and craft materials. She spends quality time with her mother on making artefacts. Such practice involves a lot of imagination and practicing affective qualities, aesthetics and beauty that are refracted simultaneously in Amy's imaginary role-play in preschool. Our findings show that emotionally charged moments are source of conscious awareness in scientific learning. Teachers in early years can capture on these moments for better understanding children learning science in preschools. This will support studies like Liu et al. (2014) that emphasise teacher awareness about learners' emotional state important for teaching science. According (Vygotsky, 1997, p. 99), “Scientific consciousness… considers revolution and evolution as two mutually connected and closely interrelated forms of development. Scientific consciousness considers the leap itself that is made in the development of the child during such changes as a certain point in the entire line of development as a whole”. The findings in this present study critically identifies new understanding on the scientific consciousness for scientific concept development using scientific perezhivanie that is different than other studies examining state of emotional changes during concept development (Bellocchi & Ritchie, 2015).

Vygotsky states, “…perezhivanie to be a unity of environmental and personal features” (Vygotsky, 1994, p. 342). He explains this statement as such that a phenomenon in the environment is a concrete situation that is also represented in a given emotional experience. Vygotsky further discussed this with the empirical evidence of the development of three children in the situation of their sick mother, all the three children responded differently to the situation. The eldest child responds to the situation with a sense of maturity than his biological age. The very concrete situation and the child’s emotional qualities unite to respond him in the situation with his ‘above age’ maturity. According to (Vygotsky, 1994, p. 339), “…the essential factors which explain the influence of environment on the psychological development of children, and on the development of their conscious personalities, are made up of their emotional experiences [perezhivanie]” Such unity is reflected in our study during the dramatic moment that is different than other moments of Alisa’s everyday life. This exclusive emotional moment of conscious awareness about the relationship between everyday and scientific concepts is identified in a unity that appear as a scientific perezhivanie (Vygotsky, 1994, p. 339). Therefore, it is not just the moment when Alisa look at the real plants grown but also her response with emotional quality of wonder in that very moment explains her conceptual awareness. This awareness is about the relationship between an everyday understanding towards a scientific understanding. This special relationship between emotional state and everyday and scientific concept relates to Vygotsky suggesting- "…it is not any of the factors [in the environment] in themselves…which determines how they will influence the future course of his [the child's] development, but the same factors refracted through the prism of the child's emotional experience" (Vygotsky, 1994, p. 339). The study shows that everyday and scientific concepts and emotionally charged science experiences are in a unity where perezhivanie is the unit of analysis. As such, perezhivanie as a unit of 'person and environment' (Veresov, 2017) explains the unity of Alisa's emotional experience. Such perezhivanie is a conscious state that named scientific perezhivanie where the everyday concepts become meaningful with the blazing of the scientific concepts for instance when Alisa becomes aware that plants actually do not grow sky high overnight but they grow gradually everyday with the help of sunlight and water. The emotional quality of wonder and curiosity informs the state of conscious awareness. The finding of unity between emotional experience with everyday and scientific concept supports empirical studies (e.g., Fleer et al., 2016; Roth & Jornet, 2013) that emphasise the inseparability of emotion in science learning. In relation to the existing literature, the present study theorises such inseparable relationship by using a new analytical concept of scientific perezhivanie for better understanding of children learning science in everyday situations. Scientific perezhivanie therefore explains the emotionally charged science-learning experiences. How a person responds to the environment is directly related to how they experience the everyday life activities happening around them. The same environment brings different developmental conditions for different persons at the same time (Vygotsky, 1994). In the above analysis we can see Alisa is responding to the science experiences in a way that expresses her emotions, captures her imagination and expresses her scientific understanding in various modes such as drawing, artwork, role-play and through other hands on science activities. How the child interprets, becomes aware of and relates to the environment is significant while analysing children's everyday emotional experiences (Vygotsky, 1994). To understand development we need to study the child's relationship to their environment and the person themselves. For this, we use the concept of perezhivanie as a phenomenon and as a concept to observe what the child experiences and how the child is experiencing this in a given context. The social situations the child interacts in at preschool are supported by the various engaging planned activities created by the educators. The home practices further nurtures the preschool experiences. As Vygotsky points out any function in the child's cultural development appears on stage twice, that is, on two planes. It firstly appears on the social plane and then on a psychological plane. Firstly it appears among people as an inter-psychological category, and then within the child as an intra-psychological category (Vygotsky, 1997). The children and the educators interact in a social situation that makes the child aware of and interact with the environment with the sense of wonder. The preschool play culture deliberately creates conditions that support a new scientific awareness of their environment. The playful experiences at home strengthen the preschool planting experience. There is a reciprocal relationship of emotions that supports scientific concept development. As such, Perezhivanie captures not an event in the environment or a phenomenon in itself, but the 'meaning' of this event or phenomenon for the individual (Bozhovich, 2009).

Conclusion

This study aimed to explore science-learning possibilities in play-based environment and identify the relationship between emotion and scientific concept development. It was found that conscious scientific awareness about an event or the environment plays a significant role in development of scientific understanding, particularly when we are discussing child development. Conscious awareness is none-the-less significant aspect of how a person/child is experiencing an event following general genetic law of cultural development. Scientific perezhivanie analyses the relationship between emotions and scientific concept development process for preschool children. The rudimentary form of the concept of plant growth is present in the social interactions for the child that can be further explained with other cultural-historical concepts. The study findings are drawn from a one-child case study situated at home and preschool environment. It is anticipated that each child experiences the same situation differently and brings their own social situation to the context hence their developmental trajectory is formed accordingly. Future studies can give more insight into exploring this subjective sense and subjective configuration aspect for scientific concept development of preschool children. Scientific perezhivanie advances the concept of perezhivanie within Vygotsky's system of concepts that explains the relationship between children's emotional state, play and everyday and scientific concept. Such understanding will contribute for better understanding children's emotional experiences during science activities in everyday life and support preschool science pedagogy.

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Table 1. Analysing the home and preschool play experiences

Emotionally charged moments Play /Playful experience	**Objects**	**Imaginary meaning**	**Emotional category**	**Context**
Making props out of recycled materials	Recycled materials (e.g., cardboard, Aluminium foil cupcake holders, tissue rolls core, yarn, paints, Styrofoam pieces)	Giant, eyes, hair, Giant's castle,	Imaginary play- changing meaning of objects Joy, happiness, aesthetics	Collective imaginary playful experience in preschool
One of the Educators reading out the story and other educator participating in role playing the fairly tale with group of children	Puppet props, plastic cow figure, bean seeds	Jack, mother, giant, farmer, cow Daisy in the story, bean seeds	Role play- Imagination, joy, happiness, aesthetics	
Role play- 'it's a good story!'	Giant prop made together with children	Giant	Drama, role play, imagination, happiness, aesthetic appreciation	Focus Child playing alone/with peer
Art work during free play guided by educator – themed on the fairy	Recycled materials (e.g., paper characters, yarn,	Detailing favourite part of the story through aesthetics such	Imagination and cognition- educator	Child interacting with educator

tale	paints, Styrofoam pieces, paint, beads and seeds)	as art work	asks questions for understanding child's meaning making of the objects	
Observing plant growth	Seedlings in paper cups	Contradiction between imaginary and real world	Dramatic moments Wonder Questioning/ curiosity	With peers
Observing plant growth	Seedlings in paper cups	Real world-Imaginary world contradiction observing the actual plants grow everyday	Dramatic moments Wonder	Sitting around a table With educator and group of children
Showing the researcher the backyard garden	Gardening play materials (e.g., watering can, garden scissors, water trolley)		Nurturing plants- "this is how I do it (water the plants) with my mom'- aesthetics	Home play
Drawing that show plants need sunlight, water and soil for growth	Paper, pencil		Drawing and explaining plant growth. Imagination and cognition,	Home play

			aesthetics and beauty	

CHAPTER 10
Conclusion

10.1 Introduction

This final chapter summarises the arguments and findings from the publications and provides a very brief synthesis of the overall findings in relation to the main research problem. The chapter ends discussing the study's contributions, implications, limitations and future research directions.

10.2 Summary of the findings

This cultural-historical study explored the science learning possibilities in children's everyday life that contribute towards the process of scientific concept formation for preschool children. As settings for this, home and preschool are considered the main science rich environments that 3 to 5 years old children participate in. Teacher and parent perceptions about science are considered important in this aspect, assuming their knowledge and disposition further contribute to scientific concept development in the children. Drawing upon the cultural-historical concepts of everyday and scientific concepts, play, motives, social situation of development and an extended link with perezhivanie, the key arguments and findings that comprise the chapters in this thesis are presented in Table 10.1 below.

Table 10.1 Arguments and Findings presented in the Chapters 5-9

Chapter 5 Paper 1	Argument 1	A sciencing approach from a researcher's perspective alone is not sufficient for explaining how

		preschool teachers use the preschool environment for teaching science in their regular teaching practices.
	Findings 1	Introducing science walk as an innovative method captures preschool teachers' sciencing attitude, which develops understandings about teacher thinking regarding science affordances in the preschool physical environment, routines and everyday practices.
Chapter 6 Paper 2	Argument 2	Teachers' knowledge about science and conceptualising science affordances in the preschool environment influence their teaching approach.
	Findings 2	The notions of a conceptually oriented sciencing attitude and an activity oriented sciencing attitude explain the pedagogical complexity of teachers with different science orientations in the same preschool setting. A *conceptually oriented sciencing attitude* leads pedagogical awareness about science in the everyday environment.
Chapter 7 Paper 3	Argument 3	Parents' perceptions about science learning in everyday life can support the creation of possibilities for children's scientific concept formation in everyday home practice.

	Findings 3	The parent with a science background thinks children can learn science in everyday life. Parents can create conditions for a motive orientation for science learning in everyday practice situations.
Chapter 8 Paper 4	Argument 4	Children's scientific play across home and preschool creates conditions for developing scientific concepts.
	Findings 4	A *scientific motive* explains children's sustained interest in scientific concepts in play across institutions.
Chapter 9	Argument 5	Home affordances and preschool experiences, along with emotions, can create conditions for scientific concept formation.
	Findings 5	The analytical concept *Scientific perezhivanie* explains the relationship between emotions and concept formation within the science learning play-based environments in the everyday life of children.

The central argument in this thesis is based on cultural-historical understandings of child development and concept formation. This suggests that preschool children do not develop scientific concepts alone, but through interacting in an environment supporting both everyday and scientific concepts. The study attempted to fill the gap within the broader empirical literature mainly by identifying: 1) the home and preschool relationships in the process of children's scientific concept formation through observing preschool children in their everyday environment, and 2) parents' and teachers' perceptions about science in the everyday life of preschool children. The science learning possibilities available in children's everyday life lay the foundation for the process of scientific concept formation. Concept formation is a higher mental function that, like any other higher mental functions, originates at the social level, and only later becomes personal (Chapter 3). Vygotsky's cultural historical theory (1998) provides the theoretical concepts to study this organic process, which it is not possible to understand by studying the child's chronological age-based development alone or by detaching the child from his or her everyday activity settings.

In this study, preschool teachers' perspectives about the everyday environment unveil the conceptual relationship teachers build with the environment and children for teaching science. Teachers' conceptually oriented sciencing attitude about the environment informs us about the scientific meaning they give to the everyday environment for science learning possibilities in children's everyday life (Chapters 5 and 6). With the use of the science walk method, the concept of sciencing has been applied in a new way in this thesis. Earlier literature mainly used this concept focusing on children's science skills development or analysing the environment from a researcher's perspective (e.g., Neuman, 1971; Tu, 2006). The present study applied the concept from a pedagogical perspective to explore the natural everyday preschool environment for teaching science. Although the teachers have competent knowledge about science and perspectives about the relevance of science in children's everyday environment, their differing science pedagogical perspectives paint different pictures.

The concept-focused science teaching perspective includes teacher awareness about both everyday concepts and scientific concepts (Vygotsky, 1987), while the activity-focused science perspective focuses only on the everyday aspects of science in a child's environment. Such a difference in teacher perspective captures the complexities in existing preschool science teaching-learning practice. Using the theoretical concept of social situation of development (Vygotsky, 1994b) the present study has provided an authentic understanding of the relationship between science and the everyday environment from the two teachers' views and has interpreted their understandings in the context of an everyday environment with which children interact on a daily basis. The findings are consistent with previous studies that suggest teacher knowledge should be studied in authentic everyday environments (Traianou, 2007). The findings also support studies (e.g., Siry & Lang, 2010) suggesting children's personal everyday experiences should be drawn on by teachers for context based science teaching, and that doing this would eventually increase teacher confidence, competence and content knowledge for early years science teaching. The findings further concur with studies (e.g., Siry, 2014) that suggest teachers do not need to be 'experts' in a content area—if they have an epistemological understanding about the real problem and process of children's science learning, a more authentic relationship is possible to build at every moment of science teaching.

The evidence suggests that the participating parents had a differing perspective about science. However it was evident that both family practices afforded science learning in the everyday home context. The parent with a science background created deliberate conditions for science learning in everyday activities. This parent's deliberate interaction with children turned an everyday moment into a stimulating scientific moment in regular everyday activities at home (Chapter 7). Although it was found that the parent with little or no science background did not discuss science concepts with her child in everyday life to a great extent but may interact and support in the child's home play with cultural tools such as toys, books and play materials that afford conditions for providing scientific themes in children's imaginary play (Chapter 8). Therefore, children's imaginary play (Vygotsky, 1966) and observing adult-child interaction in the everyday home environment provide an understanding about the affordances available in the process of concept formation in children's everyday informal home contexts. From a theoretical perspective this informs us about children's motive orientation for learning science (Hedegaard, 2002). Observing children's play practices across their participating institutions permits the identification of a scientific motive, which in turn explains the home and preschool relationship between everyday concepts and scientific concepts (Vygotsky, 1987) in the process of abstract scientific concept formation. The study not only analyses the child's imaginary play conditions but also the home play episode (Paper 4, Chapter 8) on recreating storyline on plant growth and building earthquake LEGO model, both themes borrowed from preschool learning experiences explains the child's psychological movement in the process of concept formation as the play motive proceeds towards a learning motive.

In essence, the study suggests that there is a reciprocal relationship between home and preschool everyday practice that can lay the foundation for possibilities for preschool children's scientific concept formation. The findings reveal teachers' and parents' perceptions and the conditions they create for learning science in the everyday life of children. This also confirms that a child's scientific concept formation process is a two way process. The child's everyday context is not studied as a one-sided factor of development but as the source of development where various relationships occur—and can be studied—holistically as a dialectical relationship. Teacher and parent perceptions about science possibilities and home-preschool activities are all embedded in the social-cultural context in a child’s life. The interactions between children and adults during play or in other everyday activity settings that comprise part of this everyday cultural context are not separate phenomena in a child’s life but collectively linked to each other. Of significance, the study suggests that parents’ involvement and support at home and teachers’ deliberate teaching about science concepts in preschool can together support the development of a sustained interest for learning science from an early age.

10.3 Contributions

The study contributions are identified in relation to methodological, theoretical, pedagogical and empirical areas in the field of early childhood science education. These contributions are discussed below.

10.3.1 Theoretical contribution

The everyday and scientific concept (Vygotsky, 1987) is the central cultural-historical concept in this study. The theoretical relationships between everyday and scientific concepts are captured in a model in Paper One (Chapter 5). This working model supported the theoretical discussion for explaining the relationships between everyday concepts and scientific concepts, which in turn was used for analysing the empirical data in the subsequent chapters. Between the second and third phase of his intellectual work Vygotsky had started theorising the concept formation process by introducing everyday concepts and scientific concepts. He explained the relationships between these concepts. His work discussed concept formation drawing upon experimental examples mainly of the language development process in formal institutional instructional practice. Study of the informal home environment was absent in his work. By including empirical evidence from informal home environments together with formal preschool environment, this study has attempted to theorise the institutional relationships in the scientific concept formation process.

The cultural-historical concept of motive (Hedegaard, 2002, 2012b) has been discussed in this study in science learning activities included in both home and preschool contexts. The theoretical concept of motive has been discussed in Hedegaard's (2002) work involving the three kinds of Motive—dominant motive, meaning-giving motive, and stimulating motive in relation to children's institutional practice. The cultural-historical concept of motives has a very different meaning from the studies on motivation in traditional constructivist inspired science education research. The cultural-historical concept of motive is not only an external or an internal characteristic of a person but it brings a much deeper sense for understanding the internal and external mechanisms in the process of child development and learning. A new concept, *scientific motive* orientation, has been introduced in children's imaginary play contexts and everyday interactions to help us understand the concept formation process in everyday social and cultural contexts (Chapter 8). Moreover, the concept of stimulating motive was used to study the way the family home environment supports children to develop a science awareness in everyday life. What science everyday family practice can bring to a preschool child and the child's active participation in the environment explains the scientific moments embedded in everyday informal home culture and practice situations. This contextual relationship strengthens the study of children's everyday contexts from a theory-guided perspective.

Further, the present study discusses teacher sciencing attitudes using the everyday and scientific concept together with the concept of social situation of development. Employing the social situation of development is a new way of theorising the findings in a preschool context regarding science pedagogy. This concept helps inform the relationships teachers could build for science teaching between the child's everyday activities and the everyday environment. To show the relationships between the everyday concept and scientific concept and the social situation of development I developed a theoretical model in Chapter 6 (Figure 6.1) that captures the conceptual relationships teachers build with the everyday environment. Further, *scientific perezhivanie* (Chapter 9) helps to analyse the extended links between scientific concept formation and children's emotional experiences in everyday science and illuminates new possibilities for research in this area.

A broad picture of the theoretical cultural-historical concepts employed in this thesis for understanding the relationships between home and preschool in the process of scientific concept formation is presented in Figure 10.1 below.

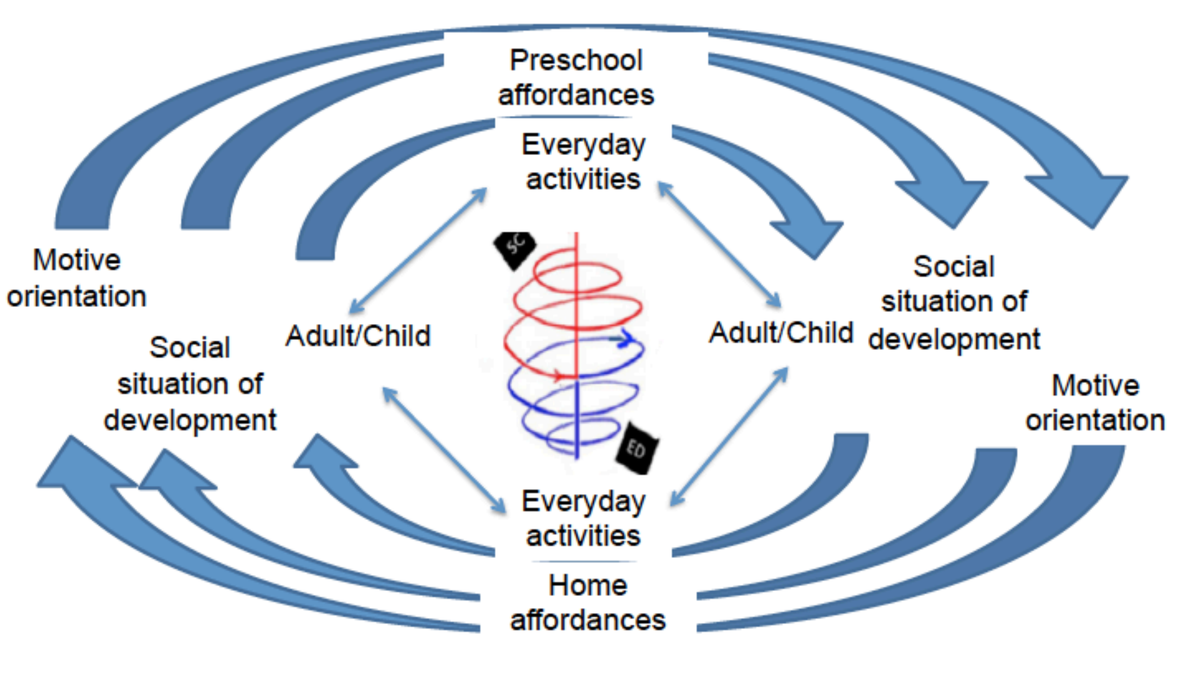

Figure 10.1 Scientific concept formation possibilities across home and preschool environments: A cultural-historical theoretical model

The process of concept formation is in constant motion in a child's everyday life. The cultural-historical concepts used in this study captured in figure 10.1 describes that in the process of scientific concept formation home and preschool environment are dialectically related since learning experiences at both institutions reciprocally support each other. Central for concept formation are the everyday activities in these social institutions where both the child and the adult actively participate and contribute. Aanlysing the social situation of development for conceptualising the environment particularly from a science pedagogical perspective hence add a second layer to this process of constant motion. In addition, studying children's motive orientation in both social institutions appear significant while studying concept formation that serve another layer to this dialectical process. Together all these concepts are connected and support studying the possibilities of scientific concept formation in a child's everyday life.

10.3.2 Methodological contribution

This case study employs a holistic approach for investigating preschool children's scientific concept formation possibilities. The overarching study design is situated across children's home and preschool contexts. The literature shows that studies investigating scientific concept development use a traditional approach for interpreting children's understandings, which excludes the everyday contexts children interact with. Such an approach is fragmented as the overall societal and material conditions and interactions are often left out.

The present study uses digital video observations and photographs across both preschool and home settings to capture everyday life and the children's scientific concept formation process in natural everyday settings. The research data gathering started in the preschool followed by home visits to the focus children's families. Children were already familiar with the video recording tools and the researcher had already established a friendly relationship with the children during data gathering in the preschool. The researcher also met the parents occasionally during drop-off time or in parent volunteering sessions in the preschool. This familiarity made for smooth interactions between participants and the researcher in the family home contexts. The study brings parents' perspectives about science in their children's everyday life, which that provide new understandings about how home cultures support scientific concept development. The perspectives were made available through interviews in context and a cultural-historically framed questionnaire.

For teachers, the study employed a *science walk* method for interviewing in the preschool context in a non-intrusive way. The science walk method captures teachers' everyday teaching practices in the context. The science walk interview approach is rich in its power to reveal the perceptions of teachers working in pairs in the same context. During my PhD supervision I was trained to gather data using the science walk approach by my supervisor, Professor Marilyn Fleer (Chapter 5). The method was replicated in a later ARC study with which the PhD study was linked. In my thesis I used the cultural-historical concept of social situation of development for the science walk data analysis to enable new understandings of teachers' conceptualisation of the everyday environment (Chapter 6). This study initiated this conceptual addition to the science walk method. Teacher conceptualisation of what meaning they give to children's everyday context is thus captured with application of the cultural-historical concept of social situation of development to data captured through the science walk method.

10.3.3 Pedagogical contribution

In a preschool context, the study found two types of teacher sciencing attitude—*conceptually oriented sciencing* and *activity-oriented sciencing*. A conceptually oriented sciencing explains teacher competence and confidence for teaching preschool science. Conceptually oriented science pedagogical awareness helps recognise opportunities for exploring science in children's everyday life so as to teach science in preschools in a more authentic way.

In particular, the findings suggest that science affordances are possible not only through experiments but acknowledging the holistic affordance of the environment that can be utilised by teachers with a *conceptually oriented sciencing attitude* for developing early science pedagogy. This can help teachers become familiar with the relationships between science and the natural and material world that are in line with curriculum goals in early childhood.

The home data suggests aspects of family pedagogy in informal home contexts that are helpful for identifying science in everyday life of children. The family home science affordances available through everyday play materials and the parents' intentional engagement with the child constitutes family science pedagogy in natural everyday settings, and helps develop a scientific motive orientation. Often parents with little or no science background struggle with discussing science with their children or sometimes parents think that science is a subject for high school only. It can be suggested that the findings on the value of developing a scientific motive orientation could inform and encourage struggling parents in their efforts to develop home science pedagogy.

10.4 Implications

10.4.1 Science education

Studies on preschool science learning are limited. Most of these science education studies on concept development view children's scientific concepts from a deficit model. The cultural-historical framing of this study captures the holistic development process of concept formation in realistic contexts. Identifying the relationships in the process of concept formation contributes to the field of early childhood science education. The study findings are theorised using the most relevant cultural-historical concepts and by introducing new theoretical concepts such as scientific motives. The new concepts and findings could be helpful for investigating further research problems in this area. The various relationships between the child's everyday environments in the process of scientific concept formation for preschool children present new understandings in early childhood science education research.

10.4.2 Teacher education

The study findings directly contribute towards science teacher education. Lack of confidence, competence and content knowledge for teaching science is a major problem area in all levels of education. Most teachers find it challenging to teach science by relating it to children's everyday life. Following children's scientific motives in play can be an area that teacher education studies could include for better understanding children's concept development in natural settings. Science walk methods can be used for developing teacher's understandings of science in the everyday life of preschool children. A conceptually oriented sciencing strengthens teachers' competence—and confidence—in identifying science possibilities beyond traditional experiment-based activities and sensory-motor skills development perspectives. Teachers could engage children in regular science walk activities for developing an intimate relationship with the natural environment and extending understanding of science in everyday life.

10.5 Limitations

The study is situated in a context of a larger study funded by the Australian Research Council (ARC) conducted by the PhD supervisor Professor Marilyn Fleer. It should be recognised that the PhD thesis dialectic-interactive case study findings are not generalisable because of the small sample size. Only two children's families, two parents and three educators participated in this one-site case study. The limited time frame for conducting the PhD study made it difficult to extend the data collection period over four weeks. Maximum three home visits could be made for a family according to their convenience. One of the participant families (Alisa) moved overseas later in the project and the other child (Jimmy) moved to a different preschool at the end of the year. Although the study findings are not generalisable and the time frame is limited, the overall study findings are theorised drawing on cultural-historical concepts that significantly contribute to the early childhood science education area. The study informs the process of scientific concept formation rather than claiming that scientific concepts were developed as a product.

10.6 Future Studies

Preschool children's play themes can be diverse. These play themes could be further investigated to extend our understanding of children's everyday science experiences. More preschool centres and families could be included in future studies to explore the cultural relationships. Other informal interaction contexts for children in everyday life could be explored. Children's play and interdisciplinary research, as well as STEM education research, could be further investigated in holistic ways, so as to expand knowledge in this area.

Preschool contexts in many countries are becoming increasingly multicultural. Further studies could be conducted exploring interaction patterns more closely in home contexts to develop deeper knowledge about the cultural nature of scientific concept development. Understandings about children's scientific concept development could be further explored by integrating other social institutions in which children participate in their everyday life. Involving parents in preschool activities—with a science focus wherever possible—could increase school-community engagement. The science learning possibilities could be investigated, integrating such approaches. The theoretical models and the new cultural-historical concepts introduced in this study could be further explored and extended to include other cultural-historical concepts in future research.

10.7 Final Words

This study was initiated to address the gap in the broader science education research and to understand more fully the process of scientific concept formation for preschool children within both the home and preschool environments. This study is just a beginning; more studies are needed in this area. In particular, children' s play-based environments need to be studied holistically. Cultural-historical studies in this area are still limited in number when compared with constructivist literature. Although science education in early years has received increased attention in past decades, a lot more needs to be known about children's authentic science concept formation process. The environment as a *source of development, not a factor for development* (Vygotsky, 1994b) has a very deep meaning, regarding which much more needs to be understood. Cultural-historical conceptual framing provides a very powerful lens that researchers could continue integrating into early childhood science education studies. The strength of this theory lies in its powerful system of concepts, which needs to be further explored and extended through more authentic research in the actual everyday contexts of children. Such holistic research can capture the joy and wonder of children making new connections, new realisations and developing new directions for learning.

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(This reference list contains references from the thesis Chapters 1, 2, 3, 4 and 10 only. The references for Chapters 5, 6, 7, 8 and 9 are self-contained in each chapter.)

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Appendices

Appendix 1: Questionnaire for teachers

I am interested in your ideas about children's play and their learning. I am also interested in what kinds of play the children in your centre engage in that might include some scientific play or thinking. There is no right or wrong answers because I am only interested in your ideas and your children's experiences, Please fill in the following questionnaire as appropriate.

1. Please list some of the common play themes and activities that occur within your centre?

2. There are many definitions of play. Can you please give your definition of play.

3. What theory(ies) do you draw upon, or that originally informed upon your view of play?

4. What role do you think (if any) an adult takes in children's play? Can you give an example of play that illustrates the role you commonly adopt?

5. When you think of the word science, what comes to mind? Please briefly describe what you understand by this term.
Please describe briefly what you understand by 'science'?

6. Do you think young children experience science in their everyday life?

Yes No

Can you describe an example:

7. Do you think children should be taught 'science' concepts through play?

Yes No

8. Do you do any science activity with the preschool children?

Yes No

If yes, please give an example of a recent planned science activity with preschool children.

9. Do you do any informal science activities with children?

Yes No

If yes, please give an example of a recent informal science activity with preschool children.

10. Have you ever done any incidental/unplanned science activity with the preschool children?

Yes No

If yes, please give an example of a recent unplanned science activity with preschool children.

Would you like to take part in an interview later at some point?

Yes No

If Yes, please provide your details below

Name: ....

Contact details: ....

Thank you for your time.

Note:

❖ Formal science activity: Teacher pre plans an activity and arranges materials for that science activity.

❖ Informal science activity: Teacher arranges a science corner or provides materials (e.g. magnets, magnifying glass etc.) that children can use for play and explore in their own way if they feel interested.

❖ Incidental science activity: Any incident that interests one or more students that could be explained scientifically by the teacher.

Appendix 2: Questionnaire for parents

I am interested in your ideas about children's play and their learning. I am also interested in what kinds of everyday play your child does at home that might include some scientific play or thinking. There is no right or wrong answers because I am only interested in your ideas and your child's experiences, please fill in the following questionnaire as appropriate.

11. Your child's play: Please list some of the common play activities that your child engages in at home.

Can you please describe an example for any of the above play activities?

12. When you think of the word science, what comes to mind? Please briefly describe what you understand by this term.

Science to me is....

13. Do you think your child experiences science in everyday life at home?
Yes No

Can you describe an example:

14. Do you think children learn ‘science’ concepts through play at home?
Yes No

If yes: Can you describe one example where you specifically discussed a science concept with your child:

If no: Why not?

15. Can you list one or more science related play activities your child might experience in the indoor and outdoor area at home? (Please indicate what science concept it could be you think is related with the play you mention below.)

Play activity that occurred indoors	Science concept it might have developed (or could develop)

1. ______________________ 2. ______________________	1. ________________ 2. ________________

Play activity that occurred outdoors	Science concept it might have developed (or could develop)
1. ______________________ 2. ______________________	1. ________________ 2. ________________

16. Have you intentionally thought of explaining your child any science concept during play?

Yes No

If yes, please give an example.

17. Has your child ever asked questions related with everyday activities that could be explained scientifically?

Yes No

If yes, please give an example.

Would you like to participate in an interview later sometime?

Yes No

Please provide your details below

Name: ....

Child's name: .... Age: ....

Contact details: ....

Thank you for your time.

Appendix 3: Interview questions for parents

1. Please tell me about your child's play. What are your child's favourite play activities?
2. What do you think about your child's imagination and play?
3. What do you think about your child's play and everyday science experiences?
4. Please tell me about your role with your children during their playtime.
5. How do you negotiate with the science experiences your child brings from the centre to home?

Appendix 4: Interview questions for teachers

1. Please tell me about yourself-

- How long have you been teaching?

2. Can you please tell me about your regular teaching activities with the children?

3. What do you think about children's play and imagination?

4. Do you see differences in children's play in your centre as they come from different culture and families?

5. What do you think about children's play and science in their everyday life?

6. If the children ask scientific questions, do you make plans to explore it further together with the children? If yes, please give an example. If not, please discuss why.

7. How do you negotiate the science experiences children bring to the centre from home or outside?

8. What is your thinking about children's learning science from an early age and their future interest in science?

Appendix 5: Explantory letter for staff

MONASH University
Education

September 2012

Dear colleagues,

Please find enclosed a copy of a letter and consent form for a proposed study on science and play. The Director has agreed to pass on this material, but she is not involved in the recruitment process. If you wish to be involved, please post the signed consent form into the box that is located at the entrance to the centre. Thank you.

Yours sincerely,

[redacted]

Judith Gomes

PhD Student

MONASH University
Education

Explanatory letter for staff participating in:

A Study of Play, Culture and Science: The Scientific Conceptual Development of Preschool Children

Dear Colleagues,

I am Judith Gomes. I am writing to you regarding a research project which contributes towards my PhD study, under the supervision of Marilyn Fleer, a professor in the Faculty of Education. This means that I will be writing a thesis which is the equivalent of a 300 page book. The research will be carried out with children aged between 3 and 5 years attending a preschool centre. Your centre director has kindly passed on this letter. My project aims to investigate how preschool children's play activities contribute to scientific concept development. This study is important for learning more about how children learn concepts in play. My study is directly related to the project that is already occurring in your centre (Ethics No. CF11/3199 – 2011001746). However, my study seeks to follow 3-5 different focus children from the overall study, and to conduct a survey about parents and teachers' beliefs about play and science learning.

I am interested to explore the nature of play across cultures that could lead children's scientific conceptual development from an early age. For doing this, home and childcare centres are considered the main science rich environments children participate in. Teachers' and parents' perception about science is considered important in this aspect assuming their knowledge further contributes to scientific concept development through play for the children.

I am seeking your permission to include in my observations of the children any interactions they may have with you during the implementation of the program of teaching. I will be making observational notes of the children's activities and some video recording and photographing of the children as they interact with you and when they are playing. I would also like you to respond to a questionnaire and informally interview you about the teaching program so that we can learn more about science learning and teaching. I will be supported by a colleague and we expect to be in your centre for two hours per day for three sessions per week for 2 to 3 weeks observing the children's play and learning.

It is possible that some of the photographic images (not video) may be selected for publication in a journal article or a book for teachers and other professionals involved in education who are interested in research findings about young children's learning through play. It may also be possible for short video clips (e.g., of up to a minute) taken from the video material to be selected for sharing at conferences or to student teachers who are studying early childhood education. The showing of images will be in the form of video sequences, still photographs, descriptive reports and scholarly discussion limited to the field of early childhood education research or relevant debate among early childhood professionals who may be interested in research about young children's learning through play. No image will appear on a website.

You can withdraw at any time from the study without penalty or indicate at any stage if you prefer us to simply keep written notes rather than audio or visual recording.

Storage of the data collected will adhere to the University regulations and will be kept on University premises in a locked cupboard/filing cabinet for 10 years. A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report.

If you have any queries or would like to be informed of the aggregate research findings please contact my supervisor by email at Marilyn.Fleer@monash.edu or me care of 03 9905 2602 or by email at judith.gomes@monash.edu

If you have any concerns about the study, please contact the secretary of the Human Ethics Committee and tell him or her that the number of the project is ___________. The contact details are:

Executive Officer, Human Research Ethics

Monash University Human Research Ethics Committee (MUHREC)

[redacted]

If you agree to participate, please keep this letter for your records and complete and return the consent form to the box located at the entrance to the centre.

Thank you for your time and for considering involvement in this study of child development.

Yours sincerely,

Judith Gomes

[redacted]

October 2012

INFORMED CONSENT FORM FOR STAFF

Project Number: CF12/3871 – 2012001777. *A Study of Play, Culture and Science: The Scientific Conceptual Development of Preschool Children*

I agree to participate in the above named research project. The project has been explained to me and I have read the Explanatory Statement.

I understand that participation is voluntary and that, in agreeing to take part in this project, I am willing (please tick):

- ☐ To be observed at preschool/childcare (as relevant)
- ☐ For these observations to be video/audio-taped and photographed
- ☐ To fill out a questionnaire about my teaching program
- ☐ To be interviewed about my teaching program
- ☐ For these interviews to be video/audio-taped and photographed

Upon completion of this project, the researcher would like to use the words, and images collected from this project for different purposes. I give permission for my images and words to be used in (please tick):

☐ The researcher's thesis

☐ Scholarly journal articles or book chapters

☐ Conference presentations

☐ The researcher's teaching practice at a university, specifically for undergraduate and postgraduate coursework programs about learning science through play

I also understand (please tick) that:

☐ I may be identifiable

☐ images will be in the form of video sequences, still photographs, descriptive reports and scholarly discussion limited to the field of early childhood education or relevant debate among educational professionals who may be interested in new research about learning science through play.

☐ the video data and other photographic recordings will be stored by the university researchers in a secure place on the university's premises, for a period of ten years after the conclusion to the research, with the proviso that access to this recorded data will only be provided in the context of scholarly presentations or university study. There will not be a provision for open public access to this recorded data and I am providing consent only to the researchers' use of this material for the sake of enhancing knowledge within the field of early childhood education.

☐ recorded video and other photographic data will not be published in an online context.

☐ the researcher will advise me by email to provide me with an opportunity to view any video or other photographic material of me. At this time I have the opportunity to view video or other photographic material which may be used by the researcher for public access i.e., with the understanding that “public access” will always mean scholarly or professional discussions in the field of early childhood education.

Please select 1 or 2 (please tick):

☐ 1. At the conclusion to the research I would like the researcher to arrange a time to view all the data of me that could be selected for public access i.e., with the understanding that “public access” will always mean scholarly or professional discussions in the field of early childhood education. I understand that I will complete a form giving further consent.

or

☐ 2. I do not wish to view the data of me. However, I can change my mind and email the researcher requesting to view the images of myself at some stage in the future. I understand that I do not need to complete an additional consent form.

My name: …………..……………………………………………………………

Signature: ………………………………………………………………………

Date: ………………………………………………………..

Email and/or phone: …………………………………………………….

Appendix 6: Explanatory letter for participating families

MONASH University
Education

September 2012

Dear families,

Please find enclosed a copy of a letter and consent form for a proposed study on science and play. The Director has agreed to pass on this material, but she is not involved in the recruitment process. If you wish to be involved, please post the signed consent form into the box that is located at the entrance to the centre. Thank you.

Yours sincerely,

[redacted]

Judith Gomes

PhD Student

MONASH University
Education

Explanatory letter for parents/guardians of children who wish to participate in:

A Study of Play, Culture and Science: The Scientific Conceptual Development of Preschool Children

Dear Parent/Guardian,

I am Judith Gomes. I am writing to you regarding a research project which contributes towards my PhD study, under the supervision of Marilyn Fleer, a professor in the Faculty of Education. This means that I will be writing a thesis which is the equivalent of a 300 page book. The research will be carried out with children aged between 3 and 5 years attending a preschool centre. Your centre director has kindly passed on this letter. My project aims to investigate how preschool children's play activities contribute to scientific concept development. This study is important for learning more about how children learn concepts in play. My study is directly related to the project that is already occurring in your centre (Ethics No. CF11/3199 – 2011001746). However, my study seeks to follow 3-5 different focus children from the overall study and to conduct a survey about parents and teachers' beliefs about play and science learning.

I am interested to explore the nature of play across cultures that could lead children's scientific conceptual development from an early age. For doing this, home and childcare centres are considered the main science rich environments children participate in. Teachers' and parents' perception about science is considered important in this aspect assuming their knowledge further contributes to scientific concept development through play for the children.

I would like to observe your child:

In the Centre:

- Participating in a unit of work that the teacher prepares (up to 2-3 weeks, three times per week for two hours each visit).

In your home:

- Participating in their regular play or other everyday activities (up to 5 visits lasting each 1 or 2 hours),
- A possible follow up visit 6 months later.

Participation will involve:

In the centre: Whilst we will make field notes, we will also videotape and photograph specific play events.

At home: a series of up to 5 visits to your home at a time that suits you. I will be accompanied by a colleague on these visits. Each visit is likely to last between 1-2 hours. I will invite your child to share their favourite play activities with us. Whilst we will make field notes, we will also videotape and photograph specific play events. I would also like to informally interview you about your child's play activities in your family. I will phone and arrange a time that suits you and your family. It is possible that a follow-up visit will be made after six months to observe your child's play and informally interview you about your child's play.

At the end of the research I will prepare a summary of your child's journey throughout the study (such as a CD of photos and video clips) as a record of your child's development. Whilst the images will focus just on your child, it will have some photos and comments of your child playing/working with other children in the preschool.

These images will be from all the participating families who have agreed that their child's images are fine to share more broadly.

It is possible that some of the photographic images (not video) may be selected for publication in a journal article or a book for teachers and other professionals involved in education who are interested in research findings about young children's learning through play. It may also be possible for short video clips (e.g., of up to a minute) taken from the video material to be selected for sharing at conferences or to student teachers who are studying early childhood education. The showing of images will be in the form of video sequences, still photographs, descriptive reports and scholarly discussion limited to the field of early childhood education research or relevant debate among early childhood professionals who may be interested in research about young children's learning through play. No image will appear on a website.

You can withdraw at any time from the study without penalty or indicate at any stage if you prefer us to simply keep written notes rather than audio or visual recording.

Storage of the data collected will adhere to the University regulations and be kept on University premises in a locked cupboard/filing cabinet for 10 years. A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report.

If you have any queries or would like to be informed of the aggregate research findings please contact my supervisor by email at Marilyn.Fleer@monash.edu or me care of 03 9905 2602 or by email at judith.gomes@monash.edu

You can complain about the study if you don't like something about it. To complain about the study, you can write, email, fax or phone. You can direct your concerns to the secretary of the Human Ethics Committee and tell him or her that the number of the project is CF12/3871 - 2012001777. The details are:

Executive Officer, Human Research Ethics

Monash University Human Research Ethics Committee (MUHREC)

[redacted]

If you agree to participate, please keep this letter for your records and complete and return the consent form to the box located at the entrance to the centre.

Thank you for your time and for considering involvement in this study of child development.

Yours sincerely,

[redacted]

Judith Gomes

October 2012

INFORMED CONSENT FORM FOR PARENTS/GUARDIANS

OF PROJECT PARTICIPANTS

Project Number: CF12/3871 – 2012001777. *A Study of Play, Culture and Science: The Scientific Conceptual Development of Preschool Children*

I agree that my child may take part in the above named research project. The project has been explained to me and I have read the Explanatory Statement, which I have shared with my child. I understand that participation is voluntary and that, in agreeing to take part in this project, I am willing (please tick):

- ☐ For my child to be observed at preschool/childcare (as relevant)
- ☐ For these observations to be video/audio taped and photographed
- ☐ For my child to be observed at home
- ☐ For these observations to be video/audio taped and photographed
- ☐ To fill out a questionnaire about play activities of my child in my family
- ☐ To be interviewed about play activities of my child in my family
- ☐ For these interviews to be video/audio taped and photographed
- ☐ To receive a follow up visit after 6 months, to observe my child at home and interview me
- ☐ For this observation and interview to be video/audio taped and photographed

Upon completion of this project, the researcher would like to use the words and images collected from this project for different purposes. I give permission for my child's images and words to be used in (please tick):

☐ Thesis

☐ Scholarly journal articles or book chapters

☐ Conference presentations

☐ The researcher's teaching practice at a university, specifically for undergraduate and postgraduate coursework programs about children's learning and development through play

I also understand (please tick) that:

☐ my child may be identifiable.

☐ images will be in the form of video sequences, still photographs, descriptive reports and scholarly discussion limited to the field of early childhood education or relevant debate among educational professionals who may be interested in new research about play, learning and development.

☐ the video data and other photographic recordings will be stored by the university researchers in a secure place on the university's premises, for a period of ten years after the conclusion to the research, with the proviso that access to this recorded data will only be provided in the context of scholarly presentations or university study. There will not be a provision for open public access to this recorded data and I am providing consent only to the researchers' use of this material for the sake of enhancing knowledge within the field of early childhood education.

☐ recorded video and other photographic data will not be published in an online context.

☐ the researcher will advise me by email to provide me with an opportunity to view any video or other photographic material of my child. At this time I have the opportunity to view video or other photographic material which may be used by the researcher for public access i.e., with the understanding that "public access" will always mean scholarly or professional discussions in the field of early childhood education.

Please select 1 or 2 (please tick):

☐ 1. At the conclusion to the research I would like the researcher to arrange a time to view all the data of my child/children that could be selected for public access i.e., with the understanding that "public access" will always mean scholarly or professional discussions in the field of early childhood education. I understand that I will complete a form giving further consent.

or

☐ 2. I do not wish to view the data of my child/children. However, I can change my mind and email the researcher requesting to view the images of my child at some stage in the future. I understand that I do not need to complete an additional consent form.

Child's name ………………………………………………………………………….

Date of birth …………………………………..

Parents'/Guardians' names:

……….…………………………………………………………………

Signature of Parent/Legal Representative:

………………………………..……………………………………………………………

Other family members who may be present (name and signature)

………………………………………………………………………………

………………………………………………………………………………

Phone or/and email: ……………………………………………………….

Street address: ……………………………………………………………

………………………………………………………………………………

………………………………………………………………………………

Date: ………………………

MONASH University
Education

Explanatory letter for parents/guardians of children who wish to participate in:

A Study of Play, Culture and Science: The Scientific Conceptual Development of Preschool Children

Dear Parent/Guardian,

I am Judith Gomes. I am writing to you regarding a research project which contributes towards my PhD study, under the supervision of Marilyn Fleer, a professor in the Faculty of Education. This means that I will be writing a thesis which is the equivalent of a 300 page book. The research will be carried out with children aged between 3 and 5 years attending a preschool centre. Your centre director has kindly passed on this letter. My project aims to investigate how preschool children's play activities contribute to scientific concept development. This study is important for learning more about how children learn concepts in play. My study is directly related to the project that is already occurring in your centre (Ethics No. CF11/3199 – 2011001746). However, my study seeks to follow 3-5 different focus children from the overall study and to conduct a survey about parents and teachers' beliefs about play and science learning.

I am interested to explore the nature of play across cultures that could lead children's scientific conceptual development from an early age. For doing this, home and childcare centres are considered the main science rich environments children participate in. Teachers' and parents' perception about science is considered important in this aspect assuming their knowledge further contributes to scientific concept development through play for the children.

I would like to observe your child in the centre:

- Participating in a unit of work that the teacher prepares (2-3 weeks, three times per week for two hours each visit).

Whilst we will make field notes, we will also videotape and photograph specific play events.

It is possible that some of the photographic images (not video) may be selected for publication in a journal article or a book for teachers and other professionals involved in education who are interested in research findings about young children's learning through play. It may also be possible for short video clips (e.g., of up to a minute) taken from the video material to be selected for sharing at conferences or to student teachers who are studying early childhood education. The showing of images will be in the form of video sequences, still photographs, descriptive reports and scholarly discussion limited to the field of early childhood education research or relevant debate among early childhood professionals who may be interested in research about young children's learning through play. No image will appear on a website.

You can withdraw at any time from the study without penalty or indicate at any stage if you prefer us to simply keep written notes rather than audio or visual recording.

Storage of the data collected will adhere to the University regulations and be kept on University premises in a locked cupboard/filing cabinet for 10 years. A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report.

If you have any queries or would like to be informed of the aggregate research findings please contact my supervisor by email at Marilyn.Fleer@monash.edu or me care of 03 9905 2602 or by email at Judith.gomes@moansh.edu

You can complain about the study if you don't like something about it. To complain about the study, you can write, email, fax or phone. You can direct your concerns to the secretary of the Human Ethics Committee and tell him or her that the number of the project is CF12/3871 - 2012001777. The details are:

Executive Officer, Human Research Ethics

Monash University Human Research Ethics Committee (MUHREC)

[redacted]

If you agree to participate, please keep this letter for your records and complete and return the consent form to the box located at the entrance to the centre.

Thank you for your time and for considering involvement in this study of child development.

Yours sincerely,

[redacted]

Judith Gomes

October 2012

INFORMED CONSENT FORM FOR PARENTS/GUARDIANS OF PROJECT PARTICIPANTS

Project Number: CF12/3871 – 2012001777. *A Study of Play, Culture and Science: The Scientific Conceptual Development of Preschool Children*

I agree that my child may take part in the above named research project. The project has been explained to me and I have read the Explanatory Statement, which I have shared with my child.

I understand that participation is voluntary and that, in agreeing to take part in this project, I am willing:

☐ Please tick this box if you agree to all the points below, or select from the following:

- ☐ For my child to be observed at preschool/childcare (as relevant)
- ☐ For these observations to be video/audio taped and photographed

Upon completion of this project, the researcher would like to use the words and images collected from this project for different purposes. I give permission for my child's images and words to be used in (please tick):

☐ Thesis

☐ Scholarly journal articles or book chapters

☐ Conference presentations

☐ The researcher's teaching practice at a university, specifically for undergraduate and postgraduate coursework programs about children's learning and development through play

I also understand (please tick) that:

☐ my child may be identifiable.

☐ images will be in the form of video sequences, still photographs, descriptive reports and scholarly discussion limited to the field of early childhood education or relevant debate among educational professionals who may be interested in new research about play, learning and development.

☐ the video data and other photographic recordings will be stored by the university researchers in a secure place on the university's premises, for a period of ten years after the conclusion to the research, with the proviso that access to this recorded data will only be provided in the context of scholarly presentations or university study. There will not be a provision for open public access to this recorded data and I am providing consent only to the researchers' use of this material for the sake of enhancing knowledge within the field of early childhood education.

☐ recorded video and other photographic data will not be published in an online context.

☐ the researcher will advise me by email to provide me with an opportunity to view any video or other photographic material of my child. At this time I have the opportunity to view video or other photographic material which may be used by the researcher for public access i.e., with the understanding that "public access" will always mean scholarly or professional discussions in the field of early childhood education.

Please select 1 or 2 (please tick):

☐ 1. At the conclusion to the research I would like the researcher to arrange a time to view all the data of my child/children that could be selected for public access i.e., with the understanding that "public access" will always mean scholarly or professional discussions in the field of early childhood education. I understand that I will complete a form giving further consent.

or

☐ 2. I do not wish to view the data of my child/children. However, I can change my mind and email the researcher requesting to view the images of my child at some stage in the future. I understand that I do not need to complete an additional consent form.

Child's name: ………………………………………………………………….

Child's date of birth …………………………………..

Parents'/Guardians' names ………………………………………………………………

Signature of Parent/Legal
Representative:………………………………………………………………………………

Contact details:

Phone and/or email: ………………………………………………………………….

Date:……………………………………………………..